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Health and Environmental Protection Uranium Mining

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Public and Worker Health

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MINERAL RESOURCES BRANCH

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TABLE OF CONTENTS

TABLE OF CONTENTS – *Continued*

APPENDICES

TABLE OF CONTENTS — *Continued*

Page

APPENDICES — *Continued*

I. MINE SAFETY ADMINISTRATION IN BRITISH COLUMBIA

The first law relating to mining in what is now British Columbia, was in the form of a proclamation issued in 1853 by James Douglas, Lieutenant-Governor of Queen Charlotte Island. This provided for the payment of a mining licence to entitle a person to dig, search for, or remove gold. Other laws relating to placer gold mining followed in 1857, 1859, and 1867. Legislation enacted in 1869 and 1877 extended the existing laws to cover other metallic minerals and minerals other than coal.

In 1877, the first *Coal Mines Regulation Act* was passed and an Inspector of Mines was appointed in Victoria. Twenty years later, the first *Metalliferous Mines Regulation Act* was enacted and by 1898 there were three Inspectors of Mines in the Province. A separate Inspection Branch of the Department of Mines was formed in 1909 under a Chief Inspector of Mines. Since that time the staff of the Inspection Branch, which is now known as the Inspection and Engineering Division, has continually expanded and has been broadened to include professional specialists in addition to mining engineers. These specialists were appointed at different stages to meet demands for specific expertise which resulted from changing technology and from increased subject knowledge. An electrical engineer was hired in 1946 to ensure that the rapidly expanding use of electricity, both underground and on the surface, was being handled In a safe manner. He was also charged with advising on new safety legislation necessary for the control of electric power. Subsequently, other specialists were hired to meet the demands of changing technology in the fields of road engineering, environmental control, mechanical engineering, reclamation engineering, audiology, coal engineering, and geotechnical engineering.

Any review of mine safety in Canada shows that British Columbia has taken a lead in many branches of safety engineering and has produced one of the best records of mine safety in North America. Some details of these achievements are described in the following paragraphs.

1.1 Mine Rescue

Mine-rescue training and facilities have been required by law in British Columbia since 1909 and, because of an extensive history of coal-mining operations, mine rescue has always played a major role in mine inspection.

Mine-rescue teams are highly trained, skilled personnel. Their work is demanding and, at times, dangerous. It requires men in good physical condition and of a calm temperment. They must have an intimate knowledge of their equipment and possess the many other skills required to accomplish their rescue missions.

The mining laws in British Columbia require that trained mine-rescue personnel and mine-rescue equipment be maintained at all mines. To this end, basic mine-rescue training courses are conducted at mining properties so that miners will have the opportunity of learning the skills necessary to the mine-rescue man. Once the basic skills of the mine-rescue man are learned, many hours of team training and practice are required to develop a competent mine-rescue team, a team that can work together and, with other teams, to accomplish rescue objectives in the event of a mine disaster.

A full mine-rescue team consists of six qualified mine-rescue men. Each man must hold a valid mine-rescue certificate, be in good physical condition with a current certificate of fitness, and should have had recent practice with rescue breathing apparatus.

The Mine-Rescue section of the Inspection and Engineering Division pioneered the use of battery-operated telephones by rescue teams working underground. British Columbia mine inspectors were among the first to realize the value of competition between mines to encourage mine-rescue training, and Province-wide annual competitions were held as long ago as 1916. In 1976, British Columbia took the lead in establishing annual Canadian mine-rescue competitions. In 1971, the first open-pit mine-rescue course in Canada was set up and is today recognized as a model by many other mining authorities. Requests for British Columbia training manuals have been received from all over the world and the Inspection and Engineering Division is now giving training in surface mine rescue to officials from various areas of the United States. Up to the present time, between 30 and 40 United States mining personnel have received this training in British Columbia (*see* Appendices 12 and 13).

On May 2, 1972, a disastrous fire occurred at the Sunshine mine in Idaho, United States of America, in which 92 men lost their lives. Mine-rescue teams from British Columbia were asked for help and 32 men were sent. They performed admirably under very difficult conditions and not one machine malfunctioned throughout the six-day ordeal.

1.2 Mechanical/Electrical

In 1946, the first British Columbia Electrical Inspector of Mines was appointed and in 1966 the first Mechanical Inspector was appointed. The Inspection and Engineering Division has, since these dates, paid particular attention to the introduction and operation of mechanical and electrical equipment in mines. In general, equipment has become more sophisticated in design and larger in size so that increased skills are required for both its operation and maintenance. Design features have not always produced acceptably safe equipment. As a result, regulations have been developed over the years covering the design and manufacture of the equipment as well as its operation and today's extremely high standards are a direct result of this rigorous legislation.

The mining industry in general has recognized the work of the Inspection and Engineering Division with respect to the safe operation of large off-highway mining trucks. The Division took a worldwide lead, over 10 years ago, with regard to braking performance of new and existing mining trucks, a lead which has been maintained by a constant upgrading of input into the design and testing of these huge vehicles. No new model truck can now be put into service in British Columbia until it has passed rigorous tests, prescribed and witnessed by mechanical inspectors of the Division. These tests, which are the most stringent in the world, have established British Columbia as a clear leader in this particular field.

With the rapid increase in the use of diesel-powered equipment in underground mines, British Columbia introduced legislation in 1973 requiring the use of fire-resistant hydraulic fluids (after January 1, 1975) in all underground machinery (*Mines Regulation Act*, section 23, rule 111). In addition, the use of fire-supression equipment is also generally required on all mobile equipment operating underground. Both of these requirements were the first of their kind in Canada and have subsequently been, or are being, adopted by other provinces.

Other areas where British Columbia has been a nationwide leader in the safe operation of mechanical/electrical equipment at mines include the following:

(a) mandatory installation of roll-over protection on certain off-highway equipment (*Mines Regulation Act*, section 23, rule 277, 1973),

(b) mandatory installation of emergency steering devices on vehicles (*Mines Regulation Act*, section 23, rule 266, 1971),

(c) compulsory high-speed annual brake tests of dump trucks, on maximum grade and carrying full load (*Mines Regulation Act*, section 23, rule 263(f), 1973, and directives),

(d) issuing of guidelines covering standards of illumination at mines (issued February 1978),

(e) mandatory submission of traffic control schemes for all mines [*Mines Regulation Act*, section 23, rule 264(b), 1973],

(f) mandatory installation of fire-suppression equipment at fuel and repair depots underground (*Mines Regulation Act*, section 23, rule 112, 1973).

1.3 Environmental Inspection

In 1960, British Columbia pioneered improved measures of dust control at surface drilling operations by the use of detergents and/or alcohol-water mixtures as dust suppressants. This generally resulted in lowering dust concentrations to well below the required threshold limit value.

In 1948, legislation was introduced allowing the Chief Inspector of Mines to permit the use of diesel-powered equipment in underground mines [*Mines Regulation Act*, section 23, rule 93(a)]. This was the first use of diesel-powered equipment in underground mines in Canada. Stringent ventilation and air quality standards have been developed for the use of diesels underground and a 'diesel permit' has to be obtained and posted at the mine for each separate diesel engine being operated (*Mines Regulation Act*, section 23, rule 93). This permit stipulates the minimum quantity of ventilating air necessary for the operation of the engine (to dilute the exhaust gases to acceptable levels) and it also shows the maximum allowable fuel pump setting (to ensure that combustion characteristics are not different from those originally determined by tests for that particular engine).

Hearing conservation legislation for the mining industry in British Columbia dates back to 1967 when regulations were introduced requiring that all reasonable measures must be taken to ensure that noise levels do not exceed suitable standards and that ear protection is used when necessary. Furthermore, drills must be equipped with suitable noise attenuation devices (*Mines Regulation Act*, section 23, rule 94).

In 1966, the Environmental Control section purchased instruments to measure sound levels in and about mines in British Columbia. Surveys were made at mines to establish noise levels of equipment without any sound attenuation apparatus. The Sullivan mine, Cominco Ltd., had been carrying out research on noise suppression devices prior to 1966 and the results of this experience were made available to the Division in March 1968. This data led to the issuing of instructions by the Chief Inspector of Mines requiring the noise level on all drills to be attenuated by 7 decibels. A directive, issued by the Chief Inspector of Mines to all inspectors in July 1968, provided guidelines for suitable ear protection.

In May 1974, the major drill manufacturers supplying drilling machines to the British Columbia mining industry were contacted and advised that a new noise level standard of 110 decibels for drilling machines, operating in headings underground, would become effective on January 1, 1978. Prior to this, the Chief Inspector had recommended to a meeting of Chief Inspectors from other Canadian provinces that a mutually acceptable policy for noise control should be established and standards set for manufacturers supplying equipment in Canada. No headway was made with this approach and the Chief Inspector decided to go ahead without any commitment from other provinces.

In 1971, legislation was introduced requiring systematic audiometric testing for hearing acuity (*Mines Regulation Act*, section 23, rule 94). Here again, the Inspection and Engineering Division pioneered this type of hearing protection legislation for mining operations in Canada and it was not until 1978 that other industries in British Columbia were covered by similar legislation. Programs have been in force since 1976 for the training of technicians in audiometric testing techniques and Division staff has been asked to set up a basic program for the Northwest Territories because of the high standards of control now in effect at British Columbia mines.

More recently, a computer program has been put into effect to store and process data on individual noise exposure and hearing losses in the mining industry so that working areas requiring special attention can be determined and corrective action undertaken.

1.4 General

In addition to the former, the Inspection and Engineering Division has been the pioneer in many other aspects of safety inspection and engineering and the following is a list of other rules and policies that British Columbia was the first to implement:

(a) requirement for shiftboss certification for underground and surface operations (*Mines Regulation Act*, section 21, 1960 and 1969),
(b) the granting of the right for a worker to refuse to work in a hazardous location (*Mines Regulation Act*, section 23, rule 251, 1973),
(c) the hiring of a geotechnical engineer,
(d) requiring the use of fire-resistant conveyor belting underground (*Mines Regulation Act*, section 23, rule 102, 1967),
(e) requiring manufacturers to issue maximum load/maximum grade charts for vehicles (*Mines Regulation Act*, section 23, rule 263, 1973).

The British Columbia Inspection and Engineering Division has, over the years, exhibited the necessary degree of flexibility and ability, not only to keep abreast of new developments in the mining field, but in many instances to become recognized leaders in many aspects of mine safety engineering.

1.5 Achievements

Statistical information by the Workers' Compensation Board (*W.C.B. News*, September/October 1979, Volume 22, No. 5, pages 4 and 5), shows the mining industry of British Columbia to have a lower average wage loss claim per 100 employees than many other major industries over the five-year period from 1974-1978 as indicated below.

Sub Class	Industry	Wage Loss Claims/ 100 Employees Average 1974-1978
0403	Gravel, sand, and shale pits	10
0411	Metal and asbestos mines, ore reduction	8
0430	Coal mining	8
0102	Logging	15
0105	Saw mills	14
0706	Building construction, demolition, etc.	17
0725	Dams, reservoirs, bridges, etc.	14
0726	Road making, water works, construction, etc.	11
0748	Oil and gas producers, exploration drilling, etc.	12
0902	Stevedoring, wharf operations, etc.	17
0637	Meat packing, stock yards, etc.	20
0632	Flour mills, grain elevators	13
0604	Manufacturers of furniture, wood articles, pitch, etc.	17
All Sub Classes		6.9

II. ENVIRONMENTAL CONTROL SECTION – FORMATION AND DEVELOPMENT

As a result of considerable pressure from various groups such as the Mining Association of British Columbia, medical doctors, labour unions, and mining companies, the Minister of Mines in August 1935 commissioned Dr. C. H. Vroomon to assess the prevalence of silicosis among miners in the British Columbia mining industry. Five of the larger mines were surveyed and, out of 1,339 workers x-rayed, 105 were found to have silicosis and 10 tuberculosis. The result of this survey was that legislation was enacted through the *Mines Regulation Act* requiring all workers in dust-exposure occupations to have annual x-rays and medical examinations. On November 20, 1936, silicosis in the metalliferous mining industry was made a compensable disease under the *Workmen's Compensation Act* for persons who became disabled on or after the first day of January 1936 (*see* Appendix 11). The Mining Association of British Columbia in 1936 hired Mr. D. A. MacLeod to assess dust conditions in British Columbia mines and in September 1936 Mr. MacLeod organized a silicosis branch inspectorate under the control of the *Workmen's Compensation Act*. This was financed by assessments on mining companies.

The silicosis branch inspectorate was expanded in 1945 when Mr. R. Craig was hired and again in 1951 and 1952 when Mr. R. Campbell and Mr. S. Elias were hired. The responsibility of these inspectors under the then Workmen's Compensation Board was to control dust exposures to workers in the mining, construction, and other industries where there were known dust hazards. To achieve this goal all information on dust control obtained from any source throughout the world and from personal experience was utilized. During this period the responsibilities of the silicosis branch inspectors were confined strictly to dust control measures, mine gases as they affected silicosis, and checking to ensure that medical certificates were in order.

On September 1, 1962 an agreement was reached with the Workmen's Compensation Board for the Department of Mines and Petroleum Resources to take over responsibility for dust control at mines in British Columbia and two silicosis inspectors from the Workmen's Compensation Board were transferred to the Department of Mines and Petroleum Resources to carry out these duties under the authority of the *Metalliferous Mines Regulation Act*. Since then the *Mines Regulation Act* and the *Coal Mines Regulation Act* have been amended several times and many of the changes that have been made directly concern environmental control in mines. One example is that section 7 of the *Mines Regulation Act* which in 1960 referred only to the safety of employees, was amended in 1967 to cover the safety and health of employees, and was again amended in 1967 to cover in addition the safety of the public.

Various changes in mining legislation over the years have necessitated increases and diversification of staff to handle the increased more complex work load. The following list shows the present employees of the Environmental Control section.

Ventilation Section (Including Dust Control)

S. Elias – September 1952 to present time
D. J. Murray – July 1977 to present time
S.J.L. Miller – April 1978 to present time

Noise Control (Including Audiometry)

J. Ferguson – December 1978 to present time
V. Pyplacz – January 1979 to present time

The present staff inspects all active operating mines under the jurisdiction of the *Coal Mines Regulation Act* and the *Mines Regulation Act.*

All environmental control inspectors have been given on-the-job training in the use of testing and sampling instruments for mine gases, dusts, heat, radiation, ventilation, and noise control pertaining to mining. They have attended various courses at universities and colleges to upgrade their education in the field of environmental health control and to become familiar with changing technology affecting the health of workers. All environmental control inspectors have attended the Uranium Mine Inspectors Training Course at the Elliot Lake Centre.

III. THE DUTIES AND RESPONSIBILITIES OF ENVIRONMENTAL CONTROL INSPECTORS

3.1 Senior Inspector of Mines – Environmental Control

Under limited direction of the Deputy Chief Inspector of Mines, the Senior Inspector of Mines – Environmental Control is responsible for all aspects of environmental protection, audiology, and noise control at mines in British Columbia.

He devises and implements programs aimed at reducing the incidence of silicosis, pneumoconiosis, asbestosis, radiation exposure, and loss of hearing in the mining industry under the authority of the *Mines Regulation Act* and the *Coal Mines Regulation Act.* He trains and directs a staff of four consisting of two environmental inspectors, a noise inspector, and an audiologist. He gives advice to the district inspectors of mines on all matters pertaining to environmental protection and coordinates the work of his staff with that of the district inspectors of mines and other specialists. He advises the Chief Inspector of Mines on necessary amendments to the *Mines Regulation Act* and the *Coal Mines Regulation Act* relating to mine gases, ventilation, noise, radiation, heat exposure, and other environmental issues so that legislation will keep abreast of changing medical and engineering technology. He ensures that environmental inspections are carried out at surface and underground mining operations, sand and gravel pits, and quarries, and that regular surveys are made of dust conditions, noise levels, radiation exposure, and ventilation. He consults with, and advises where necessary, mine officials regarding control measures necessary for the maintenance of equipment and operations to the standards required by legislation.

3.2 Inspectors of Mines – Environmental Control

The duties of the environmental control inspectors are similar to those outlined above. Under the direction of the Senior Inspector of Mines – Environmental Control they carry out dust, noise, radiation, gas, ventilation, and heat exposure surveys in underground and surface operations at metal and coal mines, quarries, and sand and gravel pits throughout British Columbia. They ensure that the provisions of the *Mines Regulation Act* and the *Coal Mines Regulation Act* relating to environmental matters are being earried and they give advice, where required, to mine officials, workers, and district inspectors of mines on control measures necessary to ensure compliance with mandatory environmental standards. They give lectures and formal talks to mine personnel, students, unions, and safety committees on the prevention of silicosis, pneumoconiosis, asbestosis, and radiation hazards. They consult and liaise with medical officers, radiologists, consulting engineers, Workers' Compensation Board officials, industrial sales and engineering personnel, and other government officials in order to evaluate existing and proposed environmental control equipment and methods at mining operations.

3.3 Audiologist

Under the limited direction of the Senior Inspector of Mines – Environmental Control, the audiologist has the following responsibilities and duties:

(a) to devise and implement computer programs for the compilation and evaluation of data on noise levels and hearing acuity provided by the environmental control inspectors and by industry;

(b) to conduct basic research relating to noise hazards and their effect on hearing and also to design and implement research methods for the compilation of noise and hearing data;

(c) to investigate claims for hearing loss by interviewing claimants, examining and diagnosing hearing loss, and comparing test results with other diagnostic data in order to determine the degree of impairment. To assist in the adjudication of hearing loss claims and to perform hearing aid evaluation and reevaluation tests as required;

(d) to undertake field testing and investigation of hazardous noise exposures. To consult with management on the installation of audiometric testing facilities and to inspect these facilities from time to time to ensure that they meet required standards and that the equipment has been properly calibrated;

(e) to conduct initial training, and subsequent refresher courses, on noise and hearing conservation for industrial audiometric technicians. To exercise general supervision over the Ministry's audiometric program and to act as a consultant to management and technicians as required;

(f) to prepare educational materials on noise and hearing conservation for distribution to industry and, if requested, for the general public;

(g) to prepare talks, lectures, and courses on noise and hearing conservation, ear protection, and noise attenuation. These talks are presented to workers, unions, and management throughout the Province as well as to Ministry of Energy, Mines and Petroleum Resources personnel;

(h) to consult with Workers' Compensation Board officials, medical specialists, hearing aid dealers, equipment calibration and repair agencies, acoustical engineers, etc., regarding the effects of industrial noise on hearing, and related matters.

3.4 Inspectors of Mines — Noise Control

Under the direction of the Senior Inspector of Mines — Environmental Control, the noise control inspector carries out surveys at surface and underground operations to determine the noise hazard in all areas of the mining industry, and maintains complete records of all such surveys. He advises mine personnel on hearing protection and audiometric testing. He also checks the suitability of facilities at mines for audiometric testing to ensure that they are satisfactory for future hearing loss adjudication. He tests new equipment introduced at mines to ensure its compliance with standards established under the *Mines Regulation Act* and the *Coal Mines Regulation Act*.

IV. MONITORING METHODS AND EQUIPMENT – ENVIRONMENTAL CONTROL

Radon daughter and gamma surveys are made at established exploration operations and workers are required to wear dosimeters. Complete job employment records are kept for each worker required to wear a dosimeter at the Canadian Centre for Occupational Health and Safety in Hamilton, Ontario.

Radon daughter concentrations are measured by collecting the radon daughters on a filter paper from the mine air. The alpha activity on the filter paper is counted using an appropriately calibrated instrument. The counts per minute are converted to actual decay events occurring on the filter paper. The disintegrations per minute per litre of air are converted to the multiple or fraction of a working level at the time of sampling by taking into account the time factor. Samples are taken at locations where the ventilation is poor, in return airways, in areas where there are different types of rock intersections, in areas where groundwater is entering the workings, and at all working places such as diamond-drill stations, development headings, drill core storage areas, mill buildings, and general travelways. Samples are also taken of the ambient fresh air to establish background radiation.

4.1 Radiation-Measuring Instruments Belonging to the Inspection and Engineering Division

Air Sampling Pump

This is an H & H Custom Work sample pump with pulsation damper and timing switch. It has an air flow rate of 6 to 9 litres per minute and weighs approximately 1 kilogram without the battery. It is equipped with a 25-millimetre filter holder and is powered by a standard lamp battery. The membrane filters are of cellulose nitrate with a chemical resistance against higher alcohols, hydrocarbons, and mineral acids. The pore size is 0.8 micron.

Sample Counter

This is manufactured by Tri-Met Instruments (type TM372A) for alpha radiation. It is equipped with a foil-type open zinc sulphide detector. The instrument may also be used as a beta and gamma counter when equipped with a thin organic phosphor, such as NE103, and by attaching an external gamma scintillation detector probe.

Calibration of Above Instruments

The air sampling pump is calibrated with an American Meter Co. Wet Test Meter and the alpha sample counter is calibrated with a certified AM-241 americium standard.

Gamma Radiation Detector

Gamma radiation is measured by means of a Ludlum Model 19 'Micro R' meter with an internally mounted 1-inch by 1-inch Na(T1) scintillator to give optimum performance in counting low level gamma radiation. The instrument reads five separate ranges with 0 to 25 micro R/h being the most sensitive and 0 to 5 000 micro R/h being the highest range. The instrument is battery powered.

The following instrument is being considered at the present time for possible future purchase.

Radon Daughters Sample Counter

This instrument is a model 822 MDA Instant Work Level Meter supplied by MDA Scientific Inc. It is used to measure radon daughters in approximately a 5-minute period. Both alpha and beta ionizing radiation are measured. The advantage of this instrument is that many samples may be taken in a short period of time. The normal Kusnetz measuring technique requires from 40 to 90 minutes for each sample.

4.2 Other Radiation-Measuring Equipment Available to Inspectors

Personal Dosimeters

The accuracy of mine radiation exposure data has long been a problem and a reliable radiation-measuring device that could be easily worn by a worker is still to be developed. There are a number of devices being developed through research by governments and institutional organizations in the United States and Canada. The United States Bureau of Mines has done much research on personal dosimeters of different types including 'thermo-luminescence' type dosimeters, electronic dosimeters using cap lamp batteries for power, and 'track etch' dosimeters involving chemical change in a sensitive film due to radiation energy. In British Columbia personal dosimeters are being used at exploration projects and would be used at uranium mining operations. Personal exposures that would classify a worker an an 'atomic radiation worker' as defined by the Atomic Energy Commission regulations have not been found in any exploration work to date in British Columbia.

Radon Gas Detector

An instrument to measure radon gas has been purchased by the Ministry of Health (Dr. W. Greene) and the use of this equipment is available to the Inspection and Engineering Division whenever needed.

V. DUST CONTROL IN METAL, COAL, AND ASBESTOS MINES

5.1 Metal Mines

The standard method used for sampling dust concentrations in metal mines is by konimetry. The threshold limit value (TLV) is set at not more than 300 particles per cubic centimetre of air when using the standard method of slide treatment and counting under dark field illumination at 150 diameters magnification. The konimeter is used as the standard means of assessing dust health hazards in British Columbia and in Ontario, by the Ontario Mining Association, for engineering control and the maintenance of statistics relating to silicosis. Konimetry has been used in British Columbia since 1935 for assessing dust health hazards. A fairly well-defined dose-response relationship has been established between measured dust levels and the incidence of silicosis over the period of 42 years that the konimeter has now been in use in British Columbia.

In British Columbia the established dust-sampling policy involves the taking of a number of short-term samples to determine a worker's relative dust exposure and to effectively control dust-emitting operations in locations that are regularly travelled by workers.

Individual random samples taken over short periods of time (konimeter sampling) at various locations are considered preferable to a sample taken with an instrument that collects dust from several sources over a longer period of time (gravimetric sampling). This is because the latter instrument provides only an average result for all locations visited and therefore does not pinpoint individual trouble spots. Workers do not normally remain in one specific location for any length of time and short-term sampling therefore is considered to give a better indication of the relative health hazard, especially when the results of many years of sampling are available for statistical interpretation.

As silicosis takes many years to develop, environmental standards are based on historical and medical experience and represent conditions under which it is believed that nearly all workers may be repeatedly exposed without adverse health effects. Because of wide variations, however, in individual susceptibility, a small percentage of workers may develop some occupational illness. It is fully realized that the ultimate standard to strive for would be zero contamination. Hygiene health standards should be used simply as a guide for the control of health hazards and not as a fine distinction between 'safe' and 'dangerous' concentrations. The results of years of systematic dust studies have shown a correlation between the incidence and progression of silicosis and pneumoconiosis of exposed workers and dust concentrations. The reduction in dustiness has been followed by a parallel decrease in disease incidence. This can be shown by combining silicosis pension statistics with the average dust concentrations of mining operations in British Columbia over a period of 42 years.

The acceptable threshold limit values for various gases are shown on a memorandum issued under the authority of the *Mines Regulation Act*, section 23, rule 85(a) by the Chief Inspector of Mines (*see* Appendix 1). The threshold limit values adopted by the American Conference of Governmental Industrial Hygienists are generally followed (*see* Appendix 2.) One exception to this is that nitric oxide and nitrogen dioxide have been combined as 'nitrous fumes' and the threshold limit value set at 5 parts per million. This is because of the synergistic effect of these gases and silica dust in combination. Carbon monoxide also has a synergistic effect in combination with silica dust.

5.2 Coal Mines

The dust sampling method used in coal mines is gravimetric. The threshold limit value for coal dust at the present time is 3 milligrams per cubic metre but the intent is to lower this value to 2 milligrams per cubic metre in order to conform with the standards established by the American Conference of Governmental Industrial Hygienists. The reason for the delay in implementing this lower threshold limit value is that there is no direct evidence at the present time to suggest a high health hazard. From information available, it appears that only a few pensions are being paid for lung disease (pneumoconiosis) in the coal mining industry of British Columbia.

The term 'black lung' (anthracosis) is being used loosely in the United States to describe lung dust disease. Anthracosis is prevalent in areas where rock and coal are mined together and there is a fairly high percentage of silica in the coal. In British Columbia very little rock is mined with the coal and there is a low silica content of the coal itself and therefore very little, if any, anthracosis is found in this Province. It is probable that any cases of anthracosis occurring in British Columbia are with miners who have immigrated from England, Scotland, or the United States and this may require further investigation in the future.

The only noxious or harmful gases normally encountered in coal mines at the present time are methane and diesel engine exhaust gases and no significant problems are currently being experienced with these.

5.3 Asbestos Mines

The membrane filter method is used to assess asbestos fibre health hazards in British Columbia. The present standard in use is not more than 5 fibres per cubic centimetre (greater than 5 microns in length) as determined with a phase-contrast illuminated microscope at 625x magnification. This fibre count method was designed for insulation, fabrication, and weaving industries where a relatively pure product is used. In mining and milling operations at asbestos mines there is a greater quantity of rock dust mixed with the fibre and some authorities claim that the hazard is less in the mining industry than industries using pure products.

The only asbestos mine in British Columbia has been operating for more than 20 years. Recently the medical records of all workmen with more than five years' employment at the operation were reviewed by the silicosis department and no sign of any lung disease due to asbestos fibre or rock dust was found.

VI. INSPECTION METHODS

The following is a list of items that would normally be covered, as applicable, during an environmental inspection at a non-uranium mine. (In a uranium mine, a complete radiation survey would also be carried out.)

General: Employees' certificates of fitness would be checked.

Assay Laboratory: General inspection of housekeeping, dust control measures, and cleanup procedures. Dust samples taken during dust-producing operations such as crushing, grinding, pulverizing, etc.

Welding Operations: Inspection of ventilation facilities and testing for fumes and gases.

Milling and Concentrating Operations (Surface): Report on activity in progress. General inspection of housekeeping and dust control systems. Report on the storage of chemicals and general safety and health controls. Check on hearing protection and other personal protective equipment. The ventilation system is described and, where necessary, measured.

NOTE: Many concentrating plants now use gamma-ray gauges as part of the process control system and licences are required from Atomic Energy Control Board for these devices. The licences have to be renewed annually. Readings are taken regularly by mine staff to measure external radiation.

Crushing and Screening Operations: General inspection of housekeeping and dust control systems. Check on the type of hearing protection required and being worn. Dust samples taken at designated locations.

Open-Pit Operations: General report on activity in the area. Dust samples taken at the operator's position on all shovels and drills and in selected units of mobile equipment. Inspection of windows, doors, seals, and fan/heater systems. Report on hearing protection, dust control measures, and general atmospheric conditions.

Underground Operations:

(a) *main ventilation* – description of main ventilation system and survey of incast and outcast airways.

(b) *mechanized workings* – inspection of diesel record books. At working places, dust samples and psychrometer readings are taken and gas tests conducted. Ventilation is described and measured. A general report is made describing dust control measures, details of the equipment used, times of blasting, etc.

(c) *drilling operations* – dust samples and psychrometer readings are taken and gas tests made. Ventilation is described and measured. Muffling system of drills is inspected and detailed. Hearing protection is checked. Drilling water checked. Report made of dust control measures and equipment in use.

(d) *other underground operations (mills, shops, etc.)* – report on activity in progress. Dust samples and psychrometer readings are taken and gas tests made. Heating protection is checked and ventilation described and measured. Report on storage of chemicals and general safety and health controls.

Diesel-Powered Equipment, Underground Mines: Where diesel-powered equipment is used in an underground mine, air measurements must be taken at least once each week where the diesel equipment is operating. A record must be kept of all measurements in a log book that can be examined by the inspector. Exhaust gases must be tested at least twice per week for carbon monoxide, oxides of nitrogen, and such other gases as the inspector directs, and the results must be recorded. In addition, at least once each day, tests for the same gases must be made at the operator's location and in the general body of the air where the equipment is operating and the results recorded. A complete mine ventilation survey must be made at least every three months and adequate ventilation plans showing the normal direction and volume of the main air currents, locations of permanent fans, ventilation doors, stoppings, and connections with adjacent mines must be kept in the mine office for inspection as required. A complete environmental survey is carried out in all mines at least once a year, or as often as duties permit, by environmental control inspectors to check that company surveys are being done correctly and to pick out any problem areas that require correction to ensure the health and safety of workers. Examples of these surveys are illustrated in the appendices (*see* Appendix 9).

VII. MINING OPERATIONS – RADIATION SURVEYS

The following policy has been applied to surveying non-uranium mines in British Columbia for possible radiation hazards:

(a) all mines are to be sampled at least once for gamma radiation and radon daughter concentrations;

(b) mines having radon daughter concentrations greater than 0.3 WL shall have all working places sampled at least once each week for control purposes. Records of worker exposure and sampling programs shall be maintained at the mine and at a central registration office;

(c) mines having radon daughter concentrations between 0.1 WL and 0.3 WL shall be sampled at least every 90 days or until such time as the readings are consistently below 0.1 WL;

(d) whenever a radon daughter concentration in excess of 0.3 WL has been measured at a mine, that mine shall subsequently be sampled at least once each year even if such annual samples show no radon daughter concentration in excess of 0.1 WL.

VIII. HEARING CONSERVATION PROGRAM

Hearing conservation may be defined in terms of three aspects: (1) noise control, (2) hearing protection, and (3) audiometry. In early 1968, a noise technician was hired to carry out sound surveys at mines and to inspect audiometric booths and audiometers. An audiologist was hired at the beginning of 1979 to set up the Ministry's computer program for audiometry and to train and certify technicians to carry out hearing tests at mines.

8.1 Sound Surveys

Sound surveys record the level of noise being produced on each mining property. Eighty-five dBA is the eight-hour exposure limit after which the use of ear protection is required and annual hearing testing must be carried out. Sound surveys establish which areas on a property have hazardous noise levels.

8.2 Control of Noise at the Source

All newly manufactured drilling equipment purchased by mining companies must meet the 110-dB SPL limit and all other mobile equipment (excluding tractors) must meet the 85-dBA limit. Often these machines are being quietened by the manufacturer.

8.3 Hearing Protection

The *Mines Regulation Act* and the *Coal Mines Regulation Act* require ear protection to be worn in hazardous noise areas. There are two types of ear protectors in use, ear plugs and ear muffs, and mining companies must supply the approved type. Ear plugs are used only for the lowest noise levels.

8.4 Testing Hearing Acuity

The annual hearing test is carried out to determine if the noise control and ear protection programs in the mine are protecting the worker from hearing loss. This test takes approximately 20 minutes and is done on a calibrated audiometer in a soundproof booth by a certified industrial audiometric technician. The technician takes a three-day training course and regular refresher courses to keep upgraded. By the end of 1979, over 70 technicians had been trained by the audiologist to test hearing loss at British Columbia mines. The technician is also taught how to counsel workers on hearing test results and to encourage them to seek medical attention when hearing falls below acceptable levels.

Results of audiometric testing are recorded on a standardized audiometric data form and processed in a newly designed computer system. Output reports from the compute enable mines to keep records of hearing statistics in a readily available form. The output reports, taken on a Provincial basis, will allow the Inspection and Engineering Division to forecast and plan hearing conservation programs at mines.

8.5 General

At the present time it is estimated that over 85 per cent of all miners and industrial mineral workers have their hearing tested annually and we expect the number of hearing records submitted to us will be about 15 000 each year. Continuing cooperation from mine management, workers' unions, and the Inspection and Engineering Division will ensure that hearing losses from noise in mines will be reduced to a minimum.

IX. THRESHOLD LIMIT VALUES AND THEIR APPLICATION

The *Mines Regulation Act*, section 23, rule 85(a), gives the Chief Inspector of Mines the authority to set standards for permissible mine air.

The standards have been taken from a number of authoritative sources such as:

The American Conference of Governmental Industrial Hygienists
American Industrial Hygiene Association
Department of Employment, HM Factory Inspectorate
Asbestos Research Council
Committee on Occupational Diseases of the Chest
American College of Chest Physicians
Institute of Occupational Health, Finland
International Labour Office, Geneva, etc.

The list of standards contains substances that are most likely to be found at mining operations but where a specific substance or physical agent hazardous to health or safety is not included, then the values listed in the *'Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment'* as published by the American Conference of Governmental Industrial Hygienists on an annual basis is the permissible standard (*see* Appendix 2).

Threshold limit values represent conditions under which it is believed that nearly all workers may be repeatedly exposed, day after day, without adverse effects. Because of the wide variation in individual susceptibility however, a small percentage of workers may still experience discomfort from some substances at concentrations at or below threshold limits and a smaller percentage of persons may even be affected more seriously by aggravation of a pre-existing condition or by the development of an occupational illness.

Threshold limit values shuld be used as guides in controlling health hazards and should not be used as fine dividing lines between safe and unsafe conditibns unless a ceiling has been established medically which, when exceeded, may cause harmful irreversible physiological changes. Mixtures of two or more hazardous substances may have additive or synergistic effects and this should always be considered. The interpretation and application of threshold limit value compliance must be done by personnel who have received training in this field.

X. SPECIAL STUDIES

Special studies are carried out from time to time to investigate specific complaints or to evaluate specific dust control systems or other apparatus and equipment. The results of some of these special studies are included in the appendices to illustrate procedures and the type of information obtained, for example, tests carried out during maintenance and welding operations, tests at the drying and canning areas for molybdenum, special tests on Aerorlox liquid oxygen-breathing apparatus for asbestos fibre concentrations, etc. (*see* Appendix 6).

At present a special study is being carried out at all non-uranium mining operations to assess possible radiation exposure. A number of the reports are included in the appendices to illustrate the methods used (*see* Appendix 8). The guidelines that have been adopted for carrying out these studies are as follows:

(a) only a relatively few samples are necessary for a preliminary evaluation of any mine,
(b) samples will be taken in the following locations,
  (i) poorly ventilated areas,
  (ii) at points where different types of rock intersect,
  (iii) exhaust airways,
  (iv) areas where groundwater enters the mine,
  (v) working locations in waste rock,
  (vi) working locations in ore.
(c) If this preliminary sampling does not show significant concentrations of radon daughters it may be assumed that the health hazard from radiation is minimal and does not require further investigation at this time.

XI. URANIUM EXPLORATION SITES – SURVEYS

Radiation surveys have been carried out at the exploration sites of three significant areas of uranium mineralization. Copies of the survey results at these locations are given in the appendices (*see* Appendix 7).

XII. CONCLUSIONS

At the present time, the only direct legislation in British Columbia relating to medical requirements for workers employed in the mining industry is covered by section 18 and rule 154 of the *Mines Regulation Act* and section 18 and rule 134 of the *Coal Mines Regulation Act* (*see* Appendices 4 and 5). If uranium mining should take place in British Columbia, it is obvious that present requirements would not be adequate and more stringent controls would be required. A draft set of guidelines for the medical surveillance of atomic radiation workers has been drawn up with the advice of the British Columbia Ministry of Health. These guidelines apparently reflect a consensus reached by a special group of Atomic Energy Control Board staff and advisors (*see* Appendix 3).

It is recognized that even these guidelines might not be adequate to ensure satisfactory medical surveillance of uranium mine workers although they should provide a sound base from which more complete guidelines (or legislation) could be built up, if necessary.

It is hoped that the final report of this Royal Commission will contain guidance relative to this subject of adequate medical surveillance for atomic radiation workers.

The record shows that the staff of the Inspection and Engineering Division of the Ministry of Energy, Mines and Petroleum Resources over past years has capably enforced the legislation pertaining to safety and health of mine workers and the public in British Columbia and has aggressively initiated and carried through many special projects having a direct, beneficial effect on the health and safety of mine workers. The Environmental Control section of the Inspection and Engineering Division played an important role in this overall effort and the extent of this can be seen by referring to the 1979 annual summary of the work of the environmental control inspectors (*see* Appendix 10).

APPENDICES

APPENDIX 1

PERMISSIBLE MINE AIR – STANDARDS PRESCRIBED BY THE CHIEF INSPECTOR OF MINES UNDER THE AUTHORITY OF THE MINES REGULATION ACT

APPENDIX 2

THRESHOLD LIMIT VALUES – AMERICAN CONFERENCE OF GOVERNMENTAL HYGIENISTS

APPENDIX 3

DRAFT GUIDELINES FOR MEDICAL SURVEILLANCE OF ATOMIC RADIATION WORKERS AT URANIUM MINES, MILLS, AND REFINERIES

APPENDIX 4

MEDICAL REQUIREMENTS AND CONTROLS – BRITISH COLUMBIA MINES REGULATION ACT, 1967

APPENDIX 5

MINES REGULATION ACT – FORMS, MEDICAL CERTIFICATES, AND DIRECTIVES

APPENDIX 6

SAMPLES OF SPECIAL ENVIRONMENTAL SURVEYS AND REPORTS:

A SPECIAL REPORT, GIBRALTAR MINES LIMITED, CARPENTER SHOP

B ENVIRONMENTAL TESTS AT MAINTENANCE AND WELDING OPERATIONS, HARMER OPEN PIT, KAISER RESOURCES LIMITED, SPARWOOD, BRITISH COLUMBIA

C SUPPLEMENTARY REPORT OF CONDITIONS ABOUT MECHANIZED OPERATIONS, SULLIVAN MINE, COMINCO LIMITED, KIMBERLEY, BRITISH COLUMBIA

D NOTES REGARDING MOLYBDENUM–DRYER, ROASTER AND CANNING AREAS, ENDAKO MINES LIMITED, ENDAKO, B.C.

E FIELD TEST OF SIEBE GORMAN AERORLOX LIQUID OXYGEN BREATHING APPARATUS FOR ASBESTOS FIBRE CONCENTRATION

APPENDIX 7

RADIATION SURVEYS AT URANIUM PROSPECTS:

A P.N.C. EXPLORATIONS (CANADA) LIMITED, BEAVERDELL, BRITISH COLUMBIA

B NORCEN ENERGY RESOURCES LIMITED, BLIZZARD PROPERTY, BEAVERDELL, BRITISH COLUMBIA

C CONSOLIDATED REXSPAR MINERALS AND CHEMICALS LIMITED, BIRCH ISLAND, BRITISH COLUMBIA

APPENDICES — *Continued*

APPENDIX 1

PERMISSIBLE MINE AIR

Maximum Threshold Limit Value - Time Weighted Average (TLV-TWA) concentration permitted for air-borne contaminant substances for a normal 8 hour work day or 40 hour work week. No excursion above the TLV-TWA is permitted in an underground mine.

TLV-STEL = Threshold Limit Value - Short Term Exposure Limit, maximum average concentration permitted over any fifteen minute period.

TLV-C = Threshold Limit Value - Ceiling, places a definite limit above which contaminant shall not be permitted to exceed even instantaneously.

ppm = parts of vapour or gas per million parts of contaminated air by volume at 25°C and 760 mm Hg pressure.

mg/m^3 = approximate milligrams of material per cubic meter of air.

Substance	TLV-TWA		TLV-STEL	
	ppm	mg/m^3	ppm	mg/m^3
Acrolein	0.1	0.25	0.3	0.75
Ammonia	25	18	35	27
Arsine	0.05	0.2	0.05	0.2
Carbon dioxide	5000	9000	15000	18000
Carbon monoxide	50	55	400	440
Ethyl Mercaptan	0.5	1	0.5	1
"C" Formaldehyde	2	3	2	3
Hydrogen sulfide	10	15	15	27
Lead, inorganic, fumes and dust as Pb	-	0.15	-	0.45
Methane - not more than 1.0% - blasting operations				
1.25% - electrical equipment				
2.5% - removal of workers				
Mercury (alkyl compounds) Skin (as Hg)	0.001	0.01	0.003	0.03
Mercury (all forms except alkyl) as Hg	-	0.05	-	0.15
Molybdenum (soluble compounds) as MO	-	5	-	10
(insoluble compounds) as MO	-	10	-	20
Nitrous Fumes NO + NO_2 in terms of NO_2	5	9	5	9
"C" Nitrogen dioxide	5	9	5	9
Oil mist mineral	-	5	-	10
Oxygen - not less than 18% by volume				
Sulphur dioxide	5	13	5	13
Uranium (natural) soluble & insoluble compounds as U	-	0.2	-	0.6

Mineral Dusts*

Asbestos, all forms (a) 5 fibers of longer than 5 micrometers per cubic centimeter of air. Ceiling concentration, 10 fibers longer than 5 micrometers per cubic centimeter of air.**

(b) The total respirable dust in the return air or the make up air shall not exceed the lesser of:

a maximum of 0.20 milligrams per cubic meter of total respirable dust or,

$$C_R = \frac{1}{2} (TLV - Co) \times \frac{Q_T}{Q_R} \times \frac{1}{K}$$

where

C_R = maximum permitted concentration of fibers of longer than 5 micrometers per centimeter of air in exit air from the collection after cleaning

TLV = threshold limit value of contaminant

Co = concentration of contaminant in workers breathing zone with local exhaust discharged outside

Q_T = total ventilation flow through affected space, cfm

Q_R = recirculated air flow, cfm

K = an "effectiveness of mixing" factor of 3 ***

(c) Total dust in the atmosphere shall not exceed: the quotient obtained in dividing 30 milligrams per cubic meter by the percentage of quartz (total dust) plus 3 expressed in milligrams per cubic meter, i.e.:

$$\frac{30\ mg/m^3}{\%\ Quartz + 3} =$$

Coal dust, all forms - less than 5% quartz, respirable dust fraction 3 mg/m^3 as sampled by an approved method of the Chief Inspector of Mines.****

Mineral dusts - less than 1% quartz, total dust 10 mg/m^3 or respirable dust fraction 5 mg/m^3.

Siliceous dusts - 30% and under silica SiO_2 300 particles per cc of air
30 - 50% silica SiO_2 200 particles per cc of air
50% and over silica SiO_2 100 particles per cc of air
dust as sampled with a Konimeter and using standard British Columbia Mines Branch counting and processing method.

Heat Stress

Rules for working in hot environments will be determined by the Chief Inspector of Mines for each individual circumstance after consultation with the Division of Occupational Health of British Columbia.

*Threshold Limit Values for Mixtures with Additive Effects -

When two or more hazardous substances are present their combined effect, rather than of either individually should be given primary consideration. In the absence of information to the contrary the effects of the different hazards should be considered as additive. That is, if the sum of the following fractions exceeds unity, then the threshold limit of the mixture is exceeded.

$$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \ldots \frac{Cn}{Tn} = 1$$

Example: Air contains 25 ppm carbon monoxide (TLV 50), 2 ppm nitrous fumes (TLV 5), 100 ppcc siliceous dust (TLV 300)

$$\frac{25}{50} + \frac{2}{5} + \frac{100}{300} = 1.2 \text{ Threshold Limit is exceeded.}$$

** Intended change - 2 fibers of longer than 5 micrometers per cubic centimeter of air January 1980.

*** Effective the 1st of January 1979.

**** Intended change - 2 mg/m^3 January 1979.

Ionizing Radiation Standard Schedule:

Maximum Permissible Doses and Exposures (1, 2)

Table 1

Maximum Permissible Doses (3)

Column I Organ or Tissue	Column II Atomic Radiation Workers		Column III Female Atomic Radiation Workers of Reproductive Capacity		Column IV Any Other Person
	Rems per quarter of a year	Rems per year	Rems per quarter of a year	Rems per year	Rems per year
Whole body, gonads, bone marrow	3	5	1.3(4)	5(4)	0.5
Bone, skin, thyroid	15	30	15	30	3(5)
Any tissue of hands, forearms, feet and ankles	38	75	38	75	7.5
Lungs (6) and other single organs or tissues	8	15	8	15	1.5

Table 2

Maximum Permissible Exposures To Radon Daughters (6)

Column I Atomic Radiation Workers		Column II Any Other Persons
WLM per quarter of a year	WLM per year	WLM per year (7)
2	4	0.4

Notes to Ionizing Radiation Standard Schedule:

(1) The maximum permissible doses and exposures specified in this Table do not apply to ionizing radiation

  (a) received by a patient in the course of medical diagnosis or treatment by a qualified medical practitioner; or

  (b) received by a person carrying out emergency procedures undertaken to avert danger to human life.

(2) The Chief Inspector may, under extraordinary circumstances, permit single or accumulated doses or exposures up to twice the annual maximum permissible doses or exposures for atomic radiation workers. Such variance will not be granted

  (a) if appropriate alternatives are available;

  (b) for irradiation of the whole body or abdomen of women of reproductive capacity; or

  (c) for irradiation of the whole body, gonads or bone marrow if the average dose received from age 18 years up to and including the current year exceeds 5 rems per year.

(3) In determining the dose, the contribution from sources of ionizing radiation both inside and outside the body shall be included.

(4) The dose of the abdomen shall not exceed 0.2 rem per two weeks, and if the person is known to be pregnant, the dose to the abdomen shall not exceed 1 rem during the remaining period of pregnancy.

(5) The dose to the thyroid of a person under the age of 16 years shall not exceed 1.5 rems per year.

(6) For exposures to radon daughters, the maximum permissible exposures (in working level months) apply instead of the maximum permissible doses for the lungs (in rems).

Notes to Ionizing Radiation Standard Schedule: (Cont'd.)

(7) The WLM unit is not appropriate for exposures in the home or in other non-occupational situations. In such situations, the maximum permissible annual average concentration of radon daughters attributable to the operation of a nuclear facility shall be 0.02 WL.

These are the standards that have been accepted by:

(ICRP) International Commission on Radiological Protection
(IAEA) Internal Atomic Energy Agency

Revised - January, 1978

Ionizing Radiation Schedule
Revised - January, 1979
W. C. Robinson
"W. C. Robinson", P. Eng.
Chief Inspector of Mines

Under the Authority of General Rule 85 (a)
of the Mines Regulation Act and the Coal Mines Regulation Act

APPENDIX 2

TLVs®
Threshold Limit Values for Chemical Substances in Workroom Air Adopted by ACGIH for 1978

The American Conference of Governmental Industrial Hygienists will welcome requests for permission to republish or reprint these Threshold Limit Values. Requests for such permission should be directed to the Executive Secretary, P.O. Box 1937, Cincinnati, Ohio 45201.

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Documentation of the Threshold Limit Values for Substances in Workroom Air.© A separate companion piece to the Chemical 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.

Information concerning the availability of copies of the Documentation of the Threshold Limit Values for Substances in Workroom Air should be directed to the Executive Secretary, ACGIH (third edition, fourth printing, 1978, $20.00).

1978 TLV AIRBORNE CONTAMINANTS COMMITTEE

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TABLE OF CONTENTS

Chemical Substances — Page

Physical Agents

PREFACE
CHEMICAL CONTAMINANTS

Threshold limit values refer to airborne 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, however, a small percentage of workers may experience discomfort from some substances at concentrations at or below the threshold limit; a smaller percentage may be affected more seriously by aggravation of a pre-existing condition or by development of an occupational illness.

Tests are available (J. Occup. Med. 15: 564, 1973; Ann. N.Y. Acad. Sci., *151, Art. 2:* 968, 1968) that may be used to detect those individuals hypersusceptible to a variety of industrial chemicals (respiratory irritants, hemolytic chemicals, organic isocyanates, carbon disulfide).

Three categories of Threshold Limit Values (TLVs) are specified herein, as follows:

a) Threshold Limit Value-Time Weighted Average (TLV-TWA) — the time-weighted average concentration for a normal 8-hour workday or 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.

b) Threshold Limit Value-Short Term Exposure Limit (TLV-STEL) — the maximal concentration to which workers can be exposed for a period up to 15 minutes continuously without suffering from 1) irritation, 2) chronic or irreversible tissue change, or 3) narcosis of sufficient degree to increase accident proneness, impair self-rescue, or materially reduce work efficiency, provided that no more than four excursions per day are permitted, with at least 60 minutes between exposure periods, and provided that the daily TLV-TWA also is not exceeded. The STEL should be considered a maximal allowable concentration, or ceiling, not to be exceeded at any time during the 15-minute excursion period. STELs are based on one or more of the following criteria: (1) Adopted TLVs including those with a "C" or "ceiling" limit. (2) TWA-TLV Excursion Factors listed in Appendix D. (3) Pennsylvania Short-Term Limits for Exposure to Airborne Contaminants (Penna. Dept. of Hlth., Chapter 4, Art. 432, Rev. Jan. 25, 1968). (4) OSHA Occupational Safety and Health Standards, 40 FR 23073, May 28, 1975. (5) NIOSH criteria for recommended standards for occupational exposure to specific substances. The TWA-STEL should not be used as engineering design criterion or considered as an emergency exposure level (EEL).

c) Threshold Limit Value-Ceiling (TLV-C) — the concentration that should not be exceeded even instantaneously.

For some substances, e.g., irritant gases, only one category, the TLV-Ceiling, may be relevant. For other substances, either two or three categories may be relevant, depending upon their physiologic action. It is important to observe that if any one of these three TLVs is exceeded, a potential hazard from that substance is presumed to exist.

The TLV-TWA should be used as guides in the control of health hazards and should not be used as fine lines between safe and dangerous concentrations.

Time-weighted averages permit excursions above the limit provided they are compensated by equivalent excursions below the limit during the workday. In some instances it may be permissible to calculate the average concentration for a workweek rather than for a workday. The degree of permissible excursion is related to the magnitude of the threshold limit value of a particular substance as given in Appendix D. The relationship between threshold limit and permissible excursion is a rule of thumb and in certain cases may not apply. The amount by which threshold limits 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-factors must be taken into consideration in arriving at a decision as to whether a hazardous condition exists.

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 a guiding factor for some, whereas reasonable freedom from irritation, narcosis, nuisance or other forms of stress may form the basis for others.

The amount and nature of the information available for establishing a TLV varies from substance to substance; consequently, the precision of the estimated TLV is also subject to variation and the latest *Documentation* should be consulted in order to assess the extent of the data available for a given substance.

The committee holds to the opinion that limits based on physical irritation should be considered no less binding than those based on physical impairment. There is increasing evidence that physical irritation may initiate, promote or accelerate physical impairment through interaction with other chemical or biologic agents.

In spite of the fact that serious injury is not believed likely as a result of exposure to the threshold limit concentrations, the best practice is to maintain concentrations of all atmospheric contaminants as low as is practical.

These limits are intended for use in the practice of industrial hygiene and should be interpreted and applied only by a person trained in this discipline. They are not intended for use, or for modification for use, (1) as a relative index of hazard or toxicity, (2) in the evaluation or control of community air pollution nuisances, (3) in estimating the toxic potential of continuous, uninterrupted exposures or other extended work periods, (4) as proof or disproof of an existing disease 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.

Ceiling vs Time-Weighted Average Limits. Although the time-weighted average concentration provides the most satisfactory, practical way of monitoring airborne 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 noncompliance 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 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 D. It should be noted that the same factors are used by the Committee in determining the magnitude of the value of the STELs, or 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 airborne, 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.

Mixtures. Special consideration should be given also to the application of the TLVs in assessing the health hazards 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 C.

Nuisance Particulates. In contrast to fibrogenic dusts which cause scar tissue to be formed in lungs when inhaled in excessive amounts, so-called "nuisance" dusts have a long history of little adverse effect on lungs and do not produce significant organic disease or toxic effect when exposures are kept under reasonable control. The nuisance dusts have also been called (biologically) "inert" dusts, but the latter term is inappropriate to the extent that there is no dust which does not evoke some cellular response in the lung when inhaled in sufficient amount. However, the lung-tissue reaction caused by inhalation of nuisance dusts has the following characteristics: (1) The architecture of the air spaces remains intact. (2) Collagen (scar tissue) is not formed to a significant extent. (3) The tissue reaction is potentially reversible.

Excessive concentrations of nuisance dusts in the workroom air may seriously reduce visibility, may cause unpleasant deposits in the eyes, ears and nasal passages (Portland Cement dust), or cause injury to the skin or mucous membranes by chemical or mechanical action per se or by the rigorous skin cleansing procedures necessary for their removal.

A threshold limit of 10 mg/m^3, or 30 mppcf, of total dust < 1% quartz, or, 5 mg/m^3 respirable dust is recommended for substances in these categories and for which no specific threshold limits have been assigned. This limit, for a normal workday, does not apply to brief exposures at higher concentrations. 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 nuisance particulates are given in Appendix E.

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 percent 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 simple asphyxiants present an explosion hazard. Account should be taken of this factor in limiting the concentration of the asphyxiant. Specific examples are listed in Appendix F.

Physical Factors. It is recognized that such physical factors as heat, ultraviolet and ionizing radiation, humidity, abnormal pressure (altitude) and the like may place 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 to 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 90°F, or overtime extending the workweek more than 25%, might be considered gross deviations. In such instances judgment must be exercised in the proper adjustments of the Threshold Limit Values.

Biologic Limit Values (BLVs). Other means exist and may be necessary for monitoring worker exposure other than reliance on the Threshold Limit Values for industrial air, namely, the Biologic Limit Values. These values represent limiting amounts of substances (or their effects) to which the worker may be exposed without hazard to health or well-being as determined in his tissues and fluids or in his exhaled breath. The biologic measurements on which the BLVs are based can furnish two kinds of information useful in the control of worker exposure: (1) measure of the individual worker's over-all exposure; (2) measure of the worker's individual and characteristic response. Measurements of response furnish a superior estimate of the physiologic status of the worker, and may be made of (a) changes in amount of some critical biochemical constituent, (b) changes in activity of a critical enzyme, (c) changes in some physiologic function. Measurement of exposure may be made by (1) determining in blood, urine, hair, nails, in body tissues and fluids, the amount of substance to which the worker was exposed; (2) determination of the amount of the metabolite(s) of the substance in tissues and fluids; (3) determination of the amount of the substance in the exhaled breath. The biologic limits may be used as an adjunct to the TLVs for air, or in place of them. The BLVs, and their associated procedures for determining compliance with them, should thus be regarded as an effective means of providing health surveillance of the worker.

Unlisted Substances. Many substances present or handled in industrial processes do not appear on the TLV list. In a number of instances the material is rarely present as a particulate, vapor or other airborne contaminant, and a TLV is not necessary. In other cases sufficient information to warrant development of a TLV, even on a tentative basis, is not available to the Committee. Other substances, of low toxicity, could be included in Appendix E pertaining to nuisance particulates. This list (as well as Appendix F) is not meant to be all inclusive; the substances serve only as examples.

In addition there are some substances of not inconsiderable toxicity, which have been omitted primarily because only a limited number of workers (e.g., employees of a single plant) are known to have potential exposure to possibly harmful concentrations.

"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 Intended Changes." 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. The list of Intended Changes follows the Adopted Values in the TLV booklet. Values listed in parenthesis in the "Adopted" list are to be used during the period in which a proposed change for that Value is listed in the Notice of Intended Changes.

Legal Status. By publication in the Federal Register (Vol. 36, No. 105, May 29, 1971) the Threshold Limit Values for 1968 were made official federal standards for industrial air. Since 1971, new standards for certain of these substances have been promulgated by OSHA.

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	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
Substance	ppm[a]	mg/m³[b]	ppm[a]	mg/m³[b]
Abate	—	10	—	20
Acetaldehyde	100	180	150	270
Acetic acid	10	25	15	37
C Acetic anhydride	5	20	—	—
Acetone	1,000	2,400	1,250	3,000
Acetonitrile	40	70	60	105
Acetylene	F	—	—	—
Acetylene dichloride, see 1, 2-Dichloroethylene	200	790	250	1,000
Acetylene tetrabromide	1	14	1.5	18
Acrolein	0.1	0.25	0.3	0.8
Acrylamide — Skin	—	0.3	—	0.6
** Acrylonitrile — Skin	(20)	(45)	(30)	(65)
Aldrin — Skin	—	0.25	—	0.75
Allyl alcohol — Skin	2	5	4	10
Allyl chloride	1	3	2	6
Allyl glycidyl ether (AGE) — Skin	5	22	10	44
Allyl propyl disulfide	2	12	3	18
Alundum (Al_2O_3)	—	E	—	20
4-Aminodiphenyl — Skin	—	A1b	—	A1b
2-Aminoethanol, see Ethanolamine	3	8	6	15
2-Aminopyridine	0.5	2	2	4
Ammonia	25	18	35	27
Ammonium chloride-fume	—	10	—	20
Ammonium sulfamate (Ammate)	—	10	—	20
n-Amyl acetate	100	530	150	800
sec-Amyl acetate	125	670	150	800
** Aniline — Skin	(5)	(19)	—	—
Anisidine (o-, p-isomers) — Skin	0.1	0.5	—	—
** Antimony & Compounds (as Sb)	—	(0.5)	—	—
* Antimony trioxide, handling and use (as Sb)	—	0.5	—	—
** Antimony trioxide production (as Sb)	—	(0.5, A2)	—	—

Capital letters refer to Appendices
Footnotes (a thru g) see Page 31.
**See Notices of Intended Changes
*1978 Addition

	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
Substance	ppm$^{a)}$	mg/m$^{3\,b)}$	ppm$^{a)}$	mg/m$^{3\,b)}$
ANTU (α-Naphthyl thiourea)	—	0.3	—	0.9
Argon	F	—	F	F
** Arsenic & compounds (as As)	—	(0.5)	—	—
** Arsenic trioxide production (as As)	—	(A1a)	—	—
Arsine	0.05	0.2	—	—
** Asbestos (all forms)	—	(A1a)	—	(A1a)
Asphalt (petroleum) fumes	—	5	—	10
* Atrazine	—	10	—	—
Azinphos-methyl — Skin	—	0.2	—	0.6
Barium (soluble compounds), as Ba	—	0.5	—	—
Baygon (propoxur)	—	0.5	—	2
Benzene	10, A2	30, A2	—	—
Benzidine production — Skin	—	A1b	—	A1b
p-Benzoquinone, see Quinone	0.1	0.4	0.3	2
Benzoyl peroxide	—	5	—	—
Benz(a)pyrene	—	A2	—	A2
Benzyl chloride	1	5	—	—
Beryllium	—	0.002	—	0.025
Biphenyl	0.2	1.5	0.6	4
C Bisphenol A, see Diglycidal ether (DGE)	0.5	3.0	—	—
Bismuth telluride	—	10	—	20
Bismuth telluride, Se-doped	—	5	—	10
Borates, tetra, sodium salts,				
Anhydrous	—	1	—	—
Decahydrate	—	5	—	—
Pentahydrate	—	1	—	—
Boron oxide	—	10	—	20
Boron tribromide	1	10	3	30
C Boron trifluoride	1	3	—	—
Bromine	0.1	0.7	0.3	2
Bromine pentafluoride	0.1	0.7	0.3	2

Capital letters refer to Appendices.
Footnotes (a thru g) see Page 31.
**See Notice of Intended Changes.
*1978 Addition.

	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
Substance	ppm$^{a)}$	mg/m$^{3\,b)}$	ppm$^{a)}$	mg/m$^{3\,b)}$
Bromochloromethane/ chlorobromomethane	200	1,050	250	1,300
Bromoform — Skin	0.5	5	—	—
Butadiene (1, 3-butadiene)	1,000	2,200	1,250	2,750
Butane	600	1,430	750	1,780
Butanethiol, see Butyl mercaptan	0.5	1.5	—	—
2-Butanone	200	590	300	885
2-Butoxyethanol (Butyl Cellosolve) — Skin	50	240	150	720
n-Butyl acetate	150	710	200	950
sec-Butyl acetate	200	950	250	1,190
tert-Butyl acetate	200	950	250	1,190
* Butyl acrylate	10	55	—	—
C n-Butyl alcohol — Skin	50	150	—	—
sec-Butyl alcohol	150	450	—	—
tert-Butyl alcohol	100	300	150	450
C Butylamine — Skin	5	15	—	—
C tert-Butyl chromate (as CrO_3) — Skin	—	0.1	—	—
n-Butyl glycidyl ether (BGE)	50	270	—	—
n-Butyl lactate	5	25	—	—
Butyl mercaptan	0.5	1.5	—	—
p-tert-Butyltoluene	10	60	20	120
Cadmium, dust & salts (as Cd)	—	0.05	—	0.2
C Cadmium oxide fume (as Cd)	—	0.05	—	—
** Cadmium oxide production (as Cd)	—	(A2)	—	—
Calcium carbonate/ marble	—	E	—	20
Calcium arsenate (as As)	—	1	—	—
Calcium cyanamide	—	0.5	—	1
* Calcium hydroxide	—	5	—	—
* Calcium oxide	—	2	—	—
Camphor, synthetic	2	12	3	18
Caprolactam				
Dust	—	1	—	3
Vapor	5	20	10	40

Capital letters refer to Appendices.
**See Notice of Intended Changes.
*1978 Addition.

	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
Substance	ppm[a]	mg/m^3[b]	ppm[a]	mg/m^3[b]
Captafol (Difolatan®) — Skin	—	0.1	—	—
Captan	—	5	—	15
Carbaryl (Sevin®)	—	5	—	10
Carbofuran (Furadan®)	—	0.1	—	—
Carbon black	—	3.5	—	7
Carbon dioxide	5,000	9,000	15,000	18,000
** Carbon disulfide — Skin	(20)	(60)	(30)	(90)
Carbon monoxide	50	55	400	440
Carbon tetrabromide	0.1	1.4	0.3	4
Carbon tetrachloride — Skin	10	65	20	130
* Carbonyl chloride (Phosgene)	0.1	0.4	—	—
* Carbonyl fluoride	5	15	—	—
Catechol (Pyrocatechol)	5	20	—	—
Cellulose (paper fiber)	—	E	—	20
Cesium hydroxide	—	2	—	—
Chlordane — Skin	—	0.5	—	2
Chlorinated camphene — Skin	—	0.5	—	1
Chlorinated diphenyl oxide	—	0.5	—	2
Chlorine	1	3	3	9
Chlorine dioxide	0.1	0.3	0.3	0.9
C Chlorine trifluoride	0.1	0.4	—	—
C Chloroacetaldehyde	1	3	—	—
α-Chloroacetophenone (Phenacyl chloride)	0.05	0.3	—	—
Chlorobenzene (Monochlorobenzene)	75	350	—	—
o-Chlorobenzylidene malonoitrile — Skin	0.05	0.4	—	—
Chlorobromomethane/ Bromochloromethane	200	1,050	250	1,300
2-Chloro-1, 3-butadiene, see β Chloroprene — Skin	25	90	35	125
Chlorodifluoromethane	1,000	3,500	1,250	4,375
Chlorodiphenyl (42% Chlorine) — Skin	—	1	—	2

Capital letters refer to Appendices.
**See Notice of Intended Changes.
*1978 Addition.

	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
Substance	ppm[a]	mg/m^3[b]	ppm[a]	mg/m^3[b]
Chlorodiphenyl (54% Chlorine) — Skin	—	0.5	—	1
1-Chloro, 2, 3-epoxy-propane (Epichlorhydrin) — Skin	5	20	10	40
C 2-Chloroethanol (Ethylene chlorohydrin) — Skin	1	3	—	—
** Chloroethylene (Vinyl chloride)	(A1c)	—	(A1c)	—
* Chloroform (Trichloromethane)	10, A2	50, A2	—	—
bis-Chloromethyl ether	0.001	A1a	—	A1a
1-Chloro-1-nitro-propane	20	100	—	—
Chloropicrin	0.1	0.7	0.3	2
** β-Chloroprene — Skin	(25)	(90)	(35)	(135)
Chlorpyrifos (Dursban®) — Skin	—	0.2	—	0.6
o-Chlorostyrene	50	285	75	430
o-Chlorotoluene — Skin	50	250	75	375
2-Chloro-6-(trichloromethyl pyridine (N-Serve®)	—	10	—	20
Chromates, certain insoluble forms	—	0.05, A1a	—	A1a
Chromic acid and Chromates, (as Cr)	—	0.05	—	—
* Chromite ore processing (chromate), as Cr	—	0.05, A1a	—	—
Chromium, Sol. chromic, chromous salts (as Cr)	—	0.5	—	—
Clopidol (Coyden®)	—	10	—	20
Coal tar pitch volatiles (See Particulate polycyclic aromatic hydrocarbons)	—	0.2, A1a	—	A1a
** Cobalt metal, dust and fume (as Co)	—	(0.1)	—	—

Capital letters refer to Appendices.
Footnotes (a thru g) see Page 31.
**See Notice of Intended Changes.
*1978 Addition.

	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
Substance	ppm[a)]	mg/m^3[b)]	ppm[a)]	mg/m^3[b)]
Copper fume	—	0.2	—	—
Dusts & Mists (as Cu)	—	1	—	2
Corundum ($Al_2 O_3$)	—	E	—	E
Cotton dust, raw	—	0.2[h]	—	0.6
Crag® herbicide	—	10	—	20
Cresol, all isomers — Skin	5	22	—	—
Crotonaldehyde	2	6	6	18
Crufomate®	—	5	—	20
Cumene — Skin	50	245	75	365
Cyanamide	—	2	—	—
Cyanide, as CN — Skin	—	5	—	—
Cyanogen	10	20	—	—
Cyclohexane	300	1,050	375	1,300
Cyclohexanol	50	200	—	—
Cyclohexanone	50	200	—	—
Cyclohexene	300	1,015	—	—
Cyclohexylamine — Skin	10	40	—	—
Cyclopentadiene	75	200	150	400
2, 4-D (2, 4-Diphenoxy-acetic acid)	—	10	—	20
DDT (Dichlorodiphenyl-trichloroethane)	—	1	—	3
DDVP, see Dichlorvos — Skin	0.1	1	0.3	3
Decaborane — Skin	0.05	0.3	0.15	0.9
Demeton® — Skin	0.01	0.1	0.03	0.3
Diacetone alcohol (4-hydroxy-4-methyl-2-pentanone)	50	240	75	360
1, 2-Diaminoethane, see Ethylenediamine	10	25	—	—
Diazinon — Skin	—	0.1	—	0.3
Diazomethane	0.2	0.4	—	—
Diborane	0.1	0.1	—	—
** 1, 2-Dibromoethane (Ethylene dibromide) — Skin	(20)	(155)	(30)	(230)
Dibrom®	—	3	—	6
2-N-Dibutylaminoethanol — Skin	2	14	4	28
Dibutyl phosphate	1	5	2	10

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l) See p. 33.
Footnotes (a thru g) see Page 31.
**See Notice of Intended Changes.

	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
Substance	ppm[a)]	mg/m^3[b)]	ppm[a)]	mg/m^3[b)]
Dibutyl phthalate	—	5	—	10
C Dichloracetylene	0.1	0.4	—	—
C o-Dichlorobenzene	50	300	—	—
p-Dichlorobenzene	75	450	110	675
Dichlorobenzidine — Skin	—	A2	—	A2
Dichlorodifluoromethane	1,000	4,950	1,250	6,200
1, 3-Dichloro-5, 5-dimethyl hydantoin	—	0.2	—	0.4
1, 1-Dichloroethane	200	810	250	1,010
** 1, 2-Dichloroethane	(50)	(200)	(75)	(300)
1, 2-Dichloroethylene	200	790	250	1,000
Dichloroethyl ether — Skin	5	30	10	60
** Dichloromethane, see Methylene chloride	(200)	(700)	(250)	(870)
** Dichloromonofluoro-methane	(1,000)	(4,200)	—	—
C 1, 1-Dichloro-1-nitroethane	10	60	—	—
1, 2-Dichloropropane, see Propylene dichloride	75	350	110	510
Dichlorotetrafluoro-ethane	1,000	7,000	1,250	8,750
Dichlorvos (DDVP) — Skin	0.1	1	0.3	3
Dicrotophos (Bidrin®) — Skin	—	0.25	—	—
Dicyclopentadiene	5	30	—	—
Dicyclopentadienyl iron	—	10	—	20
Dieldrin — Skin	—	0.25	—	0.75
Diethylamine	25	75	—	—
Diethylaminoethanol — Skin	10	50	—	—
Diethylene triamine — Skin	1	4	—	—
Diethyl ether, see Ethyl ether	400	1,200	500	1,500
Diethyl phthalate	—	5	—	10
Difluorodibromomethane	100	860	150	1,290

Capital letters refer to Appendices.
**See Notice of Intended Changes.

	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
Substance	ppm[a]	mg/m^3[b]	ppm[a]	mg/m^3[b]
C Diglycidyl ether (DGE)	0.5	3	—	—
Dihydroxybenzene, see Hydroquinone	—	2	—	4
Diisobutyl ketone	25	150	—	—
Diisopropylamine — Skin	5	20	—	—
Dimethoxymethane, see Methylal	1,000	3,100	1,250	3,875
Dimethyl acetamide — Skin	10	35	15	50
* Dimethyl carbamyl chloride	A2	A2	—	—
Dimethylamine	10	18	—	—
Dimethylaminobenzene, see Xylidene — Skin	5	25	10	50
Dimethylaniline (N, N-Dimethylaniline) — Skin	5	25	10	50
Dimethylbenzene, see Xylene — Skin	100	435	150	650
Dimethyl-1, 2-dibromo-2-dichloroethyl phosphate, see Dibrom	—	3	—	6
Dimethylformamide — Skin	10	30	20	60
2, 6-Dimethyl-4-heptanone, see Diisobutyl ketone	25	150	—	—
1, 1-Dimethylhydrazine — Skin	0.5	1	1	2
Dimethylphthalate	—	5	—	10
C Dimethyl sulfate — Skin	0.1, A2	0.5, A2	—	—
Dinitrobenzene (all isomers) — Skin	0.15	1	0.5	3
Dinitro-o-cresol — Skin	—	0.2	—	0.6
3, 5-Dinitro-o-toluamide (Zoalene®)	—	5	—	10
Dinitrotoluene — Skin	—	1.5	—	5
Dioxane, tech. grade — Skin	50	180	—	—
Dioxathion (Delnav®) — Skin	—	0.2	—	—

Capital letters refer to Appendices.
Footnotes (a thru g) see Page 31.
*1978 Addition.

	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
Substance	ppm[a]	mg/m^3[b]	ppm[a]	mg/m^3[b]
Diphenyl, see Biphenyl	0.2	1.5	0.6	4
Diphenylamine	—	10	—	20
C Diphenylmethane diisocyanate, see Methylene bisphenyl isocyanate (MDI)	0.02	0.2	—	—
Dipropylene glycol methyl ether — Skin	100	600	150	900
Diquat	—	0.5	—	1
Di-sec, octyl phthalate (Di-2-ethylhexyl-phthalate)	—	5	—	10
Disulfiram	—	2	—	5
Disyston — Skin	—	0.1	—	0.3
2, 6-Ditert. butyl-p-cresol	—	10	—	20
Diuron	—	10	—	—
Dyfonate	—	0.1	—	—
Emery	—	E	—	20
Endosulfan (Thiodan®) — Skin	—	0.1	—	0.3
Endrin — Skin	—	0.1	—	0.3
** Epichlorhydrin — Skin	(5)	(20)	(10)	(40)
EPN — Skin	—	0.5	—	2
1, 2-Epoxypropane, see Propylene oxide	100	240	150	360
2, 3-Epoxy-1-propanol, see Glycidol	50	150	75	225
Ethane	F	—	F	—
Ethanethiol, see Ethyl mercaptan	0.5	1	2	3
Ethanolamine	3	8	6	15
Ethion (Nialate®) — Skin	—	0.4	—	—
2-Ethoxyethanol — Skin	100	370	150	560
2-Ethoxyethyl acetate (Cellosolve acetate) — Skin	100	540	150	810
Ethyl acetate	400	1,400	—	—
Ethyl acrylate — Skin	25	100	—	—
Ethyl alcohol (Ethanol)	1,000	1,900	—	—
Ethylamine	10	18	—	—

Capital letters refer to Appendices.
**See Notice of Intended Changes.

	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
Substance	ppm$^{a)}$	mg/m$^{3\,b)}$	ppm$^{a)}$	mg/m$^{3\,b)}$
Ethyl sec-amyl ketone (4-Methyl-3-heptanone)	25	130	—	—
Ethyl benzene	100	435	125	545
Ethyl bromide	200	890	250	1,110
Ethylbutyl ketone (3-Heptanone)	50	230	75	345
Ethyl chloride	1,000	2,600	1,250	3,250
Ethyl ether	400	1,200	500	1,500
Ethyl formate	100	300	150	450
Ethyl mercaptan	0.5	1	2	3
** Ethyl sillicate	(100)	(850)	—	—
Ethylene	F	—	F	—
C Ethylene chlorohydrin — Skin	1	3	—	—
Ethylenediamine	10	25	—	—
** Ethylene dibromide, see 1, 2-Dibromoethane	(20)	(155)	(30)	(230)
** Ethylene dichloride, see 1, 2-Dichloroethane	(50)	(200)	(75)	(300)
Ethylene glycol, Particulate	—	10	—	20
Vapor	100	250	125	325
C Ethylene glycol dinitrate and/or Nitroglycerin — Skin	0.2$^{d)}$	2	—	—
Ethylene glycol monomethyl ether acetate (Methyl cellosolve acetate) — Skin	25	120	35	170
Ethylene oxide	50	90	75	135
Ethylenimine — Skin	0.5	1	—	—
Ethylidene chloride, see 1, 1-Dichloroethane	200	810	250	1,010
C Ethylidene norbornene	5	25	—	—
N-Ethylmorpholine — Skin	20	94	—	—
Fensulfothion (Dasanit)	—	0.1	—	—
Ferbam	—	10	—	20
Ferrovanadium dust	—	1	—	0.3
Fluoride (as F)	—	2.5	—	—
Fluorine	1	2	2	4

Capital letters refer to Appendixes.
**See Notice of Intended Changes.

	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
Substance	ppm$^{a)}$	mg/m$^{3\,b)}$	ppm$^{a)}$	mg/m$^{3\,b)}$
Fluorotrichloromethane	1,000	5,600	1,250	7,000
C Formaldehyde	2	3	—	—
Formamide	20	30	30	45
Formic acid	5	9	—	—
Furfural — Skin	5	20	15	60
Furfuryl alcohol — Skin	5	20	10	40
Gasoline	—	B2	—	B2
Germanium tetrahydride	0.2	0.6	0.6	1.8
Glass, fibrous$^{e)}$ or dust	—	10	—	—
** C Glutaraldehyde, activated or unactivated	—	(0.25)	—	—
Glycerin mist	—	E	—	E
Glycidol (2, 3-Epoxy-1-propanol)	50	150	75	225
Glycol monoethyl ether, see 2-Ethoxyethanol — Skin	100	370	150	560
Graphite (Synthetic)	—	E	—	—
Guthion®, see Azinphos-methyl — Skin	—	0.2	—	0.6
Gypsum	—	E	—	20
Hafnium	—	0.5	—	1.5
Helium	F	—	F	—
Heptachlor — Skin	—	0.5	—	2
Heptane (n-Heptane)	400	1,600	500	2,000
Hexachlorocyclopentadiene	0.01	0.1	0.03	0.3
Hexachloroethane — Skin	1	10	3	30
Hexachloronaphthalene — Skin	—	0.2	—	0.6
Hexafluoroacetone	0.1	0.7	0.3	2
Hexane (n-hexane)	100	360	125	450
* Hexamethyl phosphoramide — Skin	A2	A2	—	—
2-Hexanone, see Methyl butyl ketone — Skin	25	100	40	165
Hexone (Methyl isobutyl ketone) — Skin	100	410	125	510

Capital letters refer to Appendices.
Footnotes (a thru g) see Page 31.
*1978 Addition.
**See Notice of Intented Changes.

	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
Substance	ppm[a)]	mg/m^3[b)]	ppm[a)]	mg/m^3[b)]
sec-Hexyl acetate	50	300	—	—
C Hexylene glycol	25	125	—	—
Hydrazine — Skin	0.1, A2	0.1, A2	—	—
Hydrogen	F	—	F	—
Hydrogenated terphenyls	0.5	5	—	—
Hydrogen bromide	3	10	—	—
C Hydrogen chloride	5	7	—	—
** Hydrogen cyanide — Skin	(10)	(11)	(15)	(16)
Hydrogen fluoride	3	2	—	—
Hydrogen peroxide	1	1.5	2	3
Hydrogen selenide	0.05	0.2	—	—
Hydrogen sulfide	10	15	15	27
Hydroquinone	—	2	—	4
Indene	10	45	15	70
Indium & Compounds (as In)	—	0.1	—	0.3
C Iodine	0.1	1	—	—
Iodoform	0.6	10	1	20
Iron oxide fume	B3	5	—	10
Iron pentacarbonyl	0.01	0.08	—	—
Iron salts, soluble (as Fe)	—	1	—	2
Isoamyl acetate	100	525	125	655
Isoamyl alcohol	100	360	125	450
Isobutyl acetate	150	700	187	875
Isobutyl alcohol	50	150	75	225
C Isophorone	5	25	—	—
Isophorone diisocyanate — Skin	0.01	0.09	—	—
Isopropyl acetate	250	950	310	1,185
Isopropyl alcohol — Skin	400	980	500	1,225
Isopropylamine	5	12	10	24
Isopropyl ether	250	1,050	310	1,320
Isopropyl glycidyl ether (IGE)	50	240	75	360
Kaolin	—	E	—	20
Ketene	0.5	0.9	1.5	3
Lead, inorg., fumes & dusts (as Pb)	—	0.15	—	0.45
Lead arsenate (as Pb)	—	0.15	—	0.45
Lead chromate (as Cr)	—	0.05, A2	—	—

Capital letters refer to Appendices.
**See Notice of Intended Changes.

	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
Substance	ppm[a)]	mg/m^3[b)]	ppm[a)]	mg/m^3[b)]
Limestone	—	E	—	20
Lindane — Skin	—	0.5	—	1.5
Lithium hydride	—	0.025	—	—
L.P.G. (Liquified petroleum gas)	1,000	1,800	1,250	2,250
Magnesite	—	E	—	20
Magnesium oxide fume (as Mg)	—	10	—	—
Malathion — Skin	—	10	—	—
Maleic anhydride	0.25	1	—	—
C Manganese & Compounds (as Mn)	—	5	—	—
Manganese cyclopentadienyl tricarbonyl (as Mn) — Skin	—	0.1	—	0.3
* Manganese Tetroxide	—	1	—	—
Marble/calcium carbonate	—	E	—	20
Mercury (Alkyl compounds) — Skin, (as Hg)	0.001	0.01	0.003	0.03
Mercury (All forms except alkyl), as Hg	—	0.05	—	0.15
Mesityl oxide	25	100	—	—
Methane	F	—	F	—
Methanethiol, see Methyl mercaptan	0.5	1	—	—
Methomyl (Lannate®) — Skin	—	2.5	—	—
Methoxychlor	—	10	—	—
2-Methoxyethanol — Skin (Methyl cellosolve)	25	80	35	120
Methyl acetate	200	610	250	760
Methyl acetylene (propyne)	1,000	1,650	1,250	2,040
Methyl acetylene-propadiene mixture (MAPP)	1,000	1,800	1,250	2,250
Methyl acrylate — Skin	10	35	—	—

Capital letters refer to Appendices.
*1978 Addition.

	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
Substance	ppm$^{a)}$	mg/m$^{3\,b)}$	ppm$^{a)}$	mg/m$^{3\,b)}$
Methylacrylonitrile — Skin	1	3	2	6
Methylal (dimethoxymethane)	1,000	3,100	1,250	3,875
Methyl alcohol (methanol) — Skin	200	260	250	310
Methylamine	10	12	—	—
Methyl amyl alcohol, see Methyl isobutyl carbinol — Skin	25	100	40	160
Methyl 2-cyanoacrylate	2	8	4	16
Methyl n-amyl ketone (2-Heptanone)	100	465	150	710
Methyl bromide — Skin	15	60	—	—
Methyl butyl ketone, see 2-Hexanone — Skin	25	100	40	165
Methyl cellosolve — Skin see 2-Methoxyethanol	25	80	35	120
Methyl cellosolve acetate — Skin, see Ethylene glycol monomethyl ether acetate	25	120	35	170
Methyl chloride	100	210	125	260
Methyl chloroform (1, 1, 1-Trichloroethane)	350	1,900	450	2,380
Methylcyclohexane	400	1,600	500	2,000
Methylcyclohexanol	50	235	75	350
o-Methycyclohexanone — Skin	50	230	75	345
Methylcyclopentadienyl manganese tricarbonyl (as Mn) — Skin	0.1	0.2	0.3	0.6
Methyl demeton — Skin	—	0.5	—	1.5
C Methylene bisphenyl isocyanate (MDI)	0.02	0.2	—	—
** Methylene chloride (dichloromethane)	(200)	(700)	(250)	(870)
4, 4'-Methylene bis (2-chloraniline) — Skin	0.02, A2	—	A2	—
C Methylene bis (4-cyclohexylisocyanate)	0.01	0.11	—	—

Capital letters refer to Appendices.

** See Notice of Intended Changes.

	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
Substance	ppm$^{a)}$	mg/m$^{3\,b)}$	ppm$^{a)}$	mg/m$^{3\,b)}$
Methyl ethyl ketone (MEK), see 2-Butanone	200	590	300	885
C Methyl ethyl ketone peroxide	0.2	1.5	—	—
Methyl formate	100	250	150	375
Methyl iodide — Skin	5	28	10	56
Methyl isoamyl ketone	100	475	150	710
Methyl isobutyl carbinol — Skin	25	100	40	165
Methyl isobutyl ketone, see Hexone — Skin	100	410	125	510
Methyl isocyanate — Skin	0.02	0.05	—	—
Methyl mercaptan	0.5	1	—	—
Methyl methacrylate	100	410	125	510
Methyl parathion — Skin	—	0.2	—	0.6
Methyl propyl ketone, see 2-Pentanone	200	700	250	875
C Methyl silicate	5	30	—	—
C α-Methyl styrene	100	480	—	—
Molybdenum (as Mo)				
Soluble compounds	—	5	—	10
Insoluble compounds	—	10	—	20
Monocrotophos (Azodrin®)	—	0.25	—	—
Monomethyl aniline — Skin	2	9	4	18
C Monomethyl hydrazine — Skin	0.2	0.35	—	—
Morpholine — Skin	20	70	30	105
Naphthalene	10	50	15	75
β-Naphthylamine	—	A1b	—	A1b
Neon	F	—	F	—
Nickel carbonyl	0.05	0.35	—	—
Nickel metal	—	1	—	—
Nickel, soluble compounds (as Ni)	—	0.1	—	0.3
Nickel sulfide roasting, fume & dust (as Ni)	—	1, A1a	—	—
Nicotine — Skin	—	0.5	—	1.5
Nitric acid	2	5	4	10

Capital letters refer to Appendices
Footnotes (a thru g) see Page 31.

	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
Substance	ppm[a]	mg/m^3[b]	ppm[a]	mg/m^3[b]
Nitric oxide	25	30	35	45
p-Nitroaniline — Skin	1	6	2	12
Nitrobenzene — Skin	1	5	2	10
p-Nitrochlorobenzene — Skin	—	1	—	2
4-Nitrodiphenyl	—	A1b	—	A1b
Nitroethane	100	310	150	465
C Nitrogen dioxide	5	9	—	—
Nitrogen trifluoride	10	29	15	45
C Nitroglycerin — Skin	0.2[d]	2	—	—
Nitromethane	100	250	150	375
1-Nitropropane	25	90	35	135
** 2-Nitropropane	(25)	(90)	—	—
N-Nitrosodimethylamine (dimethylnitrosoamine) — Skin	—	A2	—	A2
Nitrotoluene — Skin	5	30	10	60
Nitrotrichloromethane, see Chloropicrin	0.1	0.7	0.3	2
Nonane	200	1,050	250	1,300
Octachloronaphthalene — Skin	—	0.1	—	0.3
Octane	300	1,450	375	1,800
Oil mist, mineral	—	5[f]	—	10
Osmium tetroxide (as Os)	0.0002	0.002	0.0006	0.006
Oxalic acid	—	1	—	2
Oxygen difluoride	0.05	0.1	0.15	0.3
Ozone	0.1	0.2	0.3	0.6
Paraffin wax fume	—	2	—	6
* Paraquat, respirable sizes	—	0.1	—	—
Parathion — Skin	—	0.1	—	0.3
Particulate polycyclic aromatic hydrocarbons (PPAH), as benzene solubles	—	0.2, A1a	—	A1a
Pentaborane	0.005	0.01	0.015	0.03
Pentachloronaphthalene	—	0.5	—	2
Pentachlorophenol — Skin	—	0.5	—	1.5

Capital letters refer to Appendices.
Footnotes (a thru g) see Page 31.
*1978 Addition.
**See Notice of Intended Changes.

	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
Substance	ppm[a]	mg/m^3[b]	ppm[a]	mg/m^3[b]
Pentaerythritol	—	E	—	20
Pentane	600	1,800	750	2,250
2-Pentanone	200	700	250	875
Perchloroethylene — Skin	100	670	150	1,000
Perchloromethyl mercaptan	0.1	0.8	—	—
Perchloryl fluoride	3	14	6	28
Phenol — Skin	5	19	10	38
Phenothiazine — Skin	—	5	—	10
p-Phenylene diamine — Skin	—	0.1	—	—
Phenyl ether (vapor)	1	7	2	14
Phenyl ether-Diphenyl mixture (vapor)	1	7	2	14
Phenylethylene, see Styrene, monomer	100	420	125	525
Phenyl glycidyl ether (PGE)	10	60	15	90
* Phenyl mercaptan	0.5	2	—	—
Phenylhydrazine — Skin	5	22	10	44
C Phenylphosphine	0.05	0.25	—	—
Phorate (Thimet®) — Skin	—	0.05	—	0.2
Phosdrin (Mevinphos®) — Skin	0.01	0.1	0.03	0.3
* Phosgene (carbonyl chloride)	0.1	0.4	—	—
Phosphine	0.3	0.4	1	1
Phosphoric acid	—	1	—	3
Phosphorus (yellow)	—	0.1	—	0.3
** Phosphorus pentachloride	—	(1)	—	(3)
Phosphorus pentasulfide	—	1	—	3
Phosphorus trichloride	0.5	3	—	—
Phthalic anhydride	1	6	4	24
m-Phthalodinitrile	—	5	—	—
Picloram (Tordon®)	—	10	—	20
Picric acid — Skin	—	0.1	—	0.3
Pival® (2-Pivalyl-1, 3-indandione)	—	0.1	—	0.3
Plaster of Paris	—	E	—	20

Capital letters refer to Appendices.
*1978 Addition.
**See Notices of Intended Changes.

	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
Substance	ppm$^{a)}$	mg/m$^{3\,b)}$	ppm$^{a)}$	mg/m$^{3\,b)}$
Platinum (Soluble salts) as Pt	—	0.002	—	—
Polychlorobiphenyls, see Chlorodiphenyls — Skin	—	—	—	—
Polytetrafluoroethylene decomposition products	—	B1	—	B1
C Potassium hydroxide	—	2	—	—
Propane	F	—	F	—
β-Propiolactone	—	A2	—	A2
Propargyl alcohol — Skin	1	2	3	6
n-Propyl acetate	200	840	250	1,050
Propyl alcohol — Skin	200	500	250	625
n-Propyl nitrate	25	105	40	470
Propylene	F	—	F	—
Propylene dichloride (1, 2-Dichloropropane)	75	350	110	510
*C Propylene glycol dinitrate — Skin	0.2	2	—	—
Propylene glycol monomethyl ether	100	360	150	540
Propylene imine — Skin	2	5	—	—
Propylene oxide	100	240	150	360
Propyne, see Methyl acetylene	1,000	1,650	1,250	2,040
Pyrethrum	—	5	—	10
Pyridine	5	15	10	30
Quinone	0.1	0.4	0.3	2
RDX — Skin	—	1.5	—	3
Resorcinol	10	45	20	90
Rhodium, Metal fume and dusts (as Rh)	—	0.1	—	0.3
Soluble salts (as Rh)	—	0.001	—	0.003
Ronnel	—	10	—	—
Rosin core solder pyrolysis products (as formaldehyde)	—	0.1	—	0.3
Rotenone (commercial)	—	5	—	10
Rouge	—	E	—	20

Capital letters refer to Appendices.
*1978 Addition.

	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
Substance	ppm$^{a)}$	mg/m$^{3\,b)}$	ppm$^{a)}$	mg/m$^{3\,b)}$
Rubber solvent (Naphtha)	400	1,600	—	—
Selenium compounds (as Se)	—	0.2	—	-
Selenium hexafluoride, as Se	0.05	0.4	0.05	0.4
Sevin® (see Carbaryl)	—	5	—	10
Silane (see Silicon tetrahydride)	0.5	7	1	2
Silicon	—	E	—	20
Silicon carbide	—	E	—	20
Silicon tetrahydride (Silane)	0.5	0.7	1	2
** Silver, metal and soluble compounds, as Ag	—	(0.01)	—	(0.03)
C Sodium azide	0.1	0.3	—	—
Sodium fluoroacetate (1080) — Skin	—	0.05	—	0.15
C Sodium hydroxide	—	2	—	—
Starch	—	E	—	20
Stibine	0.1	0.5	0.3	1.5
Stoddard solvent	100	575	125	720
Strychnine	—	0.15	—	0.45
Styrene, monomer (Phenylethylene)	100	420	125	525
C Subtilisins (Proteolytic enzymes as 100% pure crystalline enzyme)	—	0.00006$^{m)}$	—	—
Sucrose	—	E	—	20
** Sulfur dioxide	(5)	(13)	—	—
Sulfur hexafluoride	1,000	6,000	1,250	7,500
Sulfuric acid	—	1	—	—
Sulfur monochloride	1	6	3	18
Sulfur pentafluoride	0.025	0.25	0.075	0.75
Sulfur tetrafluoride	0.1	0.4	0.3	1
Sulfuryl fluoride	5	20	10	40
Systox, see Demeton® — Skin	0.01	0.1	0.03	0.3
2, 4, 5-T	—	10	—	20
Tantalum	—	5	—	10

Capital letters refer to Appendices.
**See Notice of Intended Changes.

	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
Substance	ppm$^{a)}$	mg/m$^{3b)}$	ppm$^{a)}$	mg/m$^{3b)}$
TEDP — Skin	—	0.2	—	0.6
Teflon® decomposition products	—	B1	—	B1
Tellurium & compounds (as Te)	—	0.1	—	—
Tellurium hexafluoride, as Te	0.02	0.2	—	—
TEPP — Skin	0.004	0.05	0.01	0.2
**C Terphenyls	(1)	(9)	—	—
1, 1, 1, 2-Tetrachloro-2, 2-difluoroethane	500	4,170	625	5,210
1, 1, 2, 2-Tetrachloro-1, 2-difluoroethane	500	4,170	625	5,210
1, 1, 2, 2-Tetrachloroethane — Skin	5	35	10	70
Tetrachloroethylene, see Perchloroethylene — Skin	100	670	150	1,000
Tetrachloromethane, see Carbon tetrachloride — Skin	10	65	20	130
Tetrachloronaphthalene	—	2	—	4
Tetraethyl lead (as Pb) — Skin	—	0.100$^{e)}$	—	0.3
Tetrahydrofuran	200	590	250	735
Tetramethyl lead (as Pb) — Skin	—	0.150$^{e)}$	—	0.5
Tetramethyl succinonitrile — Skin	0.5	3	2	9
Tetranitromethane	1	8	—	—
Tetryl (2, 4, 6-trinitrophenyl-methylnitramine) — Skin	—	1.5	—	3.0
Thallium, soluble compounds (as Tl) — Skin	—	0.1	—	—
4, 4'-Thiobis (6-tert. butyl-m-cresol)	—	10	—	20
* Thioglycolic acid	1	5	—	—

Capital letters refer to Appendices.
*1978 Addition.
**See Notice of Intended Changes.

	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
Substance	ppm$^{a)}$	mg/m$^{3b)}$	ppm$^{a)}$	mg/m$^{3b)}$
Thiram®	—	5	—	10
Tin, inorganic compounds, except SnH_4 and SnO_2 (as Sn)	—	2	—	4
Tin, organic compounds (as Sn) — Skin	—	0.1	—	0.2
Tin oxide (as Sn)	—	E	—	20
Titanium dioxide (as Ti)	—	E	—	20
Toluene (toluol) — Skin	100	375	150	560
**C Toluene-2, 4-diisocyanate (TDI)	(0.02)	(0.14)	—	—
o-Toluidine	5	22	10	44
Toxaphene, see Chlorinated camphene — Skin	—	0.5	—	2.0
Tributyl phosphate	—	5	—	5
*C 1, 2, 4-Trichlorobenzene	5	40	—	—
1, 1, 1-Trichloroethane, see Methyl chloroform	350	1,900	440	2,380
1, 1, 2-Trichloroethane — Skin	10	45	20	90
Trichloroethylene	100	535	150	800
* Trichloromethane, see Chloroform	10, A2	50, A2	—	—
Trichloronaphthalene	—	5	—	10
1, 2, 3-Trichloropropane	50	300	75	450
1, 1, 2-Trichloro 1, 2, 2-trifluoroethane	1,000	7,600	1,250	9,500
Triethylamine	25	100	40	160
Tricyclohexyltin hydroxide (Plictran®)	—	5	—	10
Trifluoromonobromo-methane	1,000	6,100	1,200	7,300
Trimethyl benzene	25	125	35	170
2, 4, 6-Trinitrophenol, see Picric acid — Skin	—	0.1	—	0.3
2, 4, 6-Trinitrophenyl-methylnitramine, see Tetryl — Skin	—	1.5	—	3.0
*C 2, 4, 6-Trinitrotoluene (TNT)	—	0.5	—	—

Capital letters refer to Appendices.
*1978 Addition.
**See Notice of Intended Changes.

	ADOPTED VALUES		TENTATIVE VALUES	
	TWA		STEL	
Substance	ppm$^{a)}$	mg/m$^{3\,b)}$	ppm$^{a)}$	mg/m$^{3\,b)}$
Triorthocresyl phosphate	—	0.1	—	0.3
Triphenyl phosphate......	—	3	—	6
Tungsten & compounds, as W				
Soluble	—	1	—	3
Insoluble	—	5	—	10
Turpentine	100	560	150	840
Uranium (natural) soluble & insoluble compounds, as U......	—	0.2	—	0.6
Vanadium (V_2O_5), as V				
Dust	—	0.5	—	1.5
C Fume	—	0.05	—	—
* Valeraldehyde	50	175	—	—
Vinyl acetate	10	30	20	60
Vinyl benzene, see Styrene	100	420	150	630
** Vinyl bromide	(250)	(1,100)	—	—
** Vinyl chloride.............	(A1c)	—	(A1c)	—
Vinyl cyanide, see Acrylonitrile — Skin ...	20	45	30	65
Vinyl cyclohexene dioxide	10	60	—	—
Vinylidene chloride	10	40	20	80
Vinyl toluene..............	100	480	150	720
Warfarin...................	—	0.1	—	0.3
Welding fumes (NOC)† ..	—	5, B3	—	B3
Wood dust (nonallergenic)	—	5	—	10
Xylene (o-, m-, p-isomers) — Skin	100	435	150	655
C m-Xylene α, α'-diamine .	—	0.1	—	—
Xylidene — Skin	5	25	10	50
Yttrium	—	1	—	3
Zinc chloride fume........	—	1	—	2
Zinc chromate (as Cr)....	—	0.05, A2	—	—
Zinc oxide fume	—	5	—	10
Zinc stearate..............	—	E	—	20
Zirconium compounds (as Zr)	—	5	—	10

Capital letters refer to Appendices.
†(NOC) not otherwise classified
*1978 Addition.
**See Notice of Intended Changes.

a) Parts of vapor or gas per million parts of contaminated air by volume at 25°C and 760 mm. Hg. pressure.
b) Approximate milligrams of substance per cubic meter of air.
d) An atmospheric concentration of not more than 0.02 ppm, or personal protection may be necessary to avoid headache for intermittent exposure.
e) $< 7\ \mu m$ in diameter.
f) As sampled by method that does not collect vapor.
g) For control of general room air, biologic monitoring is essential for personnel control.

Radioactivity: For permissible concentrations of radioisotopes in air, see U.S. Department of Commerce, National Bureau of Standards Handbook 69, "Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure," June 5, 1959; Addendum 1, August 1963 (NCRP Report No. 22). Also, see U.S. Department of Commerce National Bureau of Standards, Handbook 59, "Permissible Dose from External Sources of Ionizing Radiation," September 24, 1954, an addendum of April 15, 1958. A report, Basic Radiation Protection Criteria, published by the National Committee on Radiation Protection, revises and modernizes the concept of the NCRP standards of 1954, 1957 and 1958; obtainable as NCRP Rept. No. 39, 7910 Woodmont Ave., Washington, D.C. 20014.

MINERAL DUSTS

Substance
SILICA, SiO_2

Crystalline
Quartz

TLV in mppcf$^{h)}$:

$$\frac{300^{i)}}{\%\ \text{quartz} + 10}$$

TLV for respirable dust in mg/m^3:

$$\frac{10\ \text{mg/m}^{3\,j)}}{\%\ \text{Respirable quartz} + 2}$$

TLV for "total dust," respirable and nonrespirable:

$$\frac{30\ \text{mg/m}^3}{\%\ \text{quartz} + 3}$$

Cristobalite	Use one-half the value calculated from the count or mass formulae for quartz.
Tridymite	Use one-half the value calculated from formulae for quartz.
Silica, fused	Use quartz formulae.
Tripoli	Use respirable[o] mass quartz formula

**Amorphous .... (20 mppcf[h])

SILICATES (< 1% quartz)

**Asbestos, all forms	(5 fibers/cc> 5μm in length[m]; A1a)
Mica	20 mppcf
Mineral wool fiber	10 mg/m^3
Perlite	30 mppcf
Portland Cement	30 mppcf
Soapstone	20 mppcf
Talc (nonasbestiform)	20 mppcf

**Talc (fibrous), use Asbestos limit.
**Tremolite, see Asbestos.

COAL DUST

2 mg/m^3 (respirable dust fraction < 5% quartz). If > 5% quartz, use respirable mass formula.

NUISANCE PARTICULATES

(see Appendix E)

30 mppcf or 10 mg/m^3[k]
of total dust < 1% quartz, or, 5 mg/m^3 respirable dust.

Conversion factors:
mppcf × 35.3 = Million particles per cubic meter
= particles per cc

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h) Millions of particles per cubic foot of air, based on impinger samples counted by light-field technics.

i) The percentage of quartz in the formula is the amount determined from airborne samples, except in those instances in which other methods have been shown to be applicable.

j) Both concentration and percent quartz for the application of this limit are to be determined from the fraction passing a size-selector with the following characteristics:

Aerodynamic Diameter (μm) (unit density sphere)	% passing selector
≲ 2	90
2.5	75
3.5	50
5.0	25
10	0

k) containing <1% quartz; if quartz content > 1%, use formulae for quartz.

l) Lint-free dust as measured by the vertical-elutriator, cotton-dust sampler described in the Transactions of the National Conference on Cotton Dust, J. R. Lynch, pg. 33, May 2, 1970.

m) As determined by the membrane filter method at 400–450X magnification (4 mm objective) phase contrast illumination.

n) Based on "high volume" sampling.

o) "Respirable" dust as defined by the British Medical Research Council Criteria (1) and as sampled by a device producing equivalent results (2).
   (1) Hatch, T. E. and Gross, P., Pulmonary Deposition and Retention of Inhaled Aerosols, p. 149. Academic Press, New York, New York, 1964.
   (2) Interim Guide for Respirable Mass Sampling, AIHA Aerosol Technology Committee, AHIA J. *31:* 2, 1970, p. 133.

NOTICE OF INTENDED CHANGES
(for 1978)

These substances, with their corresponding values, comprise those for which either a limit has been proposed for the first time, or for which a change in the "Adopted" listing has been proposed. In both cases, the proposed limits should be considered trial limits that will remain in the listing for a period of at least two years. If, after two years no evidence comes to light that questions the appropriateness of the values herein, the values will be reconsidered for the "Adopted" list. Documentation is available for each of these substances.

**See Notice of Intended Changes.

Substance	TWA ppm$^{a)}$	TWA mg/m$^{3b)}$	STEL ppm$^{a)}$	STEL mg/m$^{3b)}$
† Acetylsalicylic acid (Aspirin)	—	5	—	—
† Acrylonitrile	A1c	A1c	—	—
Aluminum metal and oxide	—	10	—	20
Aluminum pyro powders	—	5	—	—
Aluminum welding fumes	—	5	—	—
Aluminum, soluble salts	—	2	—	—
Aluminum, alkyls (NOC)*	—	2	—	—
3-Amino 1, 2, 4-triazole	A2	A2	—	—
† Aniline and homologues -- Skin	2	10	5	20
Antimony, soluble salts (as Sb)	—	2	—	—
Antimony trioxide production	—	—, A2	—	—
Arsenic (soluble), as As	—	0.2	—	—
Arsenic trioxide production	—	—, A1a	—	—
† Baytex	—	0.1	—	0.3
Benomyl	—	10	—	15
Bromacil	—	10	—	20
† o-sec Butylphenol — Skin	5	—	—	—
Cadmium oxide production	—	—, A2	—	—
† Carbon disulfide	10	30	—	—
† Chloroacetyl chloride	0.05	0.2	—	—
† Chloromethyl methyl ether	A1b	A1b	—	—
† β-Chloroprene — Skin	10	45	—	—
Cobalt metal, dust & fume (as Co)	—	0.05	—	0.1
†C Cyanogen chloride	0.3	0.6	—	—
Cyclopentane	300	850	450	1,000
† Dalapon	1	—	—	—
† 1, 2-Dibromoethane — Skin	A1c	A1c	—	—
† Dichloromonofluoromethane	10	40	—	—
† Dichloropropene	1	5	10	50
† Diethanolamine	3	15	—	—
† Divinyl benzene	10	50	—	—
† Epichlorhydrine — Skin	2	10	5	20

Capital letters refer to Appendices.
†1978 Revision or Addition.
*Not otherwise classified (NOC).

Substance	TWA ppm$^{a)}$	TWA mg/m$^{3b)}$	STEL ppm$^{a)}$	STEL mg/m$^{3b)}$
Ethyl silicate	10	85	30	250
† Ethylene dibromide, see 1, 2-Dibromoethane	A1c	A1c	—	—
† Ethylene dichloride, see 1, 2-Dichloroethane	10	40	15	60
C Glutaraldehyde	0.2	0.8	—	—
Hexachlorobutadiene	A2	A2	—	—
†C Hydrogen cyanide — Skin	10	10	—	—
† 2-Hydroxypropyl acrylate — Skin	0.5	3	—	—
† N-Isopropylaniline — Skin	2	10	5	20
Manganese fume (as Mn)	—	1	—	3
† Methylene chloride (dichloromethane)	100	360	500	1,700
† 4, 4-Methylene dianiline	0.1	0.8	0.5	4
†C 2-Nitropropane	25, A2	90, A2	—	--
Phenyl-beta-naphthylamine	A2	A2	—	—
† Phosphorous pentachloride	0.1	1	—	—
† Propionic acid	10	30	15	45
† Silver, metal	—	0.1	—	—
† Sodium bisulfite	—	5	—	—
† Sodium metabisulfite	—	5	—	—
† Sulfur dioxide	2	5	5	15
†C Terphenyls	0.5	5	—	—
† Tetrasodium pyrophosphate	—	5	—	—
† Toluene-2, 4-diisocyanate (TDI)	0.002	0.015	0.005	0.035
† Trichloroacetic acid	—	1	—	—
† Vinyl bromide	5, A2	20, A2	—	—
† Vinyl chloride	5, A1a	10, A1a	—	—
VM & P Naphtha	300	1,350	400	1,800

Capital letters refer to Appendices.
†1978 Addition.

NOTICE OF INTENDED CHANGES
MINERAL DUSTS

Substance	TLV
† Asbestos	
Amosite	0.5 fiber/cc, A1a
Chrysotile	2 fibers/cc, A1a
Crocidolite	0.2 fiber/cc, A1a
Tremolite	0.5 fiber/cc, A1a
Other forms	2 fibers/cc, A1a
Diatomaceous earth, natural	1.5 mg/m^3, Respirable dust
Silica, amorphous	5 mg/m^3, Total dust (all sampled sizes) 2 mg/m^3, Respirable dust ($< 5\ \mu m$)
† Talc (fibrous)	0.5 fiber/cc

APPENDIX A
CARCINOGENS

The Committee lists below those substances in industrial use that have proven carcinogenic in man, or have induced cancer in animals under appropriate experimental conditions. Present listing of those substances carcinogenic for man takes three forms: Those for which a TLV has been assigned (1a), those for which environmental conditions have not been sufficiently defined to assign a TLV (1b), and (1c), those whose reassignment of a TLV is awaiting more definitive data, and hence should be treated as a 1b carcinogen.

A1a. *Human Carcinogens*. Substances, or substances associated with industrial processes, recognized to have carcinogenic or cocarcinogenic potential, with an assigned TLV:

	TLV
** Arsenic trioxide production	(As_2O_3, 0.05 mg/m^3 as As) (SO_2, C 5.0 ppm)
	(Sb_2O_3, 0.5 mg/m^3 (as Sb))
** Asbestos, all forms*	(5 fibers/cc, $> 5\ \mu m$ in length)
bis (Chloromethyl) ether	0.001 ppm
Chromite ore processing (chromate)	0.05 mg/m^3 (as Cr)
Nickel sulfide roasting, fume & dust	1.0 mg/m^3 (as Ni)
Particulate Polycyclic Aromatic Hydrocarbons (PPAH)	0.2 mg/m^3, as benzene solubles
Vinyl Chloride	5 ppm

A1b. *Human Carcinogens*. Substances, or substances associated with industrial processes, recognized to have carcinogenic potential without an assigned TLV:

Chloromethyl methyl ether
4-Aminodiphenyl (p-Xenylamine)
Benzidine production
beta-Naphthylamine
4-Nitrodiphenyl

A1c. *Human Carcinogens*. Substances with recognized carcinogenic potential awaiting reassignment of TLV pending further data acquisition:

Acrylonitrile
1, 2-Dibromoethane (Ethylene dibromide)

For the substances in 1b or 1c, no exposure or contact by any route — respiratory, skin or oral, as detected by the most sensitive methods — shall be permitted.

"No exposure or contact" means hermitizing the process or operation by the best practicable engineering methods. The worker should be properly equipped to insure virtually no contact with the carcinogen.

**See Notice of Intended Changes
†1978 Addition.

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*Cigarette smoking can enhance the incidence of respiratory cancers from this and others of these substances or processes.

A2. *Industrial Substances Suspect of Carcinogenic Potential for MAN*. Chemical substances or substances associated with industrial processes, which are suspect of inducing cancer, based on either (1) limited epidemiologic evidence, exclusive of clinical reports of single cases, or (2) demonstration of carcinogenesis in one or more animal species by appropriate methods.

3-Amino 1, 2, 4-triazole	
** Antimony trioxide production*	(0.5 mg/m³)
Benzene	10 ppm
Benz(a)pyrene	——
Beryllium	2.0 μg/m³
** Cadmium oxide production	(0.05 mg/m³)
Chloroform	10 ppm
Chromates of lead and zinc (as Cr)	0.05 mg/m³
3, 3'-Dichlorobenzidine	——
Dimethylcarbamyl chloride	——
1, 1-Dimethyl hydrazine	0.5 ppm
Dimethyl sulfate — Skin	0.1 ppm
Epichlorhydrin	5 ppm
Hexachlorobutadiene	——
Hexamethyl phosphoramide — Skin	——
Hydrazine	0.1 ppm
Lead chromate	0.05 mg/m³
4, 4'-Methylene bis (2-chloroaniline) — Skin	0.02 ppm
Monomethyl hydrazine	0.2 ppm
C 2-Nitropropane	25 ppm
Nitrosamines	——
Phenyl-beta-naphthylamine	——
Propane sultone	——
beta-Propiolactone	——
Vinyl cyclohexene dioxide	10 ppm
Zinc chromate (as Cr)	0.05 mg/m³

For the above, worker exposure by all routes should be carefully controlled to levels consistent with the animal and human experience data (see Documentation), including those substances with a listed TLV.

A3. *Guidelines for the Classification of Experimental ANIMAL Carcinogens*. The following guidelines are offered in the present state of knowledge as an aid in classifying substances in the occupational environment found to be carcinogenic in experimental animals. A need was felt by the Threshold Limits Committee for such a classification in order to take the first step in developing an appropriate TLV for occupational exposure.

Determination of Approximate Threshold of Response Requirement. In order to determine in which category to classify an experimental carcinogen for the purpose of assigning an industrial air limit (TLV), an approximate threshold of neoplastic response must be determined. Because of practical experimental difficulties, a precisely defined threshold cannot be attained. For the purposes of standard-setting, this is of little moment, as an appropriate risk, or safety, factor can be applied to the approximate threshold, the magnitude of which is dependent on the degree of potency of the carcinogenic response.

To obtain the best 'practical' threshold of neoplastic response, dosage decrements should be less than logarithmic. This becomes particularly important at levels greater than 10 ppm (or corresponding mg/m³). Accordingly, after a range-finding determination has been made by logarithmic decreases, two additional dosage levels are required within the levels of "effect" and "no effect" to approximate the true threshold of neoplastic response.

The second step should attempt to establish a metabolic relationship between animal and man for the particular substance found carcinogenic in animals. If the metabolic pathways are found comparable, the substance should be classed highly suspect as a carcinogen for man. If no such relation is found, the substance should remain listed as an experimental animal carcinogen until evidence to the contrary is found.

Proposed Classification of Experimental Animal Carcinogens. Substances occurring in the occupational environment found carcinogenic for animals

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*Cigarette smoking can enhance the incidence of respiratory cancers from this or others of these substances or processes.

may be grouped into three classes, those of high, intermediate and low potency. In evaluating the incidence of animal cancers, significant incidence of cancer is defined as a neoplastic response which represents, in the judgment of the Committee, a significant excess of cancers above that occurring in negative controls.

EXCEPTIONS: No substance is to be considered an occupational carcinogen of any practical significance which reacts by the respiratory route at or above 1000 mg/m^3 for the mouse, 2000 mg/m^3 for the rat; by the dermal route, at or above 1500 mg/kg for the mouse, 3000 mg/kg for the rat; by the gastrointestinal route at or above 500 mg/kg/d for a lifetime, equivalent to about 100 g T.D. for the rat, 10g T.D. for the mouse.

These dosage limitations exclude such substances as dioxane and trichlorethylene from consideration as carcinogens.

Examples: Dioxane — rats, hepatocellular and nasal tumors from 1015 mg/kg/d, oral

Trichloroethylene — female mice, tumors (30/98 @ 900 mg/kg/d), oral

A3a. *INDUSTRIAL SUBSTANCES OF HIGH CARCINOGENIC POTENCY IN EXPERIMENTAL ANIMALS*

1. A substance to qualify as a carcinogen of high potency must fulfill one of the three following conditions in two animal species:

   1a. *Respiratory*. Elicit cancer from (1) dosages below 1 mg/m^3 (or equivalent ppm) via the respiratory tract in 6- 7-hour daily repeated inhalation exposures throughout lifetime; or (2) from a single intratracheally administered dose not exceeding 1 mg of particulate, or liquid, per 100 ml or less of animal minute respiratory volume;

   Examples: bis-Chloromethyl ether, malignant tumors, rats, @ 0.47 mg/m^3 (0.1 ppm) in 2 years;

   Hexamethyl phosphoramide, nasal squamous cell carcinoma, rats, @ 0.05 ppm, in 13 months

   OR

   1b. *Dermal*. Elicit cancer within 20 weeks by skin-painting, twice weekly at 2 mg/kg body weight or less per application for a total dose equal to or less than 1.5 mg, in a biologically inert vehicle;

   Examples: 7, 12-Dimethylbenz(a)anthracene — skin tumors @ 0.12-0.8 mg T.D. in four weeks

   Benz(a)pyrene, mice 12 μg, 3X/wk for 18 mos. T.D. 2.6 mg, 90.9% skin tumors

   OR

   1c. *Gastrointestinal*. Elicit cancer by daily intake via the gastrointestinal tract, within six months, with a six-month holding period, at a dosage below 1 mg/kg body weight per day; total dose, rat, ≤ 50 mg; mouse, ≤ 3.5 mg;

   Examples: 7, 12-Dimethylbenz(a)anthracene — mammary tumors from 10 mg 1X

   3-Methylcholanthrene — Tumors @ 3 sites from 8 mg in 89 weeks

   Benz(a)pyrene, mice, 3.9% leukemias, from 30 mg T.D. 198 days

2. Elicit cancer by all three routes in at least two animal species at dose levels prescribed for high or intermediate potency.

A3b. *INDUSTRIAL SUBSTANCES OF INTERMEDIATE CARCINOGENIC POTENCY IN EXPERIMENTAL ANIMALS*

To qualify as a carcinogen of intermediate potency, a substance should elicit cancer in two animal species at dosages intermediate between those described in A3a and A3c by two routes of administration.

Example: Carbamic acid ethyl ester
Dermal, mammary tumors, mice, 100%, 63 weeks, 500–1400 mg T.D.
Gastrointestinal, various type tumors, mice 42 weeks, 320 mg T.D.

Gastrointestinal, various type tumors, rats, 60 weeks, 110–930 mg T.D.

A3c. *INDUSTRIAL SUBSTANCES OF LOW CARCINOGENIC POTENCY IN EXPERIMENTAL ANIMALS*

To qualify as a carcinogen of low potency, a substance should elicit cancer in one animal species by any *one* of three routes of administration at the following prescribed dosages and conditions:

1a. *Respiratory*. Elicit cancer from (1) dosages greater than 10 mg/m^3 (or equivalent ppm) via the respiratory tract in 6- 7-hour, daily repeated inhalation exposures, for 12 months' exposure and 12 months' observation period; or (2) from intratracheally administered dosages totaling more than 10 mg of particulate or liquid per 100 ml or more of animal minute respiratory volume;

Examples: Beryl (beryllium aluminum silicate) malig. lung tumors, rats, @ 15 mg/m^3 @ 17 months

Benzidine, var. tumors, rats, 10–20 mg/m^3 @ > 13 mos.

OR

1b. *Dermal*. Elicit cancer by skin-painting of mice in twice weekly dosages of > 10 mg/kg body weight in a biologically inert vehicle for at least 75 weeks, i.e., ≥ 1.5g T.D.

Examples: Shale tar, mouse, 0.1 ml × 50 – g T.D. 59/60 skin tumors

Arsenic trioxide, man, dose unknown, but estimated to be high

1c. *Gastrointestinal*. Elicit cancer from daily oral dosages of 50 mg/kg/day or greater during the lifetime of the animal.

APPENDIX B
SUBSTANCES OF VARIABLE COMPOSITION

B1 *Polytetrafluoroethylene* decomposition products*. Thermal decomposition of the fluorocarbon chain in air leads to the formation of oxidized products containing carbon, fluorine and oxygen. Because these products decompose in part by hydrolysis in alkaline solution, they can be quantitatively determined in air as fluoride to provide an index of exposure. No TLV is recommended pending determination of the toxicity of the products, but air concentrations should be minimal.

B2 *Gasoline*. The composition of gasoline varies greatly and thus a single TLV for all types of these materials is no longer applicable. In general, the aromatic hydrocarbon content will determine what TLV applies. Consequently the content of benzene, other aromatics and additives should be determined to arrive at the appropriate TLV (Elkins, et al. A.I.H.A.J. *24*:99, 1963); Runion, ibid. *36*, 338, 1975).

B3 *Welding Fumes — Total Particulate*
*(NOC)***
TLV, 5 mg/m^3

Welding fumes cannot be classified simply. The composition and quantity of both are dependent on the alloy being welded and the process and electrodes used. Reliable analysis of fumes cannot be made without considering the nature of the welding process and system being examined; reactive metals and alloys such as aluminum and titanium are arc-welded in a protective, inert atmosphere such as argon. These arcs create relatively little fume, but an intense radiation which can produce ozone. Similar processes are used to arc-weld steels, also creating a relatively low level of fumes. Ferrous alloys also are arc-welded in oxidizing environments which generate considerable fume, and can produce carbon monoxide instead of ozone. Such fumes generally are composed of discreet particles of amorphous slags con-

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*Trade Names: Algoflon, Fluon, Halon, Teflon, Tetran.
**Not otherwise classified (NOC).

taining iron, manganese, silicon and other metallic constituents depending on the alloy system involved. Chromium and nickel compounds are found in fumes when stainless steels are arc-welded. Some coated and flux-cored electrodes are formulated with fluorides and the fumes associated with them can contain significantly more fluorides than oxides. Because of the above factors, arc-welding fumes frequently must be tested for individual constituents which are likely to be present to determine whether specific TLV's are exceeded. Conclusions based on total fume concentration are generally adequate if no toxic elements are present in welding rod, metal, or metal coating and conditions are not conducive to the formation of toxic gases.

Most welding, even with primitive ventilation, does not produce exposures inside the welding helmet above 5 mg/m³. That which does, should be controlled.

APPENDIX C
MIXTURES

C.1 THRESHOLD LIMIT VALUES FOR MIXTURES

When two or more hazardous substances are present, their combined effect, rather than that of either individually, should be given primary consideration. In the absence of information to the contrary, the effects of the different hazards should be considered as additive. That is, if the sum of the following fractions,

$$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \dots \frac{C_n}{T_n}$$

exceeds unity, then the threshold limit of the mixture should be considered as being exceeded. C_1 indicates the observed atmospheric concentration, and T_1 the corresponding threshold limit (See Example 1A.a. and 1A.c.).

Exceptions to the above rule may be made when there is a good reason to believe that the chief effects of the different harmful substances are not in fact additive, ~~but~~ *~~ind~~ependent* as when purely local effects on different organs of the body are produced by the various components of the mixture. In such cases the threshold limit ordinarily is exceeded only when at least one member of the series $\left(\frac{C_1}{T_1} + \text{or} + \frac{C_2}{T_2}\text{ etc.}\right)$ itself has a value exceeding unity (See Example 1A.c.).

Antagonistic action or potentiation may occur with some combinations of atmospheric contaminants. Such cases at present must be determined individually. Potentiating or antagonistic agents are not necessarily harmful by themselves. Potentiating effects of exposure to such agents by routes other than that of inhalation is also possible, e.g. imbibed alcohol and inhaled narcotic (trichloroethylene). Potentiation is characteristically exhibited at high concentrations, less probably at low.

When a given operation or process characteristically emits a number of harmful dusts, fumes, vapors or gases, it will frequently be only feasible to attempt to evaluate the hazard by measurement of a single substance. In such cases, the threshold limit used for this substance should be reduced by a suitable factor, the magnitude of which will depend on the number, toxicity and relative quantity of the other contaminants ordinarily present.

Examples of processes which are typically associated with two or more harmful atmospheric contaminants are welding, automobile repair, blasting, painting, lacquering, certain foundry operations, diesel exhausts, etc.

C.1A Examples of THRESHOLD LIMIT VALUES FOR MIXTURES

The following formulae apply only when the components in a mixture have similar toxicologic effects; they should not be used for mixtures with widely differing reactivities, e.g. hydrogen cyanide & sulfur dioxide. In such case the formula for Independent Effects (1A.c.) should be used.

1A.a. General case, where air is analyzed for each component:

a. *Additive effects. (Note: It is essential that the atmosphere be analyzed both qualitatively and quantitatively for each component present, in order to evaluate compliance or noncompliance with this calculated TLV.)*

$$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \frac{C_3}{T_3} + \dots = 1$$

Example No. 1A.a.: Air contains 400 ppm of acetone (TLV = 1000 ppm) 150 ppm of secbutyl acetate (TLV = 200 ppm) and 100 ppm of 2-butanone (TLV = 200 ppm)

Atmospheric concentration of mixture = 400 + 150 + 100 = 650 ppm of mixture

$$\frac{400}{1000}+\frac{150}{200}+\frac{100}{200}=0.4+0.75+0.5=1.65$$

Threshold Limit is exceeded.

1A.b. Special case when the source of contaminant is a liquid mixture and the atmospheric composition is *assumed* to be similar to that of the original material; e.g. on a time-weighted average exposure basis, all of the liquid (solvent) mixture eventually evaporates.

Additive effects (approximate solution)

1. The percent composition (by weight) of the liquid mixture is known, the TLVs of the constituents must be listed in mg/m^3.

(Note: In order to evaluate compliance with this TLV, field sampling instruments should be calibrated, in the laboratory, for response to this specific quantitative and qualitative air-vapor mixture, and also to fractional concentrations of this mixture; e.g., 1/2 the TLV; 1/10 the TLV; 2 × the TLV; 10 × the TLV; etc.)

TLV of mixture =

$$\frac{1}{\frac{f_a}{TLV_a}+\frac{f_b}{TLV_b}+\frac{f_c}{TLV_c}+\cdots\frac{f_n}{TLV_n}}$$

Example No. 1: Liquid contains (by weight)

50% heptane: TLV = 400 ppm or 1600 mg/m^3
1 mg/m^3 ≡ 0.25 ppm

30% methyl chloroform: TLV = 350 ppm or 1900 mg/m^3
1 mg/m^3 ≡ 0.28 ppm

20% perchloroethylene: TLV = 100 ppm or 670 mg/m^3
1 mg/m^3 ≡ 0.15 ppm

$$\text{TLV of Mixture} = \frac{1}{\frac{0.5}{1600}+\frac{0.3}{1900}+\frac{0.2}{670}}$$

$$= \frac{1}{0.00031+0.00016+0.00030}$$

$$= \frac{1}{0.00077} = 1300 \text{ mg/m}^3$$

of this mixture

50% or (1300) (0.5) = 650 mg/m^3 is heptane

30% or (1300) (0.3) = 390 mg/m^3 is methyl chloroform

20% or (1300) (0.2) = 260 mg/m^3 is perchloroethylene

These values can be converted to ppm as follows:

heptane: 650 mg/m^3 × 0.25 = 162 ppm
methyl chloroform: 390 mg/m^3 × 0.18 = 70 ppm
perchloroethylene: 260 mg/m^3 × 0.15 = 39 ppm

TLV of mixture = 162 + 70 + 39 = 271 ppm, or 1300 mg/m^3

1A.c. *Independent effects*.

Air contains 0.15 mg/m^3 of lead (TLV, 0.15) and 0.7 mg/m^3 of sulfuric acid (TLV, 1).

$$\frac{0.15}{0.15}=1;\qquad \frac{0.7}{1}=0.7$$

Threshold limit is not exceeded.

1B. TLV for Mixtures of Mineral Dusts.

For mixtures of biologically active mineral dusts the general formula for mixtures may be used.

For mixture containing 80% nonasbestiform talc and 20% quartz, the TLV for 100% of the mixture is given by:

$$\text{TLV} = \frac{1}{\frac{0.8}{20}+\frac{0.2}{2.7}} = 9 \text{ mppcf}$$

TLV of nonasbestiform talc (pure) = 20 mppcf

TLV of quartz (pure) =

$$\frac{300}{100 + 10} = \frac{300}{110} = 2.7 \text{ mppcf}$$

Essentially the same result will be obtained if the limit of the more (most) toxic component is used provided the effects are additive. In the above example the limit for 20% quartz is 10 mppcf.

For another mixture of 25% quartz, 25% amorphous silica and 50% talc:

25% quartz — TLV (pure) = 2.7 mppcf
25% amorphous silica — TLV (pure) = mppcf
50% talc TLV (pure) = 20 mppcf

$$\text{TLV} = \frac{1}{\frac{0.25}{2.7} + \frac{0.25}{20} + \frac{0.5}{20}} = 8 \text{ mppcf}$$

The limit for 25% quartz approximates 9 mppcf.

APPENDIX D
PERMISSIBLE EXCURSIONS FOR TIME-WEIGHTED AVERAGE (TWA) LIMITS

The Excursion TLV Factor in the Table automatically defines the magnitude of the permissible excursion above the limit for those substances not given a "C" designation; i.e., the TWA limits. Examples in the Table show that nitrobenzene, the TLV for which is 1 ppm, should never be allowed to exceed 3 ppm. Similarly, carbon tetrachloride, TLV = 10 ppm, should never be allowed to exceed 20 ppm. By contrast, those substances with a "C" designation are not subject to the excursion factor and must be kept at or below the TLV ceiling.

These limiting excursions are to be considered to provide a "rule-of-thumb" guidance for listed substances generally, and may not provide the most appropriate excursion for a particular substance e.g., the permissible excursion for CO is 400 ppm for 15 minutes.

For appropriate excursions for 142 substances consult Pa. Rules & Regs., Chap. 4, Art. 432, and "Acceptable Concentrations," ANSI.

Substance	TLV	Excursion Factor	Max. Conc. Permitted for short time
Nitrobenzene	1	3	2
Carbon tetrachloride	10	2	20
Trimethyl benzene	25	1.5	35
Acetone	1000	1.25	1250
Boron trifluoride	C 1	—	1
Butylamine	C 5	—	5

EXCURSION FACTORS

For all substances not bearing C notation

		Excursion Factor	
TLV> 0-1	(ppm or mg/m³),		= 3
TLV> 1-10	"	"	= 2
TLV> 10-100	"	"	= 1.5
TLV> 100-1000	"	"	= 1.25

The number of times the excursion above the TLV is permitted is governed by conformity with the Time-Weighted Average TLV.

INTERPRETATION OF MEASURED PEAK CONCENTRATIONS

With increasing use of rapid, direct-reading analytical instruments for airborne contaminants in the work area, the question of interpretation of essentially "instantaneous" peaks arises. Although no general statement can be made covering all occupational substances, the following guidelines should prove helpful, assuming peak excursions conform to time-weighted average TLV as stated above.

The toxicologic importance of momentary peak concentrations depends on whether the substance is fast or slow acting. If slow acting, as for quartz, lead, or carbon monoxide, momentary peaks are of no toxicologic concern provided, of course, they are not astronomic. On the other hand, fast-acting substances that rapidly produce disabling narcosis, e.g., H_2S, or intolerable irritation or asphyxiation, NH_3, SO_2, CO_2, or initiate sensitization — the organic isocyanates, even "instantaneous" peaks appreciably above the permissible excursion, should not be permitted, unless information exists to the contrary. Other more specific excursions will be developed in the future.

APPENDIX E
Some Nuisance Particulates[p]

TLV, 30 mppcf or 10mg/m^3 of total
dust < 1% quartz, or, 5 mg/m^3
respirable dust

Alundum (Al_2O_3)
Calcium carbonate
Calcium silicate
Cellulose (paper fiber)
Portland Cement
Corundum (Al_2O_3)
Emery
Glycerin Mist
Graphite (synthetic)
Gypsum
Vegetable oil mists
  (except castor, cashew nut, or similar irritant oils)
Kaolin
Limestone
Magnesite
Marble
Mineral Wool Fiber
Pentaerythritol
Plaster of Paris
Rouge
Silicon
Silicon Carbide
Starch
Sucrose
Tin Oxide
Titanium Dioxide
Zinc Stearate
Zinc oxide dust

p) When toxic impurities are not present, e.g. quartz < 1%.

APPENDIX F
Some Simple Asphyxiants[q]

Acetylene
Argon
Butane
Ethane
Ethylene
Helium
Hydrogen
Methane
Neon
Propane
Propylene

q) As defined on pg. 6.

APPENDIX G

Calculations for Conversion of Particle Count Concentration (by Standard Light Field — Midget Impinger Techniques), in mppcf, to Respirable Mass Concentration (by Respirable Sampler) in mg/m^3.[†]

1. In 1967, Jacobsen and Tomb,[†] derived an empirical relationship of 5.6 mppcf to 1 milligram of respirable dust per cubic meter of air, based on 23 sets of samples, mostly coal dust. The following calculation results in an equivalence of 6.37 mppcf to 1 mg/m^3 of respirable dust. Thus, an approximate ratio of 6 mppcf to 1 mg/m^3 of respirable dust is suggested for conversion of TLVs from a count to a mass basis when the density and mass median diameter have not been determined.

2. Basic assumptions:
   a) Average density for silica containing dusts $\approx$ 2.5 gms/cm^3 (2500 mg/cm^3). Pulmonary significant dust densities may vary from 1.2 gm/cm^3 for coal dust to 3.1 gms/cm^3 for Portland Cement. Silica densities vary from 2.2 (amorphous) to 2.3 (cristobalite and tridymite) to 2.5 (alpha-quartz.) gms per cm^3.
   b) The mass median diameter (mmd) of particles collected in midget impinger samplers and counted by the standard light field technique, *and* collected in a respirable sampler is approximately 1.5 μm or 1.5×10^{-4} cm. This assumption is, of course, quite arbitrary since the mmd of all dust clouds is quite variable, depending on many independent parameters, such as source of dust, age of dust cloud, meteorological conditions, etc.

3. Calculation:
   a) vol. per particle: $4/3\ \pi\ r^3$; $r = 0.75 \times 10^{-4}$ cm
      $= 4/3 \cdot \pi \cdot (0.75 \times 10^{-4})^3$
      $= 1.77 \times 10^{-12}$ cm^3
   b) wt. per particle = vol. × density
      $= 1.77 \times 10^{-12}$ $cm^3 \times 2.5 \times 10^3$ mg/cm^3
      $= 4.425 \times 10^{-9}$ mg/particle
   c) 1 particle/$ft.^3$ = 35.5 part./m^3
      (since 35.5 cu ft = 1 cu m.)
      10^6 part./ft^3 = mppcf = 35.5×10^6 part./m^3

[†] "Relationship Between Gravimetric Respirable Dust Concentration and Midget Impinger Number Concentration," by Murray Jacobson and T. F. Tomb, AIHAJ, 28: Nov.-Dec. 1967.

wt. of 1 mppcf ≡ 35.5 × 10^6 part./m^3 × 4.425 × 10^{-9} mg/part.

1 mppcf ≡ 0.157 mg/m^3
or
6.37 mppcf ≡ 1 mg/m^3
or approximately 6 mpccf ≡ 1 mg/m^3.

4. Equivalent TLVs in mppcf and mg/m^3 (respirable mass) for Mineral Dusts.

Substance	Threshold Limit Value		
	Count mppcf	Resp. Mass mg/m^3	Total Mass* mg/m^3
Silica (SiO_2)			
Amorphous	20	(3)**	(6)
Cristobalite	1.5	0.05	0.15
Fused silica	3	0.1	0.3
Quartz	3	0.1	0.3
Tridymite	1.5	0.05	0.15
Coal Dust	(12)	2	(4)
Diatomaceous earth, natural	—	1.5	—
Graphite (natural)	15	(2.5)	(5)
Mica	20	(3)	(6)
Mineral wool fiber	—	(5)	10
Nuisance particulates	30	(5)	10
Perlite	30	(5)	(10)
Portland Cement	30	(5)	(10)
Soapstone	20	(3)	(6)
Talc (nonasbestiform)	20	(3)	(6)
Tripoli	(3)	0.1	(0.3)

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*Unless otherwise specified, respirable mass is presumed to equal approximately 50% of total mass.

**All values in parentheses ( ) represent newly calculated values based on equivalence of 6 mppcf ≡ 1 mg/m^3 respirable mass and respirable mass ≡ 50% total mass.

TLVs®
Threshold Limit Values for Physical Agents Adopted by ACGIH for 1978

1978 TLV PHYSICAL AGENTS COMMITTEE

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PREFACE

PHYSICAL AGENTS

These threshold limit values refer to levels of physical agents 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 variations in individual susceptibility, exposure of an occasional individual at, or even below, the threshold limit may not prevent annoyance, aggravation of a pre-existing condition, or physiological damage.

These 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.

These limits are intended for use in the practice of industrial hygiene and should be interpreted and applied only by a person trained in this discipline. They are not intended for use, or for modification for use, (1) in the evaluation or control of the levels of physical agents in the community, (2) as proof or disproof of an existing physical disability, or (3) for adoption by countries whose working conditions differ from those in the United States of America.

These values are reviewed annually by the Committee on Threshold Limits for Physical Agents for revisions or additions, as further information becomes available.

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 physical agents to be added to the list. The suggestions should be accompanied by substantiating evidence.

As Legislative Code — The Conference recognizes that the Threshold Limit Values may be adopted in legislative codes and regulations. If 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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THRESHOLD LIMIT VALUES

HEAT STRESS

These Threshold Limit Values refer to heat stress conditions under which it is believed that nearly all workers may be repeatedly exposed without adverse health effects. The TLVs shown in Table 1 are based on the assumption that nearly all acclimatized, fully clothed workers with adequate water and salt intake should be able to function effectively under the given working conditions without exceeding a deep body temperature of 38°C (WHO technical report series #412, 1969 *Health Factors Involved in Working Under Conditions of Heat Stress*; F. N. Dukes-Dobos and A. Henschel: "*Development of Permissible Heat Exposure Limits for Occupational Work.*" ASHRAE Journal, Vol. 15: No. 9, September 1973, pp. 57–62.)

Since measurement of deep body temperature is impractical for monitoring the workers' heat load, the measurement of environmental factors is required which most nearly correlate with deep body temperature and other physiological responses to heat. At the present time Wet Bulb-Globe Temperature Index (WBGT) is the simplest and most suitable technique to measure the environmental factors. WBGT values are calculated by the following equations:

1. Outdoors with solar load:
   WBGT = 0.7WB + 0.2GT + 0.1 DB
2. Indoors or Outdoors with no solar load:
   WBGT = 0.7WB + 0.3GT

where:

WBGT = Wet Bulb-Globe Temperature Index
WB = Natural Wet-Bulb Temperature
DB = Dry-Bulb Temperature
GT = Globe Thermometer Temperature

The determination of WBGT requires the use of a black globe thermometer, a natural (static) wet-bulb thermometer, and a dry-bulb thermometer.

TABLE 1

Permissible Heat Exposure Threshold Limit Values
(Values are given in °C. WBGT)

	Work Load		
Work — Rest Regimen	Light	Moderate	Heavy
Continuous work	30.0	26.7	25.0
75% Work — 25% Rest, Each hour	30.6	28.0	25.9
50% Work — 50% Rest, Each hour	31.4	29.4	27.9
25% Work — 75% Rest, Each hour	32.2	31.1	30.0

Higher heat exposures than shown in Table 1 are permissible if the workers have been undergoing medical surveillance and it has been established that they are more tolerant to work in heat than the average worker. Workers should not be permitted to continue their work when their deep body temperature exceeds 38.0°C.

EVALUATION AND CONTROL

I. *Measurement of the Environment*

The instruments required are a dry-bulb, a natural wet-bulb, a globe thermometer, and a stand. The measurement of the environmental factors shall be performed as follows:

A. The range of the dry and the natural wet bulb thermometer shall be −5°C to 50°C with an accuracy of ±0.5°C. The dry bulb thermometer must be shielded from the sun and the other radiant surfaces of the environment without restricting the airflow around the bulb. The wick of the natural wet-bulb thermometer shall be kept wet with distilled water for at least 1/2 hour before the temperature reading is made. It is not enough to immerse the other end of the wick into a reservoir of distilled water and wait until the whole wick becomes wet by capillarity. The wick shall be wetted by direct application of water from a syringe 1/2 hour before each reading. The wick shall extend over the bulb of the thermometer, covering the stem about one additional bulb length. The wick should always be clean and new wicks should be washed before using.

B. A globe thermometer, consisting of a 15 cm. (6-inch) diameter hollow copper sphere painted on the outside with a matte black finish or equivalent, shall be used. The bulb or sensor of a thermometer (range −5°C to 100°C with an accuracy of ±0.5°C) must be fixed in the center of the sphere. The globe thermometer shall be exposed at least 25 minutes before it is read.

C. A stand shall be used to suspend the three thermometers so that they do not restrict free air flow around the bulbs, and the wet-bulb and globe thermometer are not shaded.

D. It is permissible to use any other type of temperature sensor that gives identical reading as that of a mercury thermometer under the same conditions.

E. The thermometers must be so placed that the readings are representative of the condition where the men work or rest, respectively.

The methodology outlined above is more fully explained in the following publications:

1. "Prevention of Heat Casualties in Marine Corps Recruits, 1955–1960, with Comparative Incidence Rates and Climatic Heat Stresses in other Training Categories," by Captain David Minard, MC, USN, Research Report No. 4, Contract No. MR005.01–0001.01, Naval Medical Research Institute, Bethesda, Maryland, 21 February 1961.

2. "Heat Casualties in the Navy and Marine Corps, 1959–1962, with Appendices on the Field Use of the Wet Bulb-Globe Temperature Index," by Captain David Minard, MC, USN, and R. L. O'Brien, HMC, USN. Research Report No. 7, Contract No. MR 005.01–0001.01, Naval Medical Research Institute, Bethesda, Maryland, 12 March 1964.

3. Minard, D.: Prevention of Heat Casualties in Marine Corps Recruits. Military Medicine *126(4)*: 261–272, 1961.

II. *Work Load Categories*

Heat produced by the body and the environmental heat together determine the total heat load. Therefore, if work is to be performed under hot environmental conditions, the workload category of each job shall be established and the heat exposure limit pertinent to the work load evaluated against the applicable standard in order to protect the worker from exposure beyond the permissible limit.

A. The work load category may be established by ranking each job into light, medium, and heavy categories on the basis of type of operation. Where the work load is ranked into one of said three categories, i.e.

(1) light work (up to 200 Kcal/hr or 800 Btu/hr): e.g., sitting or standing to control machines, performing light hand or arm work,

(2) moderate work (200–350 Kcal/hr or 800–1400 Btu/hr): e.g., walking about with moderate lifting and pushing,

(3) heavy work (350–500 Kcal/hr or 1400–2000 Btu/hr): e.g., pick and shovel work,

the permissible heat exposure limit for that work load shall be determined from Table 1.

B. The ranking of the job may be performed either by measuring the worker's metabolic rate while performing his job or by estimating his metabolic rate by the use of the scheme shown in Table 2. Tables available in the literature listed below and in other publications as well may also be utilized. When this method is used the permissible heat exposure limit can be determined by Figure 1.

1. Per-Olaf Astrand and Kaare Rodahl: "Textbook of Work Physiology" McGraw-Hill Book Company, New York, San Francisco, 1970.

2. "Ergonomics Guide to Assessment of Metabolic and Cardiac Costs of Physical Work." Amer. Ind. Hyg. Assoc. J. *32:* 560, 1971.

3. Energy Requirements for Physical Work. Purdue

Farm Cardiac Project. Agricultural Experiment Station. Research Progress Report No. 30, 1961.

4. J. V. G. A. Durnin and R. Passmore: "Energy, Work and Leisure." Heinemann Educational Books, Ltd., London, 1967.

TABLE 2

Assessment of Work Load

Average values of metabolic rate during different activities.

A. Body position and movement	Kcal./min.
Sitting	0.3
Standing	0.6
Walking	2.0–3.0
Walking up hill	add 0.8 per meter (yard) rise

B. Type of Work		Average Kcal./min.	Range Kcal./min.
Hand work			
	light	0.4	0.2–1.2
	heavy	0.9	
Work with one arm			
	light	1.0	0.7–2.5
	heavy	1.8	
Work with both arms			
	light	1.5	1.0–3.5
	heavy	2.5	
Work with body			
	light	3.5	2.5–15.0
	moderate	5.0	
	heavy	7.0	
	very heavy	9.0	

Light hand work: writing, hand knitting

Heavy hand work: typewriting

Heavy work with one arm: hammering in nails (shoemaker, upholsterer)

Light work with two arms: filing metal, planing wood, raking of a garden

Moderate work with the body: cleaning a floor, beating a carpet

Heavy work with the body: railroad track laying, digging, barking trees

Sample Calculation: Using a heavy hand tool on an assembly line

A.	Walking along	2.0 Kcal./min.
B.	Intermediate value between heavy work with two arms and light work with the body	3.0 Kcal./min.
		5.0 Kcal./min.
C.	Add for basal metabolism	1.0 Kcal./min.
	Total	6.0 Kcal./min.

Adapted from Lehmann, G. E., A. Muller and H. Spitzer: Der Kalorienbedarf bei gewerblicher Arbeit. Arbeitsphysiol. *14:* 166, 1950.

III. *Work-Rest Regimen*

The permissible exposure limits specified in Table 1 and Figure 1 are based on the assumption that the WBGT value of the resting place is the same or very close to that of the work place. Where the WBGT of the work area is different from that of the rest area a time-weighted average value should be used for both environmental and metabolic heat. When time-weighted average values are used the appropriate curve on Figure 1 is the solid line labeled "continuous."

The time-weighted average metabolic rate (M) shall be determined by the equation:

$$\text{Av. } M = \frac{(M_1) \times (t_1) + (M_2) \times (t_2) + \ldots\ldots + (M_n) \times (t_n)}{(t_1) + (t_2) + \ldots\ldots + (t_n)}$$

Where M_1 M_2, M_n are estimated or measured metabolic rates for the various activities of the worker during the total time period. t_1, t_2, t_n are the elapsed times in minutes spent at the corresponding metabolic rate as determined by a time study.

The time-weighted average WBGT shall be determined by the equation:

$$\text{Av. WBGT} = \frac{(\text{WBGT}_1) \times (t_1) + (\text{WBGT}_2) \times t_2 + \ldots + (\text{WBGT}_n) \times (t_n)}{(t_1) + (t_2) + \ldots + (t_n)}$$

where WBGT_1, WBGT_2, WBGT_n are calculated values of WBGT for the various work and rest areas occupied during total time periods. t_1, t_2, t_n are the elapsed times in minutes spent in the corresponding areas which are determined by a time study. Where exposure to hot environmental conditions is continuous for several hours or the entire work day, the time-weighted averages shall be calculated as hourly time-weighted average i.e., $t_1 + t_2 + \ldots t_n = 60$ minutes. Where the exposure is intermittent, the time-weighted averages shall be calculated as two-hour time-weighted averages, i.e., $t_1 + t_2 + \ldots t_n = 120$ minutes.

The permissible exposure limits for continuous work are applicable where there is a work-rest regimen of a 5-day work week and an 8-hour work day with a short morning and afternoon break (approximately 15 minutes) and a longer lunch break (approximately 30 minutes). Higher exposure limits are permitted if additional resting time is allowed. All breaks, including unscheduled pauses and administrative or operational waiting periods during work may be counted as rest time when additional rest allowance must be given because of high environmental temperatures.

It is a common experience that when the work on a job is self-paced, the workers will spontaneously limit their hourly work load to 30–50% of their maximum physical performance capacity. They do this either by setting an appropriate work speed or by interspersing unscheduled breaks. Thus the daily average of the workers' metabolic rate seldom exceeds 330 kcal/hr. However, within an 8-hour work shift there may be periods where the workers' hourly average metabolic rate will be higher.

IV. *Water and Salt Supplementation*

During the hot season or when the worker is exposed to artificially generated heat, drinking water shall be made available to the workers in such a way that they are stimulated to frequently drink small amounts, i.e., one cup every 15–20 minutes (about 150 ml or 1/4 pint).

The water shall be kept reasonably cool (10°–15°C or 50.0°–60.0°F) and shall be placed close to the workplace so that the worker can reach it without abandoning the work area.

The workers should be encouraged to salt their food abundantly during the hot season and particularly during hot spells. If the workers are unacclimatized, salted drinking water shall be made available in a concentration of 0.1% (1g NaCl to 1.0 liter or 1 level tablespoon of salt to 15 quarts of water). The added salt shall be completely dissolved before the water is distributed, and the water shall be kept reasonably cool.

V. *Other Considerations*

A. Clothing: The permissible heat exposure TLVs are valid for light summer clothing as customarily worn by workers when working under hot environmental conditions. If special cothing is required for performing a particular job and this clothing is heavier or it impedes sweat evaporation or has higher insulation value, the worker's heat tolerance is reduced, and the permissible heat exposure limits indicated in Table 1 and Figure 1 are not applicable. For each job category where special clothing is required, the permissible heat exposure limit shall be established by an expert.

B. Acclimatization and Fitness: The recommended heat stress TLVs are valid for acclimated workers who are physically fit.

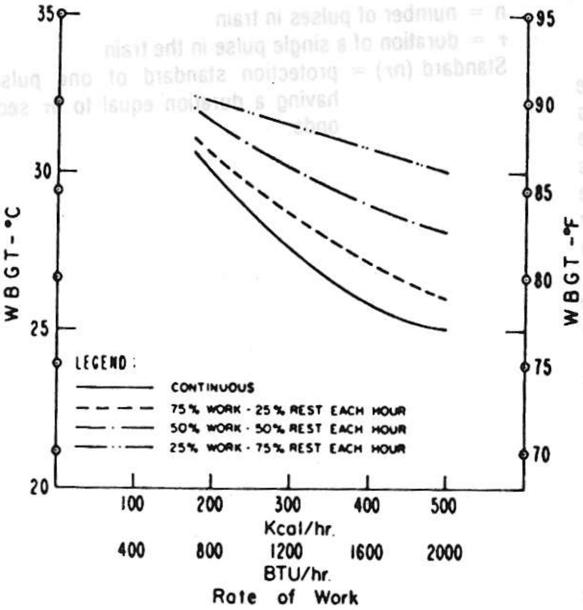

Figure 1 — Permissible Heat Exposure Threshold Limit Value

IONIZING RADIATION

The recommendations of the National Council on Radiation Protection and Measurements (NCRP) are suggested as threshold limit values to which nearly all workers may be exposed without adverse effects. The limits should be used as guides for the control of exposure and should not be regarded as fine lines between safe and dangerous levels. The underlying philosophy of radiation protection is to keep all exposures as low as reasonably achievable.

The two basic reference documents are as follows:

a. "Basic Radiation Protection Criteria," NCRP Report No. 39, issued January 15, 1971.

b. "Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure," US Department of Commerce, National Bureau of Standards Handbook 69, issued June 5, 1959, with Addendum 1 issued August 1963. Available as NCRP Report No. 22.

The above documents, as well as information on numerous other NCRP Reports addressing specific subjects in ionizing radiation protection are available from: NCRP Publications, 7910 Woodmont Ave., Washington, DC 20014.

LASERS

The threshold limit values are for exposure to laser radiation under conditions to which nearly all workers may be exposed without adverse effects. The values should be used as guides in the control of exposures and should not be regarded as fine lines between safe and dangerous levels. They are based on the best available information from experimental studies.

Limiting Apertures

The TLVs expressed as radiant exposure or irradiance in this section may be averaged over an aperture of 1 mm except for TLVs for the eye in the spectral range of 400–1400 nm, which should be averaged over a 7 mm limiting aperture (pupil); and except for all TLVs for wavelengths between 0.1–1 mm where the limiting aperture is 10 mm. No modification of the TLVs is permitted for pupil sizes less than 7 mm.

The TLVs for "extended sources" apply to sources which subtend an angle greater than α (Table 5) which varies with exposure time. This angle is *not* the beam divergence of the source.

Correction Factors A and B (C_A and C_B)

The TLVs for ocular exposure in Tables 3 and 4 are to be used as given for all wavelength ranges. The TLVs for wavelengths between 700 nm and 1049 nm are to be increased by a uniformly extrapolated factor (C_A) as shown in Figure 2. Between 1049 nm and 1400 nm, the TLV has been increased by a factor (C_A) of five. For certain exposure times at wavelengths between 550 nm and 700 nm, correction factor (C_B) must be applied.

The TLVs for skin exposure are given in Table 6. The TLVs are to be increased by a factor (C_A) as shown in Figure 2 for wavelengths between 700 nm and 1400 nm. To aid in the determination of TLVs for exposure durations requiring calculations of fractional powers Figures 3, 4, 5 and 6 may be used.

Repetitively Pulsed Lasers

Since there are few experimental data for multiple pulses, caution must be used in the evaluation of such exposures. The protection standards for irradiance or radiant exposure in multiple pulse trains have the following limitations:

(1) The exposure from any single pulse in the train is limited to the protection standard for a single comparable pulse.

(2) The average irradiance for a group of pulses is limited to the protection standard as given in Tables 3, 4, or 6 of a single pulse of the same duration as the entire pulse group.

(3) When the Instantaneous Pulse Repetition Frequency (PRF) of any pulses within a train exceeds one, the protection standard applicable to each pulse is reduced as shown in Figure 6 for pulse durations less than 10^{-5} second. For pulses of greater duration, the following formula should be followed:

$$\text{Standard}\left(\begin{matrix}\text{single pulse}\\ \text{in train}\end{matrix}\right) = \frac{\text{Standard (pulse } n\tau)}{n}$$

where:

n = number of pulses in train
τ = duration of a single pulse in the train
Standard ($n\tau$) = protection standard of one pulse having a duration equal to $n\tau$ seconds.

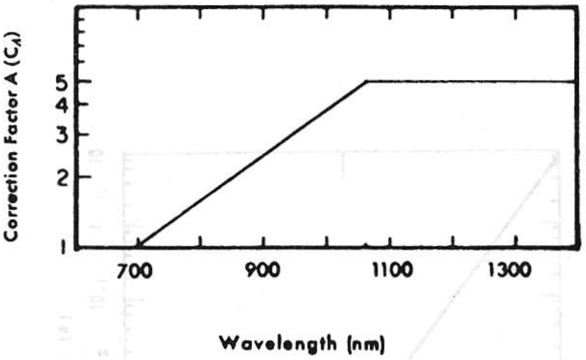

Figure 2 — TLV correction factor for
λ = 700 – 1400 nm*

*For λ = 700 – 1049 nm, $C_A = 10^{[0.002(\lambda - 700)]}$
For λ = 1050 – 1400 nm, $C_A = 5$

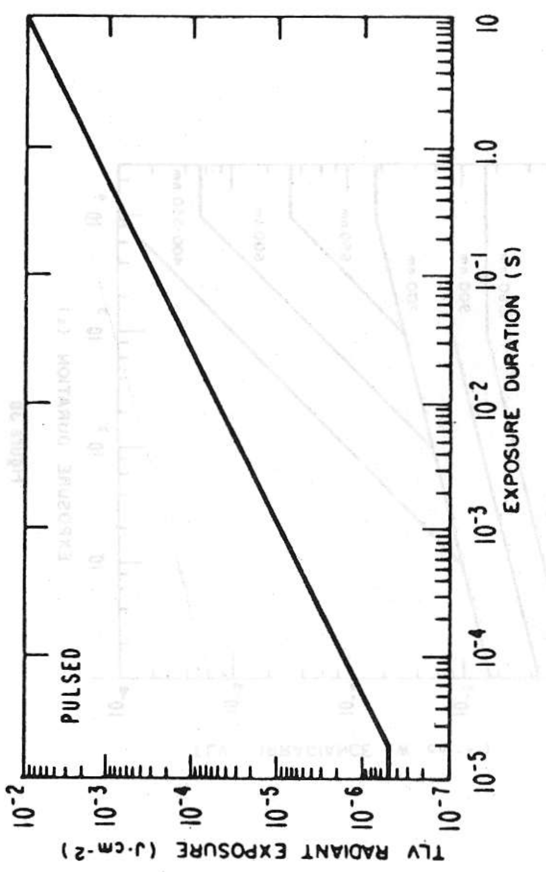

Figure 3a — TLV for intrabeam (direct) viewing of laser beam (400–700 nm).

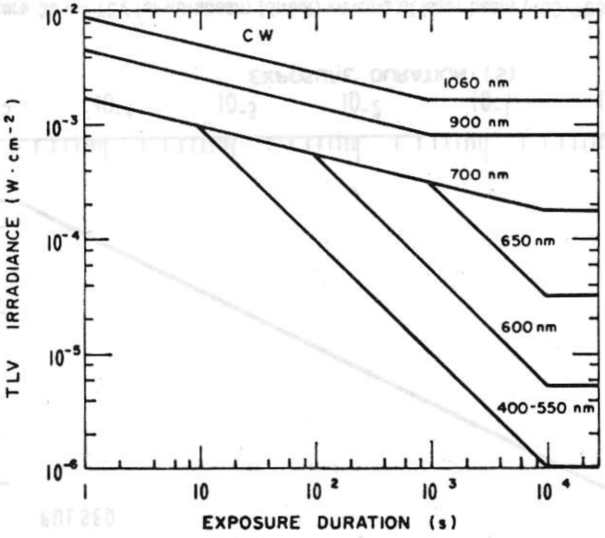

Figure 3b

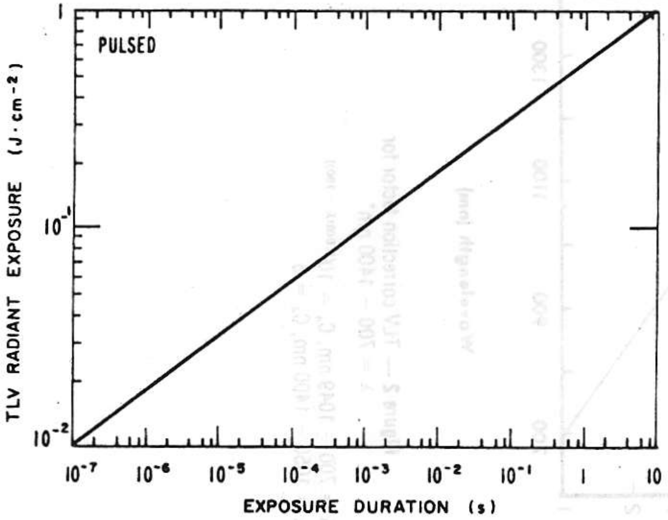

Figure 4a

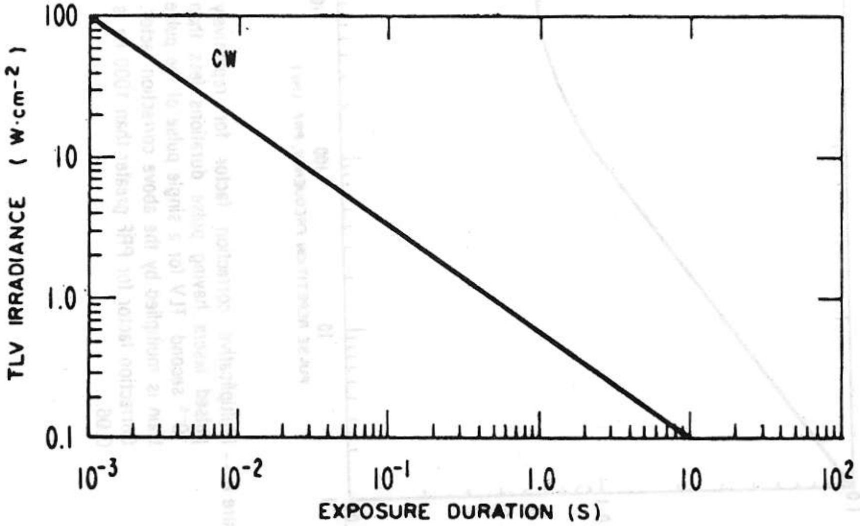

Figure 4b — TLV for CW laser exposure of skin and eyes for far-infrared radiation (wavelengths greater than 1.4 μm).

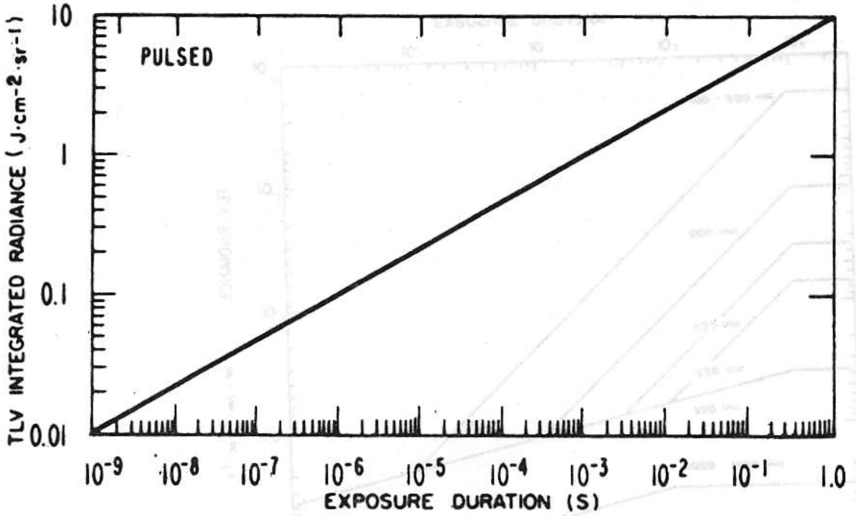

Figure 5a — TLV for extended sources or diffuse reflections of laser radiation (400–700 nm).

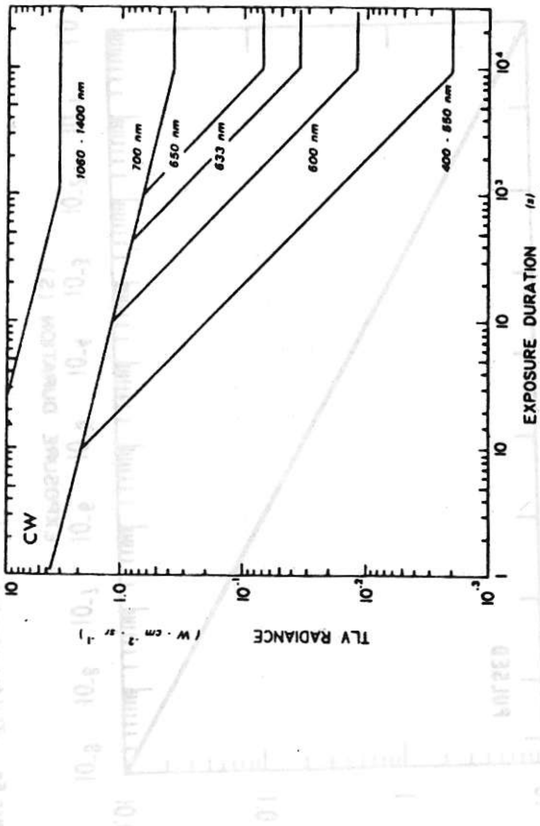

Figure 5b — TLV for intrabeam (direct) viewing of CW laser beam (400–1400 nm).

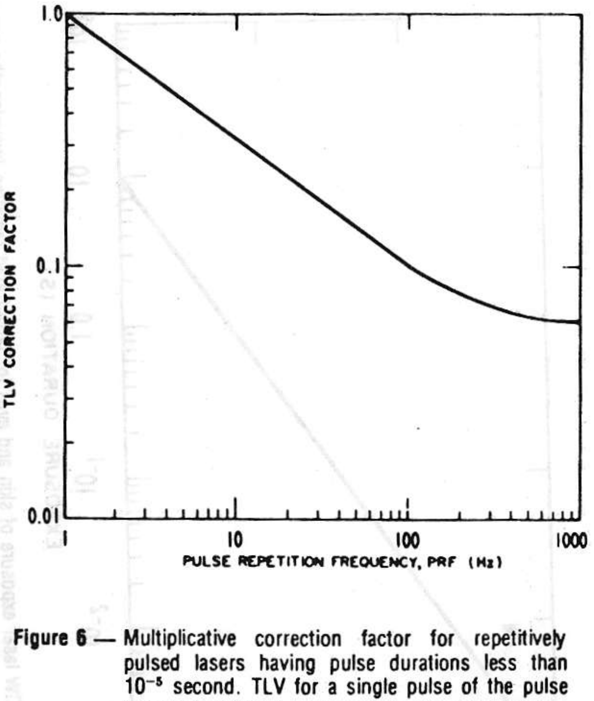

Figure 6 — Multiplicative correction factor for repetitively pulsed lasers having pulse durations less than 10^{-5} second. TLV for a single pulse of the pulse train is multiplied by the above correction factor. Correction factor for PRF greater than 1000 Hz is 0.06.

TABLE 3

Threshold Limit Value for Direct Ocular Exposures (Intrabeam Viewing) from a Laser Beam

Spectral Region	Wave Length	Exposure Time, (t) Seconds	TLV
UVC	200 nm to 280 nm	10^{-3} to 3×10^{4}	3 mJ • cm^{-2}
UVB	280 nm to 302 nm	"	3 "
	303 nm	"	4 "
	304 nm	"	6 "
	305 nm	"	10 "
	306 nm	"	16 "
	307 nm	"	25 "
	308 nm	"	40 "
	309 nm	"	63 "
	310 nm	"	100 "
	311 nm	"	160 "
	312 nm	"	250 "
	313 nm	"	400 "
	314 nm	"	630 "

TABLE 3 (Cont.)

UVA	315 nm to 400 nm	10^{-9} to 10	$.56\, t^{1/4}$ J • cm^{-2}
	" "	10 to 10^{3}	1.0 J • cm^{-2}
	" "	10^{3} to 3×10^{4}	1.0 mW • cm^{-2}
Light	400 nm to 700 nm	10^{-9} to 1.8×10^{-5}	5×10^{-7}J • cm^{-2}
	400 nm to 700 nm	1.8×10^{-5} to 10	1.8 $(t/\sqrt[4]{t})$ mJ • cm^{-2}
	400 nm to 549 nm	10 to 10^{4}	10 mJ • cm^{-2}
	550 nm to 700 nm	10 to T_1	1.8 $(t/\sqrt[4]{t})$ mJ • cm^{-2}
	550 nm to 700 nm	T_1 to 10^{4}	10 C_B mJ • cm^{-2}
	400 nm to 700 nm	10^{4} to 3×10^{4}	C_B μW • cm^{-2}
IR-A	700 nm to 1049 nm	10^{-9} to 1.8×10^{-5}	5 $C_A \times 10^{-7}$ J • cm^{-2}
	700 nm to 1049 nm	1.8×10^{-5} to 10^{3}	1.8 C_A $(t/\sqrt[4]{t})$ mJ • cm^{-2}
	1050 nm to 1400 nm	10^{-9} to 10^{-4}	5×10^{-6} J • cm^{-2}
	1050 nm to 1400 nm	10^{-4} to 10^{3}	$9(t/\sqrt[4]{t})$ mJ • cm^{-2}
	700 nm to 1400 nm	10^{3} to 3×10^{4}	320 C_A μW • cm^{-2}
IR-B & C	1.4 μm to 10^{3} μm	10^{-9} to 10^{-7}	10^{-2} J • cm^{2}
	" "	10^{-7} to 10	0.56 $\sqrt[4]{t}$ J • cm^{-2}
	" "	10 to 3×10^{4}	0.1 W • cm^{-2}

C_A – See Fig. 2.

$C_H = 1$ for $\lambda = 400$ to 549 nm; $C_B = 10^{[0.015\ (\lambda - 560)]}$ for $\lambda = 550$ to 700 nm.

$T_1 = 10$ s for $\lambda = 400$ to 549 nm; $T_1 = 10 \times 10^{[0.02\ (\lambda - 550)]}$ for $\lambda =$ 550 to 700 n.

TABLE 4

Threshold Limit Values for Viewing a Diffuse Reflection of a Laser Beam or an Extended Source Laser

Spectral Region	Wave Length	Exposure Time, (t) Seconds	TLV
UV	200 nm to 400 nm	10^{-3} to 3×10^{4}	Same as Table 3
Light	400 nm to 700 nm	10^{-9} to 10	$10 \sqrt[3]{t}\ \mathrm{J} \bullet \mathrm{cm}^{-2} \bullet \mathrm{sr}^{-1}$
	400 nm to 549 nm	10 to 10^{4}	$21\ \mathrm{J} \bullet \mathrm{cm}^{-2} \bullet \mathrm{sr}^{-1}$
	550 nm to 700 nm	10 to T_1	$3.83\ (t/\sqrt[4]{t})\ \mathrm{J} \bullet \mathrm{cm}^{-2} \bullet \mathrm{sr}^{-1}$
	550 nm to 700 nm	T_1 to 10^{4}	$21\ C_B\ \mathrm{J} \bullet \mathrm{cm}^{-2} \bullet \mathrm{sr}^{-1}$
	400 nm to 700 nm	10^{4} to 3×10^{4}	$2.1\ C_B t \times 10^{-3}\ \mathrm{W} \bullet \mathrm{cm}^{-2} \bullet \mathrm{sr}^{-1}$
IR-A	700 nm to 1400 nm	10^{-9} to 10	$10\ C_A \sqrt[3]{t}\ \mathrm{J} \bullet \mathrm{cm}^{-2} \bullet \mathrm{sr}^{-1}$
	700 nm to 1400 nm	10 to 10^{3}	$3.83\ C_A\ (t/\sqrt[4]{t})\ \mathrm{J} \bullet \mathrm{cm}^{-2} \bullet \mathrm{sr}^{-1}$
	700 nm to 1400 nm	10^{3} to 3×10^{4}	$0.64\ C_A\ \mathrm{W} \bullet \mathrm{cm}^{-2} \bullet \mathrm{sr}^{-1}$
IR-B & C	1.4 μm to 1 mm	10^{-9} to 3×10^{4}	Same as Table 3

C_A, C_B, and T_1 are the same as in footnote to Table 3.

TABLE 5

Limiting Angle to Extended Source Which May Be Used for Applying Extended Source TLVs

Exposure Duration(s)	Angle α (mrad)
10^{-9}	8.0
10^{-8}	5.4
10^{-7}	3.7
10^{-6}	2.5
10^{-5}	1.7
10^{-4}	2.2
10^{-3}	3.6
10^{-2}	5.7
10^{-1}	9.2
1.0	15
10	24
10^{2}	24
10^{3}	24
10^{4}	24

TABLE 6

Threshold Limit Value for Skin Exposure from a Laser Beam

Spectral Region	Wave Length	Exposure Time, (t) Seconds	TLV
UV	200 nm to 400 nm	10^{-3} to 3×10^{4}	Same as Table 3
Light &	400 nm to 1400 nm	10^{-9} to 10^{-7}	$2\ C_A \times 10^{-2}\ J \bullet cm^{-2}$
IR-A	" "	10^{-7} to 10	$1.1\ C_A \sqrt[4]{t}\ J \bullet cm^{-2}$
IR-B & C	1.4 μm to 1 mm	10^{-9} to 3×10^{4}	Same as Table 3

$C_A = 1.0$ for λ = 400–700 nm; see Figure 2 for λ = 700 to 1400 nm.

MICROWAVES

These Threshold Limit Values refer to microwave energy in the frequency range of 300 MHz to 300 GHz and represent conditions under which it is believed that nearly all workers may be repeatedly exposed without adverse effect.

Under conditions of moderate to severe heat stress, the recommended values may need to be reduced.* Therefore, these values should be used as guides in the control of exposure to microwave energy and should not be regarded as a fine line between safe and dangerous levels.

Recommended Values:

The Threshold Limit Value for occupational exposure to microwave energy, where power density or field intensity is known and exposure time is controlled, is as follows:

1. For exposure to continuous wave (CW) sources, the power density level shall not exceed 10 milliwatts per square centimeter (mW/cm^2) for continuous exposure, and the total exposure time shall be limited to an 8-hour workday. This power density is approximately equivalent to a free-space electric field strength of 200 volts-per-meter rms (V/m) and a free-space magnetic field strength of 0.5 ampere-per-meter rms (A/m).
2. Exposures to CW power density levels greater than 10 mW/cm^2 are permissible up to a maximum of 25 mW/cm^2 based upon an average energy density of 1 milliwatt-hour per square centimeter (mWh/cm^2) averaged over any 0.1 hour period. For example, at 25 mW/cm^2, the permissible exposure duration is approximately 2.4 minutes in any 0.1 hour period.
3. For repetitively pulsed microwave sources, the average field strength or power density is calculated by multiplying the peak-pulse value by the duty cycle. The duty cycle is equal to the pulse duration in seconds times the pulse repetition rate in Hertz. Exposure during an 8-hour workday shall not exceed the

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*Mumford, W.W., "Heat Stress Due to R. F. Radiation," Proceedings of IEEE, Vol. 57, No. 2, Feb. 1969, pp. 171–178.

following values which are averaged over any 0.1 hour period:

Power Density	10 mW/cm^2
Energy Density	1 mWh/cm^2
Mean Squared Electric Field Strength	40,000 V^2/m^2
Mean Squared Magnetic Field Strength	0.25 A^2/m^2

4. Exposure is not permissible in CW or repetitively pulsed fields with an average power density in excess of 25 mW/cm^2 or approximate equivalent free-space field strengths of 300 V/m or 0.75 A/m.

NOISE

These threshold limit values refer to sound pressure levels and durations of exposure that represent conditions under which it is believed that nearly all workers may be repeatedly exposed without adverse effect on their ability to hear and understand normal speech. The medical profession has defined hearing impairment as an average hearing threshold level in excess of 25 decibels (ANSI-S3.6-1969) at 500, 1000, and 2000 Hz, and the limits which are given have been established to prevent a hearing loss in excess of this level. The values should be used as guides in the control of noise exposure and, due to individual susceptibility, should not be regarded as fine lines between safe and dangerous levels.

It should be recognized that the application of the TLV for noise will not protect all workers from the adverse effects of noise exposure. A hearing conservation program with audiometric testing is necessary when workers are exposed to noise at or above the TLV levels.

Continuous or Intermittent

The sound level shall be determined by a sound level meter, conforming as a minimum to the requirements of the American National Standard Specification for Sound Level Meters, S1.4 (1971) Type S2A, and set to use the A-weighted network with slow meter response. Duration of exposure shall not exceed that shown in Table 7.

These values apply to total duration of exposure per working day regardless of whether this is one continuous exposure or a number of short-term exposures but does not apply to impact or impulsive type of noise.

When the daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect should be considered, rather than the individual effect of each. If the sum of the following fractions:

$$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \cdots \frac{C_n}{T_n}$$

exceeds unity, then, the mixed exposure should be considered to exceed the threshold limit value, C_1 indicates the total duration of exposure at a specific noise level, and T_1 indicates the total duration of exposure permitted at that level. All on-the-job noise exposures of 80 dBA or greater shall be used in the above calculations.

Table 7
Threshold Limit Values

Duration per day Hours	Sound Level dBA[a)]
16	80
8	85
4	90
2	95
1	100
1/2	105
1/4	110
1/8	115*

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*No exposure to continuous or intermittent in excess of 115 dBA

a) Sound level in decibels as measured on a sound level meter, conforming as a minimum to the requirements of the American National Standard Specification for Sound Level Meters, S1.4 (1971) Type S2A, and set to use the A-weighted network with slow meter response.

IMPULSIVE OR IMPACT NOISE

It is recommended that exposure to impulsive or impact noise shall not exceed the limits listed in Table 8 or taken from Figure 7. No exposures in excess of 140 decibels peak sound pressure level are permitted. Impulsive or impact noise is considered to be those variations in noise levels that involve maxima at intervals of greater than one per second. Where the intervals are less than one second, it should be considered continuous.

Table 8
Threshold Limit Values
Impulsive or Impact Noise

Sound Level dB**	Permitted Number of Impulses or Impacts per day
140	100
130	1000
120	10,000

**Decibels peak sound pressure level.

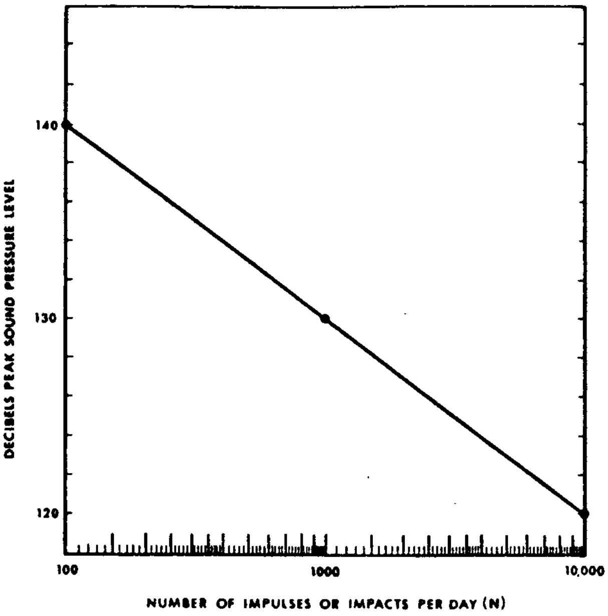

Figure 7 — Threshold Limit Values for Impulse/Impact Noise.

ULTRAVIOLET RADIATION*

These threshold limit values refer to ultraviolet radiation in the spectral region between 200 and 400 nm and represent conditions under which it is believed that nearly all workers may be repeatedly exposed without adverse effect. These values for exposure of the eye or the skin apply to ultraviolet radiation from arcs, gas, and vapor discharges, fluorescent, and incandescent sources, and solar radiation, but do not apply to ultraviolet lasers.* These values do not apply to ultraviolet radiation exposure of photosensitive individuals or of individuals concomitantly exposed to photosensitizing agents (Fitzpatrick, et al., eds., Sunlight and Man, Univ. Tokyo Press, Tokyo, Japan, 1974). These values should be used as guides in the control of exposure to continuous sources where the exposure duration shall not be less than 0.1 sec.

These values should be used as guides in the control of exposure to ultraviolet sources and should not be regarded as a fine line between safe and dangerous levels.

Recommended Values:

The threshold limit value for occupational exposure to ultraviolet radiation incident upon skin or eye where irradiance values are known and exposure time is controlled are as follows:

1. For the near ultraviolet spectral region (320 to 400 nm) total irradiance incident upon the unprotected skin or eye should not exceed 1 mw/cm² for periods greater than 10^3 seconds (approximately 16 minutes) and for exposure times less than 10^3 seconds should not exceed one J/cm².
2. For the actinic ultraviolet spectral region (200 — 315 nm), radiant exposure incident upon the unprotected skin or eye should not exceed the values given in Table 9 within an 8-hour period.
3. To determine the effective irradiance of a broadband source weighted against the peak of the spectral effectiveness curve (270 nm), the following weighting formula should be used:

$$E_{eff} = \sum E_\lambda S_\lambda \Delta\lambda$$

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*See Laser TLVs.

where:

E_{eff} = effective irradiance relative to a monochromatic source at 270 nm in W/cm² (J/s/cm²)

E_λ = spectral irradiance in W/cm²/nm

S_λ = relative spectral effectiveness (unitless)

$\Delta\lambda$ = band width in nanometers

4. Permissible exposure time in seconds for exposure to actinic ultraviolet radiation incident upon the unprotected skin or eye may be computed by dividing 0.003 J/cm² by E_{eff} in W/cm². The exposure time may also be determined using Table 10 which provides exposure times corresponding to effective irradiances in μW/cm².

TABLE 9

Relative Spectral Effectiveness by Wavelength

Wavelength (nm)	TLV (mJ/cm²)**	Relative Spectral Effectiveness S_λ
200	100	0.03
210	40	0.075
220	25	0.12
230	16	0.19
240	10	0.30
250	7.0	0.43
254	6.0	0.5
260	4.6	0.65
270	3.0	1.0
280	3.4	0.88
290	4.7	0.64
300	10	0.30
305	50	0.06
310	200	0.015
315	1000	0.003

**1 m J/cm² = 10^{-3} J/cm²

TABLE 10

Permissible Ultraviolet Exposures

Duration of Exposure Per Day	Effective Irradiance, E_{eff} (μW/cm^2)***
8 hrs.	0.1
4 hrs.	0.2
2 hrs.	0.4
1 hr.	0.8
30 min.	1.7
15 min.	3.3
10 min.	5
5 min.	10
1 min.	50
30 sec.	100
10 sec.	300
1 sec.	3,000
0.5 sec.	6,000
0.1 sec.	30,000

All the preceding TLV's for ultraviolet energy apply to sources which subtend an angle less than 80°. Sources which subtend a greater angle need to be measured only over an angle of 80°.

***1μW/cm^2 = 10^{-6} W/cm^2

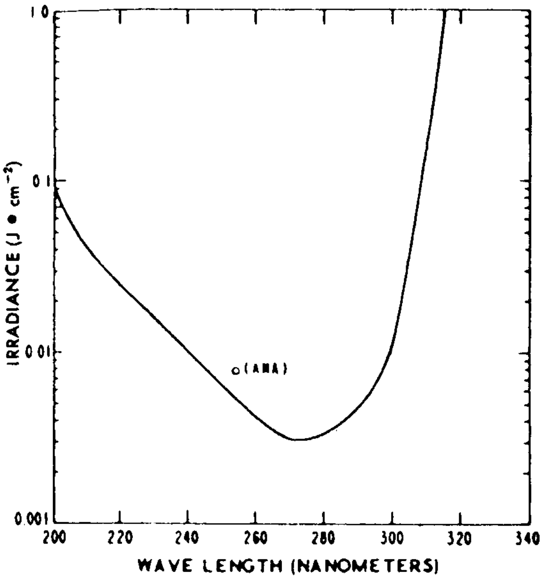

Figure 8 — Threshold Limit Values for Ultraviolet Radiation

Conditioned (tanned) individuals can tolerate skin exposure in excess of the TLV without erythemal effects. However, such conditioning may not protect persons against skin cancer.

NOTICE OF INTENDED CHANGES (for 1978)

These physical agents, with their corresponding values, comprise those for which either a limit has been proposed for the first time, or for which a change in the "Adopted" listing has been proposed. In both cases, the proposed limits should be considered trial limits that will remain in the listing for a period of at least one year. If after one year no evidence comes to light that questions the appropriateness of the values herein the values will be reconsidered for the "Adopted" list.

NOTICE OF INTENT TO ESTABLISH THRESHOLD LIMIT VALUES

LIGHT AND NEAR-INFRARED RADIATION

These Threshold Limit Values refer to visible and near-infrared radiation in the wavelength range of 400 nm to 1400 nm and represent conditions under which it is believed that nearly all workers may be exposed without adverse effect. These values should be used as guides in the control of exposure to light and should not be regarded as a fine line between safe and dangerous levels.

Recommended Values:

The Threshold Limit Value for occupational exposure to broad-band light and near-infrared radiation for the eye apply to exposure in any eight-hour workday and require knowledge of the spectral radiance (L_λ) and total irradiance (E) of the source as measured at the position(s) of the eye of the worker. Such detailed spectral data of a white light source is generally only required if the luminance of the source exceeds 1 cd cm^{-2}. At luminances less than this value the TLV would not be exceeded.

The TLV's are:

1. To protect against retinal thermal injury, the spectral radiance of the lamp weighted against the function R (Table 11) should not exceed:

$$\sum_{400}^{1400} L_\lambda R_\lambda \Delta\lambda \leq 1/\alpha t^{1/2} \qquad (1)^*$$

where L_λ is in W cm^{-2} sr^{-1} and t is the viewing duration (or pulse duration if the lamp is pulsed) limited to 1 μs to 10 s, and α is the angular subtense of the source in radians. If the lamp is oblong, α refers to the longest dimension that can be viewed. For instance, at a viewing distance r = 100 cm from a tubular lamp of length l = 50 cm, the viewing angle is:

$$\alpha = l/r = 50/100 = 0.5 \text{ rad} \qquad (2)$$

2. To protect against retinal photochemical injury from chronic blue-light exposure the integrated spectral radiance of the lamp weighted against the blue-light hazard function B_λ (Table 11) should not exceed:

$$\sum_{400}^{1400} L_\lambda t B_\lambda \Delta\lambda \leq 100 \text{ Jcm}^{-2} \text{ sr}^{-1} \; (t \leq 10^4 s) \qquad (3a)$$

$$\sum_{400}^{1400} L_\lambda B_\lambda \Delta\lambda \leq 10^{-2} \text{ Wcm}^{-2} \text{ sr}^{-1} \; (t > 10^4 s) \qquad (3b)$$

For a source radiance L which exceeds 2 mW cm^{-2} sr^{-1} in the blue spectral region, the permissible exposure duration t_{max} in seconds is simply:

$$t_{max} = 100 \text{ J cm}^{-2} \text{ sr}^{-1}/L \text{ (blue)} \qquad (4)$$

The latter limits are greater than the maximum permissible exposure limits for 440 nm laser radiation (see Laser TLV) because a 2–3 mm pupil is assumed rather than a 7 mm pupil for the Laser TLV.

3. *Infrared Radiation:* To avoid possible delayed effects upon the lens of the eye (cataractogenesis), the infrared radiation ($\lambda > 770$ nm) should be limited to 10 $mWcm^{-2}$. For an infrared heat lamp or any near-infrared source where a strong visual stimulus is absent, the near infrared (770–1400 nm) radiance as viewed by the eye should be limited to:

$$\sum_{770}^{1400} L_\lambda \Delta\lambda = 0.6/\alpha \qquad (5)^*$$

for extended duration viewing conditions. This limit is based upon a 7 mm pupil diameter.

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*Formulae (1) and (2) are empirical and are not, strictly speaking, dimensionally correct. To make the formulae dimensionally correct, one would have to insert a dimensional correction factor k in the right hand numerator in each formula. For formula (1) this would be $k_1 = 1$ W • rad • $s^{1/2}/(cm^2$ • sr), and for formula (5) $k_2 = 1$ W • rad/(cm^2 • sr).

TABLE 11

SPECTRAL WEIGHTING FUNCTIONS FOR ASSESSING RETINAL HAZARDS FROM BROAD — BAND OPTICAL SOURCES

Wavelength (nm)	Blue-Light Hazard Function B_λ	Burn Hazard Function R_λ
400	0.10	1.0
405	0.20	2.0
410	0.40	4.0
415	0.80	8.0
420	0.90	9.0
425	0.95	9.5
430	0.98	9.8
435	1.0	10
440	1.0	10
445	0.97	9.7
450	0.94	9.4
455	0.90	9.0
460	0.80	8.0
465	0.70	7.0
470	0.62	6.2
475	0.55	5.5
480	0.45	4.5
485	0.40	4.0
490	0.22	2.2
495	0.16	1.6
500–600	$10^{[(450-\lambda)/50]}$	1.0
600–700	0.001	1.0
700–1049	0.001	$10^{[(700-\lambda)/505]}$
1050–1400	0.001	0.2

AIRBORNE UPPER SONIC AND ULTRASONIC ACOUSTIC RADIATION

These threshold limit values refer to sound pressure levels that represent conditions under which it is believed that nearly all workers may be repeatedly exposed without adverse effect. The values listed in Table 15 should be used as guides in the control of noise exposure and, due to individual susceptibility, should not be regarded as fine lines between safe and dangerous levels. The levels for the third octave bands centered below 20 kHz are below those which cause subjective effects. Those levels for 1/3 octaves above 20 kHz are for prevention of possible hearing losses from subharmonics of these frequencies.

TABLE 12

Permissible Ultrasound Exposure Levels

Mid-Frequency of Third-Octave Band kHz	One-Third Octave — Band Level in dB reference 0.0002 dynes/cm^2
10	80
12.5	80
16	80
20	105
25	110
31.5	115
40	115
50	115

PHYSICAL AGENTS UNDER STUDY

These agents comprise those which the Physical Agents Committee of ACGIH proposes to study during this year to determine the feasibility of establishing proposed TLVs in 1979. Comments and suggestions, accompanied by substantitive evidence, are solicited.

1. *Radiofrequency Radiation*. Specifically, that portion of the spectrum from 10 MHz to 100 MHz.
2. *Extremely Low Frequency (ELF) Radiation*. Specifically, that portion of the spectrum from 0 to 300 Hz.
3. *Magnetic Fields*. Both pulsed and continuous.
4. *Laser Radiation*. Specifically ultraviolet radiation for pulsed exposures, and repetitively pulsed light and infrared-A laser exposures.
5. *Ultrasonic Energy*. Specifically, acoustic energy at frequencies abbve 10 kHz.
6. *Vibration*. Segmental and whole-body.
7. *Cold Stress*.
8. *Pressure Variations*.

The American Conference of Governmental Industrial Hygienists was organized in 1938 by a group of governmental industrial hygienists who desired a medium for the free exchange of ideas, experiences and the promotion of standards and techniques in industrial health. The Conference is not an official Government Agency.

It is an organization devoted to the development of administrative and technical aspects of worker health protection. The association has contributed substantially to the development and improvement of official industrial health services to industry and labor. The committees on Industrial Ventilation and Threshold Limit Values are recognized throughout the world for their expertise and contributions to industrial hygiene.

Membership is limited to professional personnel in governmental agencies or educational institutions engaged in occupational safety and health programs. The more than 1800 members from across the United States and around the world give the organization an international scope.

APPENDIX 3

- DRAFT -

MEDICAL SURVEILLANCE OF ATOMIC RADIATION WORKERS AT URANIUM MINES, MILLS AND REFINERIES

The following draft relates the guidelines for medicals and medical surveillance of persons employed in or about Uranium mines, mills and refineries on advice from the Ministry of Health, Division of Occupational Health.

General

All persons employed in mining, milling and refining of radioactive ores should be medically examined before commencing such work and at appropriate intervals while so employed.

These guidelines are provided for the use and guidance of persons directly concerned with the medical surveillance of atomic radiation workers (as defined in Atomic Energy Control Regulations) employed at uranium mines, mills, and refineries. It is important to note that the guidelines are not intended to be all-inclusive, nor to restrict in any way those accepted procedures which are considered normal components of good occupational medical practice.

Examinations mentioned in these guidelines include pre-employment and special procedures which are essential to good medical supervision. Their objective is to provide adequate information on the general health of the worker and to permit early detection of any changes which may be related to his working environment. Also included are some comments on post-illness and post-employment examinations, and personal health records.

These guidelines reflect agreement reached by a special group of Atomic Energy Control Board staff and advisers which met for this purpose. They also reflect the medical control measures described in IAEC Safety Series No. 43 "Manual on Radiological Safety in Uranium and Thorium Mines and Mills" which has been used as the basic reference in preparing this guide.

MEDICAL EXAMINATIONS

1. Pre-placement examination

Every worker should undergo a thorough pre-placement medical examination including a careful medical history for the following purposes:

- to determine fitness for the specific work for which he is to be employed
- to provide a base line reference when considering subsequent changes which may be related to occupational exposures or which may influence his fitness for work

- to provide possible biological data for later epidemiological studies

The pre-placement history should include particular attention to:

- smoking history (cigarettes, cigars, etc.)

- family history of cancer or blood disorders

- history of previous occupational exposure to ionizing radiation, other carcinogens (e.g. asbestos, coke oven gases, etc.) aerosols and dusts, etc.

- medical history of radiological examinations and therapies

- respiratory illness or chronic symptoms (cough, dyspnoea, etc.)

The medical examination should be complete and thorough in accordance with good occupational health practice and should include particular attention, in the case of these workers, to examination of the respiratory, cardiovascular, and urinary systems. The following tests should be carried out in all cases:

- vital capacity and forced expiratory volume pulmonary function tests

- base line haematological examination

- routine urinalysis

- uranium in urine where indicated by previous medical or work history

- external count of chest if indicated by previous occupational exposures

- sputum cytology where indicated by previous work history

- chest X-ray if not available within the previous 12 months

2. Periodic medical examinations

Atomic radiation workers at uranium mines and mills should have periodic examinations, the frequency to be determined by the occupational physician concerned. The periodic examination should, if necessary, consider a general examination in keeping with usual occupational health practice, with particular attention to systems most likely to be affected by the working environment in the mining and milling of radioactive ores, such as the respiratory, cardiovascular and urinary systems. The examination should also consider:

- pulmonary function tests

- blood pressure measurement

- haematological examination
- on-going smoking history
- chest X-ray once every five years unless required more frequently for special reasons
- special medical procedures as indicated below

3. Special medical procedures

These include the following

a) Bioassay tests (analysis of excreta for radiochemicals, body counting, etc.). These should be carried out routinely for mill and refinery workers and, where indicated, for miners. The frequency of testing will depend on working conditions and on agreement with the Atomic Energy Control Board.

b) Sputum cytology examinations for atypical exfoliated bronchial cells, the frequency depending on working conditions and on agreement with the Atomic Energy Control Board.

4. Post-illness examinations

In keeping with good occupational medical practice, it is important to ensure that the worker, on return from illness, is fit to resume his work, particularly after any prolonged absence on this account. An assessment of his fitness to return to full work activities may be more important than regular periodic examinations.

5. Medical examinations on termination of employment

It is in the interest of both employer and employee to ensure that all persons who have worked in mining and milling of radioactive ores undergo a thorough medical examination and assessment upon termination of their employment. Any work-related impairment should be identified and arrangements made for further periodic and follow-up examinations after employment has ceased depending on requirements.

PERSONAL HEALTH RECORDS

All individual medical, radiation exposures, and monitoring records in respect of atomic radiation workers in uranium mines, mills and refineries should be maintained with up-to-date information during employment, and for an extended period (not less than 30 years has been suggested) following cessation of work with radioactive minerals. Medical records include records of pre-employment, periodic, special, post-illness and terminal medical examinations and assessments, laboratory reports, sickness reports, medical history reports, etc. They should be handled and treated confidentially under the care of the medical facility, but without restricting the access of a worker to his own records.

Radiation exposure records include records of all internal and external radiation exposures and biossays in respect of each individual worker. These should not be considered as confidential medical records and should be available e.g. to the worker and his employer for the continuity of cumulative exposure calculations, and maintenance of a chronological history of exposure, such as is included in the National Dose Registry.

Monitoring records, including measurements of external radiation, radon and thoron and their daughters, and long-lived radionuclides, should also be maintained and made available for purposes indicated above.

URANIUM MINERS DOSE RECORDS - NATIONAL DOSE REGISTRY

The first section sets out the information for current data which should be supplied by each mine on a quarterly basis to the National Dose Registry.

The second section shows the requirements for submission of past-exposure records. This will be treated separately and can be regarded as a finite one-time requirement which may take considerable time, and in fact, may not be accomplished completely, because of the difficulty of finding, accessing and collecting past records. The actual information obtained will therefore probably range from a simple nominal role, to full identification with year by year dose information depending on the particular circumstances.

It is essential that regular reporting of Uranium miner records be initiated as soon as possible.

Occupational Radon Daughter Exposures - Routine Quarterly Submission

a) Initial Submission

Social Insurance Number
Miners Certificate Number
Surname
Given Names
Previous Surname
Province or Country of Birth
Country
Sex
Day, Month, Year of Birth
Identification Number of the Mine
Job Classification (Trade)
Previous Employers (if a mine)
Quarter Number and Year
Quarterly Accumulated Dose in WLM (to two decimal places)

b) Second or Subsequent Submission

Mine Identification
Social Insurance Number
Surname
Job Classification (Trade)
Calendar Quarter
Year
Quarterly Accumulated Dose in WLM (to two decimal places)

<u>Occupational Radon Daughter Exposures - Past Records</u>

Social Insurance Number
Miners Certificate Number
Surname
Given Names
Previous Surname
Province or Country of Birth
Sex
Day, Month, Year of Birth
Identification Number of the Mine
Job Classification (Trade)
Yearly Accumulated Dose in WLM (to two decimal places)

Repeat the above for each calendar year that data is available.

MEDICAL ADVICE TO MANAGEMENT

It is most important that medical advice to management on the suitability and fitness of individual workers for specific jobs and assignments be based on full knowledge of the workers health status and their employment requirements. Interpretation and assessment of the findings of medical surveillance examinations and records in relation to job conditions and working environments necessitates that the medical examiner has a full understanding and practical knowledge of these conditions. These examinations and assessments, therefore, should be carried out preferably by company physicians. When private physicians are employed on a part-time basis for these examinations, the company should make available suitable facilities for examinations in the vicinity of the work place, as well as provide appropriate opportunities for the examining physicians to fully familiarize themselves with the intended work activities and working environments of the individuals being examined.

APPENDIX 4

Medical Requirements and Controls

The Mines Regulation Act and Coal Mines Regulation Act Section 18 defines the occupations where medicals and/or xrays are required. M.R.A. Section 23 Rule 154 and C.M.R.A. Section 28 Rule 134 define the special medicals required by hoist operators to insure that no medical deficiency exists that will interfere with his duties. Under authority of Section 18 instructions regarding the procedure and rules are issued under a joint directive of the W.C.B. and the Chief Inspector of Mines. Copies of the documentation are included in the Appendix. The Environmental Inspectors' check the certificates of fitness held by a mine against the payroll list to insure that all workers that require certificates of fitness have a valid certificate of fitness. When such a certificate is not subsistent the worker is removed from the occupation that requires such a certificate until a valid certificate is obtained.

Mines Regulation Act Section 18:

Definitions. 18.(1) In this section, "dust-exposure occupation" means

(a) employment underground in a mine;
(b) employment on surface in open-pit and glory-hole operations;
(c) employment in crushing plants and assay grinding-rooms;
(d) employment in dry milling and dry concentrating;
(e) employment in wet concentrating plants where such plants are not adequately separated from dry crushing plants;
(f) employment at other locations designated by the Chief Inspector with the concurrence of the Workers' Compensation Board.

Examination for chest condition.

(2) Every employer shall cause each person in a dust-exposure occupation to be examined before entering employment and once in every twelve months thereafter, unless so exempted by the Chief Inspector, by a physician selected by and at the expense of the employer. Where a person receives a second examination within less than ten months after receiving his certificate, he may be charged for the second examination.

(2a) Each person so examined shall, on request, be entitled to a statement of his physical condition as determined by the examination.

Termination of employment.

(3) If the physician finds upon examination that the condition of any person is such that he is not fit for employment in a dust-exposure occupation or that his employment endangers the health of other persons, he shall promptly give written notice of such finding to the employer and to the Workers' Compensation Board. Upon receipt of such notice, and confirmation of the findings from the Board, the employer shall cease to employ the person in a dust-exposure occupation, and if employment is terminated the employee shall be entitled to four weeks' wages in lieu of notice.

Medical Requirements and Controls (Cont'd.)

Mines Regulation Act Section 18:

Termination of employment.

(3) (Cont'd.)

The examining physician, upon an application made to him by a person whose employment has been so terminated, shall furnish to the person a report of his findings in regard to the examination.

Certificate of fitness where workmen free from disease of respiratory organs.

(4) If a physician finds upon examination that the person is free from disease of the respiratory organs and otherwise fit for employment in a dust-exposure occupation, he shall deliver to the person a certificate of fitness in a form prescribed by the Workers' Compensation Board.

Power to cancel.

(5) The Workers' Compensation Board may, after investigation, cancel any certificate given by the physician or may, in its discretion, issue a certificate. When a certificate is cancelled, it shall be returned to the Board by the workman or the person who has custody of said certificate.

Certificate as condition of employment.

(6) No person shall be employed (includes self-employment) in a dust-exposure occupation unless he has been issued a certificate of fitness under subsection (4) and the certificate is subsisting. No certificate shall be deemed to have expired during the processing of the findings of the medical examination.

Custody of certificate.

(7) The owner, agent, or manager of every mine shall keep in his custody certificates of fitness for all persons working in dust-exposure occupations. Each certificate shall be returned to the person on his being discharged or leaving the employment.

Exemptions.

(8) The Chief Inspector may, with the concurrence of the Workers' Compensation Board, exempt from subsections (1) to (7) any mine, or any person working thereat, where, in his opinion, the mine does not contain a dust condition injurious to health, or where for any other reason he is of the opinion that such subsections should not apply.

(9) Subsections (1) to (7) do not apply to a person who is normally required to work less than twenty per centum of his working-time in any one month in a dust-exposure occupation.

Powers of Workers' Compensation Board to prescribe rules.

(10) Notwithstanding any of the provisions of this Act, the Workers' Compensation Board may prescribe the nature of the medical examination, the information to be obtained and recorded, and the form of certificate of fitness to be issued under the foregoing provisions, and may make such rules and give such directions as may be deemed requisite for the due administration and carrying-out of the medical provisions of this section. The physician who examines a workman shall furnish

Medical Requirements and Controls (Cont'd.)

Mines Regulation Act Section 18:

Powers of Workers' Compensation Board to prescribe rules.

(10) (Cont'd.)

to the Board the information and record from which the diagnosis was made in any case. [R.S.B.C. 1960, c. 242, s. 16 (am.)]; 1967, c. 25, s. 18; 1973 (2nd Sess.), c. 131, s. 16 (proc. eff. Jan. 1, 1974).

Form 13 Interim

MINES REGULATION ACT

WORKMEN'S COMPENSATION ACT

British Columbia

INTERIM

CERTIFICATE

OF

FITNESS

(Silicosis and Pneumoconiosis)

This Interim Certificate or a Certificate of Fitness issued to replace it shall remain in the custody of the workman's current employer.

Certificate No. ____

WORKMAN'S IDENTIFICATION

Name in Full ____

Address ____

Social Insurance No. ____

Country of Birth ____

Married ____ Single ____ Widower ____ Separated ____ Divorced ____

____

Height ____ ft. ____ in. Date of Birth ____

Colour of eyes ____ Colour of hair ____

Complexion ____

Distinguishing marks and characteristics ____

____

____

Signature of Workman ____

INTERIM CERTIFICATE

This certifies that I have examined the Form 12 and Chest X-Ray Film of

____

(full name of workman)

who is described above and have found him fit for work in any industry where this Certificate of Fitness is required.

Date of Examination ____ 19 ____

Medical Referee ____ M.D.

N.B. — This Certificate is valid for 12 months from date of examination.

SUBSEQUENT CERTIFICATES

This certifies that I have examined and had Chest X-Ray Film made of the above named and have found him fit for work in any industry where this Certificate of Fitness is required.

DATE	PLACE	PHYSICIAN
		M.D.
		M.D.
		M.D.
		M.D.
		M.D.
		M.D.
		M.D.
		M.D.
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		M.D.
		M.D.
		M.D.
		M.D.
		M.D.

Page 4

Form 13

BRITISH COLUMBIA

MINES REGULATION ACT

WORKMEN'S COMPENSATION ACT
British Columbia

CERTIFICATE
OF
FITNESS
(Silicosis and Pneumoconiosis)

This Certificate of Fitness is to be kept in the custody of the employer and is to be returned to the workman on leaving employment, or if cancelled is to be returned to the Workmen's Compensation Board.

Form 13
Serial No. ....

WORKMAN'S IDENTIFICATION

Name in Full ....

Address ....

Social Insurance No. ....

Country of Birth ....

Married .... Single .... Widower .... Separated .... Divorced ....

....

Height .... ft. .... in. Date of Birth ....

Colour of eyes .... Colour of hair ....

Complexion ....

Distinguishing marks and characteristics ....

....

....

Date .... 19 ....

Signature of Workman ....

N.B.—The holder of this Certificate is required to be re-examined not later than 24 months from the date of his last such examination and at least once in each 24 month period thereafter for so long as he is engaged in any industry where this Certificate of Fitness is required. A re-examination shall be carried out at a lesser interval of time if so ordered by the Workmen's Compensation Board.

Page 2

CERTIFICATE OF FITNESS
(Silicosis and Pneumoconiosis)
(To be filled in by WCB only)

This certifies that I have examined the Form 12 and Chest X-Ray Film of

....
(full name of workman)

who is described herein and have found him fit for work in any industry where this Certificate of Fitness is required.

Date of Examination .... 19 ......

Medical Referee .... M.D.

SUBSEQUENT CERTIFICATES

This certifies that I have examined and had Chest X-Ray Film made of the above named and have found him fit for work in any industry where this Certificate of Fitness is required.

DATE	PLACE	PHYSICIAN
		M.D.
		M.D.
		M.D.
		M.D.
		M.D.
		M.D.
		M.D.

Page 3

(Silicosis and Pneumoconiosis)

MINES REGULATION ACT

WORKERS' COMPENSATION ACT

BRITISH COLUMBIA

CERTIFICATE OF FITNESS

Serial No. ....

Workers' Employment Record and Medical Examination to be completed by employer and examining physician and sent with the worker's Chest X-ray Film to the Worker's Compensation Board, 5255 Heather Street, Vancouver, B.C. V5Z 3L8.

(On first examination submit Form 13 also)

WORKER'S EMPLOYMENT RECORD

(To be filled in by Employer)

EMPLOYER	WORKER
Name	Name ....
Address	Address ....
Location of operation	Social Insurance No. ....
....	To be employed at ....

Date of last examination .... Where .... By whom ....

Marital status .... Country of birth ....

Number of months worked in mines or tunnels since last examination ....

Period of residence in B.C. ....

	Name of Employer	Industry (Mining, Quarrying, Stone-Cutting, etc.)	Location or Address of Operation (Mine, Factory, etc.)	Period with Dates	Employed as Miner, Carpenter, Stone-Cutter, etc.
WORKER'S EMPLOYMENT RECORD (On the first examination give a complete statement of all types of work done by this worker during his/her lifetime dating from his/her very first employment. On second or subsequent examination give the occupational record since previous examination.					

I declare all the information I have given on this form is true and correct to the best of my knowledge. This will authorize the Board and Boards of Review to obtain or view, from any source whatsoever, including records of physicians, qualified practitioners or hospitals, a copy of records pertaining to examination, treatment, history and employment of the undersigned.

...., B.C. ....

Date Signed at Applicant's Signature in Ink (do not print)

Signed for Employer ....

Official Title ....

Form 12

MEDICAL EXAMINATION
(To be filled in by Examining Physician)

Worker's identification Date of birth .... Weight .... Height .... ft. .... ins.

Complexion .... Colour of eyes .... Colour of hair ....

		Yes	No		Yes	No
A. FAMILY HISTORY	**TUBERCULOSIS**	☐	☐	**CANCER LUNG**	☐	☐
B. PAST HISTORY (details below by number)	1. Asthma or hay fever	☐	☐	10. Palpitation heart	☐	☐
	2. Bronchitis	☐	☐	11. Irregular heart rate	☐	☐
	3. Pleurisy	☐	☐	12. Heart disease	☐	☐
	4. Pneumonia	☐	☐	13. Fainting spells	☐	☐
	5. Recurrent "colds"	☐	☐	14. Swelling ankles	☐	☐
	6. Spitting blood	☐	☐	15. Abnormal bruising	☐	☐
	7. Shortness of breath	☐	☐	16. High blood pressure	☐	☐
	8. Nose problems	☐	☐	17. Venereal disease	☐	☐
	9. T.B. or suspected of T.B.	☐	☐	18. Any other severe illness	☐	☐
				19. Any chest injuries	☐	☐
C. PRESENT HISTORY	Any of the above? Smoking history	☐	☐	Any medications?	☐	☐

D. DETAILS (by number as above)

CLINICAL EXAMINATION: Date: ....

1. Pulse at rest ....
   After exercise (30 bends in 60 seconds) ....
2. Respiration at rest ....
   After exercise (30 bends in 60 seconds) ....
3. Nasal obstruction — Yes .... No ....
4. Shape of chest ....
5. Expansion in inches (arms at side) ....
6. Lungs ....
7. Heart ....
8. Chronic diseases ....
9. Pulmonary function ....
   a FVC .... FeV1 ....
   b Others ....
10. Fit .... Unfit ....

X-RAY EXAMINATION:
(Sputum examinations are required in cases suspected of tuberculosis)

Date of film .... 19..........

1. Normal chest ....
2. Tuberculosis ....
3. Asbestosis) ....
   Silicosis) ....
   Pneumoconiosis) ....

Film No. ....

4. Heart ....
5. Other changes ....
   ....
6. Sputum examination ....

....
Signature Examining Physician

Signed this .... day of .... 19 .....

....
Address

Normal Chest .... Abnormal Findings ....

Remarks ....

Opinion of Consultant if in disagreement with Examining Physician's diagnosis

....

....

....
Signature Medical Consultant

RE: SECTION 18 - MINES REGULATION ACT

1. Under the above mentioned Act every employer shall cause each person in a dust-exposure occupation to be examined before entering employment and once in every twelve months thereafter, unless so exempted by the Chief Inspector, by a physician selected by and at the expense of the employer. Where a person receives a second examination within less than ten months after receiving his certificate, he may be charged for the second examination. Each person so examined shall, on request, be entitled to a statement of his physical condition as determined by the examination.

2. A "dust-exposure occupation" means:
   (a) employment underground in a mine;
   (b) employment on surface in open-pit and glory-hole operations;
   (c) employment in crushing plants and assay grinding-rooms;
   (d) employment in dry milling and dry concentrating;
   (e) employment in wet concentrating plants where such plants are not adequately separated from dry crushing plants;
   (f) employment at other locations designated by the Chief Inspector with the concurrence of the Workers' Compensation Board.

3. The Chief Inspector, as per the authority of sub-section 2, directs that each person in a dust-exposure occupation shall be examined before entering employment, once in the next twelve months, and thereafter as follows:
   (1) in occupations where there is exposure to asbestos dust - once in every twelve months.
   (2) in occupations where there is exposure to other types of dust - once in every twenty-four months.

4. Waiters and cooks employed in the preparation or serving of food to persons in a dust-exposure occupation shall be examined before entering such employment and once in every twelve months thereafter. Evidence showing that within the last twelve months they have been x-rayed and are free from tuberculosis will be accepted as an alternative to an examination.

5. Each examination shall include a medical examination of the worker and an x-ray of his chest with a film approximately fourteen inches by seventeen inches. The "Worker's Employment Record and Medical Examination" report (Form 12) shall be fully completed, the "Worker's Employment Record" portion by the employer and the "Medical Examination" portion by the examining physician. All films and Forms 12 shall be forwarded to the Board.

6. If the physician finds upon examination that the condition of any person is such that he is not fit for employment in a dust-exposure occupation or that his employment endangers the health of other persons, he shall promptly give written notice of such finding to the employer and to the Workers' Compensation Board. Upon receipt of such notice, and confirmation of the findings from the Board, the employer shall cease to employ the person in a dust-exposure occupation, and if employment is terminated the employee shall be entitled to four weeks' wages in lieu of notice. The examining physician upon an application made to him by a person whose employment has been so terminated, shall furnish to the person a report of his findings in regard to the examination.

7. If a physician finds upon examination that the person is free from disease of the respiratory organs and otherwise fit for employment in a dust-exposure occupation, he shall deliver to the person a certificate of fitness in a form prescribed by the Workers' Compensation Board.

8. The Workers' Compensation Board may, after investigation, cancel any certificate given by the physician or may, in its discretion, issue a certificate. When a certificate is cancelled, it shall be returned to the Board by the worker or the person who has custody of said certificate.

9. No person shall be employed (includes self-employment) in a dust-exposure occupation unless he has been issued a certificate of fitness and the certificate is subsisting. No certificate shall be deemed to have expired during the processing of the findings of the medical examination.

10. The owner, agent, or manager of every mine shall keep in his custody certificates of fitness for all persons working in dust-exposure occupations. Each certificate shall be returned to the person on his being discharged or leaving the employment.

11. The cost of x-rays and medical examinations shall be met from the assessments levied upon all employers whose employees require such examinations in the mining industry.

Every such employer shall pay for the medical examinations and x-rays done on his behalf and shall forward to the Board, on the form provided for that purpose, an account or accounts. The Board shall repay to the employer the amount of such account or accounts at the rates for examinations and x-rays existing at the date of these regulations, but not to exceed an aggregate amount of Eighteen Dollars ($18.00) for the examination and x-ray of each employee.

12. The above mentioned requirements do not apply at this time:

(a) to a person in a dust-exposure occupation who is employed in the recovery of limestone, dolomite, cement, gypsum, barite, phosphate, clay, shale, pozzolan, sand or gravel;

(b) to a person who is normally required to work less than twenty per centum of his working-time in any one month in a dust-exposure occupation.

13. This letter supersedes, with the concurrence of the Workers' Compensation Board, the circular dated February 1, 1968.

Victoria
June 1, 1975

J.W. Peck
Chief Inspector of Mines.

RE: SECTION 18 - COAL MINES REGULATION ACT

1. Under the above mentioned Act every employer shall cause each person in a dust-exposure occupation to be examined before entering employment and once in every twelve months thereafter, or at such greater interval as the chief inspector may direct, by a physician selected by and at the expense of the employer; but where a person receives a second examination within less than ten months after receiving a certificate under this section and does not inform his employer of the preceding examination, he may be charged for the second examination.

2. A "dust-exposure occupation" means:
   - (a) employment underground in a mine; or
   - (b) employment on surface in open-pit and glory-hole operations; or
   - (c) employment in crushing plants, assay grinding-rooms, and coal-cleaning plants; or
   - (d) employment in dry milling and dry concentrating; or
   - (e) employment in wet concentrating plants where such plants are not adequately separated from dry crushing plants; or
   - (f) employment at other locations designated by the chief inspector with the concurrence of the Workmen's Compensation Board.

3. The chief inspector directs that on and after the first day of April 1969, each person in a dust-exposure occupation shall be examined before entering employment, and thereafter once in every twenty-four months.

4. Waiters and cooks employed in the preparation or serving of food to persons in a dust-exposure occupation shall be examined before entering such employment and once in every twelve months thereafter. Evidence showing that within the last twelve months they have been x-rayed and are free from tuberculosis will be accepted as an alternative to an examination.

5. Each examination shall include a medical examination of the workman and an x-ray of his chest with a film approximately fourteen inches by seventeen inches. The "Workman's Employment Record and Medical Examination" report (Form 12c) shall be fully completed, the "Workman's Employment Record" portion by the employer and the "Medical Examination" portion by the examining physician. All films and Forms 12c shall be forwarded to the Board.

6. If the physician finds upon examination that the condition of any person is such that he is not fit for employment in a dust-exposure occupation or that his employment endangers the health of other persons, he shall promptly give written notice of such finding to the employer and to the Workmen's Compensation Board. Upon receipt of such notice, and confirmation of the findings from the Board, the employer shall cease to employ the person in a dust-exposure occupation, and if employment is terminated the employee shall be entitled to ~~two~~ Four week's wages in

lieu of notice. The examining physician, upon an application made to him by a person whose employment has been so terminated, shall furnish to the person a report of his findings in regard to the examination.

7. If a physician finds upon examination that the person is free from disease of the respiratory organs and otherwise fit for employment in a dust-exposure occupation, he shall deliver to the person a certificate of fitness in a form prescribed by the Workmen's Compensation Board.

8. The Workmen's Compensation Board may, after investigation, cancel any certificate given by the physician or may, in its discretion, issue a certificate. When a certificate is cancelled, it shall be returned to the Board by the workman or the person who has custody of said certificate.

9. No person shall be employed (includes self-employment) in a dust-exposure occupation unless he has been issued a certificate of fitness and the certificate is subsisting. No certificate shall be deemed to have expired during the processing of the findings of the medical examination.

10. The owner, agent, or manager of every mine shall keep in his custody certificates of fitness for all persons working in dust-exposure occupations. Each certificate shall be returned to the person on his being discharged or leaving the employment.

11. The above mentioned requirements do not apply to a person who is normally required to work less than twenty per cent of his working-time in any one month in a dust-exposure occupation.

12. This letter has been written with the concurrence of the Workmen's Compensation Board.

Victoria
April 2, 1969

J.W. Peck
Chief Inspector of Mines.

APPENDIX 6A

SPECIAL REPORT
GIBRALTAR MINES LIMITED
CARPENTER SHOP

S. Elias, P. Eng.
Senior Inspector
Environmental Control
March 15, 1978

GIBRALTAR MINES LIMITED

CARPENTER SHOP

The carpenter shop is equipped with all the regular wood working tool that include a cut off saw and bench saw. Wood dust concentrations were taken at two locations. One sampler was positioned over the lunch room table. The lunch room is located on a mezzanine floor over the office and storage room of the carpenter shop. There are no partitions or other mean of separation from the general carpenter shop atmosphere where the wood work is done. The second sampler was placed on one worker at shoulder elevation on his right side. The worker was sawing fir plywood on a continuous basis, for thirty minutes using the bench saw. Neither the bench or the cut-off saws are equipped with any means of collecting the saw dust and/or cuttings. There are no general ventilation fans installed in the building. The dust is trapped in the building unless the doors are opened

The maximum concentration averaged over any time period of not more than eight hours for non-allergenic wood dust is 5 mg/m^3.

The sampling results were as follows:

(1) Personnel Sampler mounted on worker adjacent to breathing area 18.33 mg/m^3 total dust for a 30 minute period of sampling.

(2) Sampler located over lunch room table at light elevation 4.97 mg/m^3 total dust sample taken during a three hour period that included the time the bench saw was in operation.

(3) The dust concentrations at the worker was well over the maximum allowable concentration, therefore it will be required that adequate dust control be installed in the carpenter shop to reduce dust concentration to within the 5 mg/m^3 TLV or less.

It is suggested that the American Conference of Governmental Industrial Hygienists specifications for saws VS-708; VS-401; VS-706; VS-707; Sanders VS-702; VS703;; VS-705; Jointers VS-701 be followed in order to insure that proper design is realized.

It is summized that the use of properly designed dust control about the equipment will alleviate the dust problem in the remainder of the building.

S. Elias, P. Eng.
Senior Inspector
Environmental Control

March 15, 1978

APPENDIX 6B

ENVIRONMENTAL TESTS AT MAINTENANCE AND WELDING OPERATIONS

HARMER OPEN PIT

KAISER RESOURCES LIMITED

SPARWOOD, BRITISH COLUMBIA

S. Elias, P. Eng.
Senior Inspector
Environmental Control

November 28, 1978

ENVIRONMENTAL TESTS AT MAINTENANCE AND WELDING OPERATIONS

HARMER OPEN PIT

KAISER RESOURCES LIMITED

SPARWOOD, BRITISH COLUMBIA

A survey of the environmental conditions was made about the Harmer truck maintenance and field maintenance component shops during November 28, 1978.

Two means of dust assessment were used: An open faced 37 mm filter in conjunction with an MSA sample pump calibrated at two liters per minute was used to do personal gravimetric sampling to establish dust loading and analysis of the collected dust; a GCA Model RDM-101-4 respirable dust monitor was used for on-the-spot measurements of mass concentrations of the respirable dust fraction. This instrument utilizes a two-stage collection system. The first stage consists of a 10 mm nylon cyclone precollector for the retention of the nonrespirable fraction of the dust. The precollector retains essentially all particles larger than approx. 10 microns in diameter (spheres of unit density) and passes all particles smaller than 2 microns. Particles not retained by the cyclone are then collected by the second stage of the instrument. The second stage consists of an impaction-beta absorption assembly with a manually operated impaction disc. Beta counts are made from which the instrument equates the mass concentration of the respirable airborne dust in milligrams per cubic meter of air.

Following are the results obtained:

Harmer Maintenance Field Component Welding Shop

Personal Samplers

T. Geneau	No. 1 sample	1.33 mg/m^3	personal sampler, open face.
Norman Hanson	No. 2 sample	6.03 mg/m^3	personal sampler, open face.

GCA RDM-101-4 Sampler respirable mass:-

General Shop area	9:15 a.m.	0.01 mg/m^3
	9:50 a.m.	0.06 mg/m^3
	10:55 a.m.	0.05 mg/m^3
	11:55 a.m.	0.04 mg/m^3
	1:20 p.m.	0.05 mg/m^3
	Average	0.042 mg/m^3

At Welding operation using Artec 223XC rods, sample taken at shoulder of worker

9:25 a.m.	0.02 mg/m^3
9:50 a.m.	0.16 mg/m^3
10:55 a.m.	0.37 mg/m^3
11:00 a.m.	0.82 mg/m^3
11:55 a.m.	0.61 mg/m^3
1:10 p.m.	0.67 mg/m^3
Average	0.442 mg/m^3

Harmer Maintenance Field Component Welding Shop (Cont'd.)

At Welding operation using 60/11 rod welding on paint and zinc coated metal

9:00 a.m. 0.39 mg/m^3

Maintenance Building Welding Areas

G. Zemck No. 3 sample 16.67 mg/m^3 personal sampler, open face, air arc welding

Worker at truck welding operator

11:07 a.m. 0.11 mg/m^3
0.14 mg/m^3

Using 70/18 welding rod - arc welding sample at shoulder.

Maintenance Shop

170 Terex Truck started up in shop. Condition:- Doors closed, fans off.	NO_2 + NO = 7 ppm CO = 50 ppm
Doors opened and fans on	NO_2 + NO = 4 ppm CO = 10 ppm
200 Electra Haul, door open, fans on	NO_2 + NO = 3 ppm CO = 10 ppm
General shop area with trucks running	NO_2 + NO = 3 ppm CO = 10 ppm

The shop rules are that all exhaust fans are operating and that the doors shall be opened before any truck is started for run up purposes. These rules must be strictly adhered to.

The company is presently installing an exhaust system, at one end of the shop, that will connect directly to the truck exhaust ports to carry the engine exhaust out of the building. This method of preventing engine exhaust air from contaminating the building will do much towards eliminating health hazards and improve working conditions.

Analysis

Following are the analysis of the open face gravimetric samples. No. 1 & 2 samples were grouped for analysis purposes as the workers were both working on the same project.

Location	Elapsed Time	Concentration milligrams per cubic meter					
		Dust	Iron Oxide	Nickel	Chromium	Manganese	Zinc
No. 1 & 2 samples Field welding shop	5 hrs	4.53	4.29	0.04	0.01	0.18	0.01
No. 3 sample Maintenance building welding shop	5 hrs 10 mins	12.06	10.78	0.13	0.01	1.13	0.01

Harmer Maintenance Field Component Shop

The Field Component Shop is equipped with six Tepco Model 2500 electronic air cleaners strategically placed three to the side of the shop measuring 51 feet wide by 91 feet long with an effective ceiling height of 22 feet. The total volume of the shop is 112,000 cubic feet and the cleaning capacity of the electronic air cleaners is 15,000 CFM thus giving an air exchange rate of 7.46 minutes of the general atmosphere in the building.

The average respirable dust concentration about the building with three welding operations in progress was 0.042 mg/m^3. The average respirable dust concentration at one welder located in a nook of the shop was 0.442 mg/m^3.

The electronic cleaners would appear to be effectively cleaning the ambient air about the general plant area but do very little to lower the welding fumes in the immediate operator's breathing zone. It is suggested that a fume exhauster that collects welding and other injurious fumes and heat "at their source" and carriea them away from the operator are better to eliminate health hazards and improve working conditions. Electronic air cleaners could be used to clean this contaminated air or it could be discharged directly to the outside of the building. It would still be required to have an acceptable means of general building ventilation.

S. Elias, P. Eng.
Senior Inspector
Environmental Control

December 11, 1978

APPENDIX 6C

SUPPLEMENTARY REPORT OF CONDITIONS ABOUT MECHANIZED OPERATIONS, SULLIVAN MINE

COMINCO LIMITED

KIMBERLEY, BRITISH COLUMBIA

S. Elias, P. Eng.
Senior Inspector
Environmental Control

January 19, 1977

SUPPLEMENTARY REPORT OF CONDITIONS ABOUT MECHANIZED OPERATIONS, SULLIVAN MINE

COMINCO LIMITED

KIMBERLEY, BRITISH COLUMBIA

A survey was made of the dust and gas concentrations about the mechanized operations in the Sullivan Mine Cominco Limited, Kimberley, British Columbia on January 19, 1977. The inspection was made in conjunction with the District Inspector of Mines and Resident Engineer in relation to a complaint received from the United Steelworkers of America Local 651 Safety Committee regarding diesel odour and dust from the mechanized operations contaminating fresh air flow to the north section of the mine.

The results and information obtained were as follows:

Underground

Mechanized Operations	No. of particles per c.c. of air.
4250 level ramp at stope dump area near portal, JDT 426 truck dumping a load of wet muck $NO + NO_2 = 2$ ppm, sample taken beside truck.	12 14 8 10
4251 drift south between 4267XCW and 4258XCW near refuge shelter, air flow from ramp area while scooptram was loading truck with muck from 4250 ramp. $NO + NO_2 = 1.5$ ppm CO = Nil	50 38 42 32
4251 drift south, south of 4267XCW at door, air flow from ramp area, while scooptram was loading truck, truck idling. $NO + NO_2 = 2$ ppm	34 32 36 28
4250 ramp collar, near scooptram while loading truck. $NO + NO_2 = 2$ ppm CO = Nil	52 38 44 36
4250 ramp at face, had been mucking, dead end, no mechanical ventilation being supplied to ramp. $NO + NO_2 = 5.5$ ppm CO = Nil	204 242 214 238
3901 ramp, at scooptram operator, scooptram bucket being used as staging to drill eye bolt holes. Ventilation duct approximately 10 meters back, ventilation fan had been turned off. $NO + NO_2 = 8$ ppm.	182 166 196 160

Mechanized Operations (Cont'd.)	No. of particles per c.c. of air.
3901 ramp, along ramp, footwall of ramp dry, scooptram had just passed by.	28 42 34 26

Air Volumes

4250 ramp air flow along ramp.	(59,700 CFM)	1690.7 m^3/min.
3900 ramp at #7 ventilation sta. just above 4150 level.	(15,600 CFM)	441.8 m^3/min.

Gas Concentrations	Parts Per Million of Air	
	$NO + NO_2$	CO
4250 level ramp at stope dump near portal	2.0	Nil
4251 drift south between 4267 and 4268 XCW	1.5	Nil
4251 drift south, south of 4267 XCW at door frame	2.0	Nil
4250 ramp collar, near scooptram	2.0	Nil
4250 ramp at face - no ventilation supplied	5.5	Nil
3901 ramp, at scooptram operator, ventilation off	8.0	Nil
3901 ramp - scooptram traversing	0.5	-

Remarks

The gases $NO + NO_2$ and CO in the general area about the mechanized operations and the air flowing to the north section of the mine were all well below the Threshold Limit Values established by the American Conference of Governmental Industrial Hygienists. However, there were two locations where diesel powered units were being operated without positive adequate ventilation as required by permit. The locations were as follows and require immediate correction:

1. Scooptram was being operated in 4250 ramp without ventilation;
2. Scooptram was being used as staging to drill eye bolt holes in 3901 ramp, ventilation fan was off.

Both of these locations are dead end headings.

No diesel powered equipment shall be operated in any area where the ventilation requirements as per permit is not subsisting.

The average dust concentration about the mechanized operations was 80 particles per c.c. of air.

Remarks (Cont'd.)

To prevent odorous diesel fumes from the mechanized operations from entering the north end mining section fresh air circuit the door along 4251 D.S. between 42179 XCE and 4267 XCW should be installed and kept in a closed position. This would allow the exhaust air from 4250 ramp development to flow to either No. 31 shaft exhaust airway or down 3900 ramp and thus to No. 39 shaft exhaust airway.

The rules governing ventilating air are quite clearly defined in MRA Rules 85, 86, 87, 88 and 93 as indicated in Rule 88 (c) the return air from all working places shall be routed as directly as possible to the return airway. When using diesel powered equipment this is especially important to avoid fresh air contamination.

S. Elias, P. Eng.
Senior Inspector
Environmental Control

January 25, 1977

DEPARTMENT OF MINES
AND PETROLEUM RESOURCES

REPORT OF INSPECTOR OF MINES

(Issued pursuant to sections 6 and 7 of the Mines Regulation Act.)

ENVIRONMENTAL CONTROL

Name of property Sullivan Mine Locality Kimberley

Owner or operator Cominco Limited

Manager Mr. R. Trenamen Address P.O. Box 2000
Kimberley, B. C.

Portions inspected and conditions found: Mechanized Operations

	No. of particles per c. c. of air
Mechanized operations	80

Remarks: No diesel powered equipment shall be operated in any area where the ventilation requirements, as per permit, is not subsisting.

The return air from all working places shall be routed as directly as possible to the return air way to prevent contamination of fresh air by dust and/or gases.

Certificates of fitness, either temporary or annual, must be obtained before a man works underground or in any of the other specified categories of work which require such a certificate. Temporary certificates are good for two months. Annual certificates are good for a period of one year.

Number of workmen that have the required certificates of fitness -

Number of workmen that do not have the required certificates of fitness -

The following workmen require certificates of fitness:

S Elias

S. Elias, Senior Inspector, Environmental Control.
P. Eng

MINISTRY OF MINES AND PETROLEUM RESOURCES
103-2747 E. HASTINGS STREET
VANCOUVER, B.C. V5K 1Z8
(Address.)

e of inspection January 19, 1977.

APPENDIX 6D

Endako Mines Limited
235
November 21-22, 1973

NOTES REGARDING
MOLYBDENUM-DRYER, ROASTER AND CANNING AREAS
ENDAKO MINES LIMITED - ENDAKO, B. C.

S. Elias
Senior Inspector
Environmental Control

November 21-22, 1973

NOTES REGARDING

MOLYBDENUM-DRYER, ROASTER AND CANNING AREAS

ENDAKO MINES LIMITED - ENDAKO, B. C.

During November 21 and 22, 1973 samples were taken to evaluate the dust and gas conditions about the molybdenum dryer, roaster and canning areas. The Monetaire personal respirable dust samplers were used to ascertain the dust concentrations and the "Drager" tester was used to evaluate the SO_2 concentrations.

The Threshold Limit Value (TLV) adopted by the American Conference of Governmental Industrial Hygienists for the above tests are as follows:

Molybdenum as MO	Soluble Compounds	- 5 mg/m^3
	Insoluble Compounds	- 10 mg/m^3
Sulphur Dioxide - SO_2		- 5 ppm (approx. 13 mg/m^3)

Roasters

The roaster in use is a Nichols Herreshoff Multiple Hearth Furnace with 12 hearths. The multiple-hearth roaster is a cylindrical vessel divided from top to bottom by horizonal hearths. Each hearth has either one or several drop holes leading to the hearth below, with drop holes located alternately on the inner and outer peripheries of successive hearths. A central, rotating steel column extends vertically through the center of the roaster. On each hearth, arms equipped with rabbles are fixed to the rotating central shaft. Feed is dropped onto the top hearth near the central shaft and rabbled to the outside of the hearth, where it falls through the drop holes to the hearth below. The rabbles on this hearth push the feed towards the central column, the feed drops to the next hearth, and so forth until feed exits at the bottom hearth. Heat is introduced to start the roasting operation. Air introduced at the bottom of the roaster passes up through the heated chambers, and the oxygen in the air stream reacts with the molybdenum and sulfur in the feed to liberate heat, which helps to sustain the roasters' hearth temperature. The gases leaving the roaster are passed through a precipitator before being discharged to the atmosphere via a stack. The SO_2 emmission via the stack will vary directly with the feed ratio. At the time of inspection the feed was approximately 35.6 tons molybdenum concentrate per 24 hour day. The operators are required to ensure that the proper temperature is maintained in the roaster and to clean the drop holes and rabbles

- - - 2

Roaster - Cont'd.

with steel cleaning tools. This means that the doors at each hearth elevation must be opened for inspection and cleaning as necessary. The workmen spend approximately equal time at work and rest. The samples taken represent a full shift exposure.

The roaster operations were considered normal by the operators during the sampling periods. It was noted that some roaster gases would issue from No. 1 hearth door vents when the hearth doors on the lower elevations (from the 7th hearth upward or when more than one hearth door was open at one time) were open to inspect operational function. During this period no workmen were at the elevation (No. 1 hearth) from which the gases were issuing. Fans on blowing duty are located in window frames on the two upper floors of the plant to provide fresh air to No. 1 hearth elevation areas. The air in the building is naturally up draft due to the heat from the roaster and dryer. There are a number of ventilation louvres in the upper wall elevations to allow heat and any gases to escape to the outside atmosphere.

Dryer

Molybdenum sulfides are dried in a Nichols Herreshoff Multiple Hearth Furnace as has been previously described above. The Molybdenum sulfides are dried before canning. The moisture in the sulfides is controlled to avoid excessive dust at canning operations.

Dust Concentrations

		Milligrams per Cubic Meter
Molybdenum roasters all floors - day shift, feed rate 35.6 tons per day.	Nov. 21/73	0.56
	Nov. 22/73	0.70
Molybdenum dryers all floors - day shift	Nov. 21/73	0.93
	Nov. 22/73	1.04
Molybdenum canning area sulfide section - 109 drums	Nov. 21/73	0.38
sulfide section - 182 drums	Nov. 22/73	0.87

- - - 3

Dust Concentrations - Cont'd.

		Milligrams per Cubic Meter
Molybdenum canning area oxide section - 112 drums	- Nov. 21/73	1.90
oxide section - approx. 1400 lbs. of briquettes	Nov. 22/73	0.52

Sulphur Dioxide Concentrations (SO_2) by "Drager"

		Parts of gas per million Parts of air by volume (ppm
Nov. 21/73 -	Day Shift Top of roaster at feed conveyor	
	Start of shift	0.5
	Middle of shift	TR.
	Near end of shift	TR.
	At various hearth elevations while operator was cleaning and inspection operations - hearth door open; these samples were taken at five locations - no gas (SO_2) was evident at any time.	Nil
Nov. 22/73 -	Day Shift Top of roaster at feed conveyor	
	Start of shift	1.0
	Near end of shift	TR.
	Tests were taken at various hearth Elevations while cleaning and inspection operations, the hearth doors were open; none of these tests gave any indication of SO_2 - five such tests were taken.	Nil

The gas that is most prevalent in sulfide roasting and drying operations is (SO_2) sulphur dioxide. Test for NO + NO_2 and CO are also made in the plant. The results of these tests (NO + NO_2 and CO) were all negative. It is therefore concluded that no additive effects are evident from the above gases.

S. Elias
Senior Inspector
Environmental Control.

November 27, 1973
SE:jt

DEPARTMENT OF MINES
AND PETROLEUM RESOURCES

REPORT OF INSPECTOR OF MINES

(Issued pursuant to sections 6 and 7 of the Mines Regulation Act.)

ENVIRONMENTAL CONTROL

Name of property ENDAKO Locality Endako

Owner or operator Endako Mines Limited

Manager Mr. J. D. Wright Address Endako, B. C.

Portions inspected and conditions found: **Roaster, Dryer and Canning Areas.**

Dust Concentrations:		Milligrams per Cubic Meter
Molybdenum roasters all floors day shift, feed rate 35.6 tons per day.	- Nov. 21/73	0.56
	Nov. 22/73	0.70
Molybdenum dryers all floors day shift	- Nov. 21/73	0.93
	Nov. 22/73	1.04
Remarks: Molybdenum canning area sulfide section - 109 drums	- Nov. 21/73	0.38
sulfide section - 182 drums	Nov. 22/73	0.87
Molybdenum canning area oxide section - 112 drums	- Nov. 21/73	1.90
oxide section - approx. 1400 lbs. of briquettes	Nov. 22/73	0.52

(Continued on Page 2)

Certificates of fitness, either temporary or annual, must be obtained before a man works underground or in any of the other specified categories of work which require such a certificate. Temporary certificates are good for two months. Annual certificates are good for a period of one year.

Number of workmen that have the required certificates of fitness

Number of workmen that do not have the required certificates of fitness

The following workmen require certificates of fitness:

S. Elias, Senior Inspector, Environmental Control.

B. C. DEPT. OF MINES & PETROLEUM RESOURCES
320-890 WEST PENDER STREET
VANCOUVER 1, B. C.
(Address.)

Date of inspection November 21-22, 1973

REPORT OF INSPECTOR OF MINES - ENVIRONMENTAL CONTROL (Cont'd.)

Sulphur Dioxide Concentrations (SO_2) by "Drager"

	Parts of gas per million Parts of air by volume (ppm)
Nov. 21/73 - Day Shift	
Top of roaster at feed conveyor	
Start of shift	0.5
Middle of shift	TR.
Near end of shift	TR.
At various hearth elevations while operator was cleaning and inspection operations - hearth door open; these samples were taken at five locations - no gas (SO_2) was evident at any time.	Nil
Nov. 22/73 - Day shift	
Top of roaster at feed conveyor	
Start of shift	1.0
Near end of shift	TR.
Tests were taken at various hearth elevations while cleaning and inspection operations, the hearth doors were open; none of these tests gave any indication of SO_2 - five such tests were taken.	Nil

The gas that is most prevalent in sulfide roasting and drying operations is (SO_2) sulphur dioxide. Test for NO + NO_2 and CO are also made in the plant. The results of these tests (NO + NO_2 and CO) were all negative. It is therefore concluded that no additive effects are evident from the above gases.

S. Elias, Senior Inspector
Environmental Control.

November 21-22. 1973

APPENDIX 6E

FIELD TEST OF SIEBE GORMAN AERORLOX LIQUID OXYGEN BREATHING APPARATUS FOR ASBESTOS FIBRE CONCENTRATION

S. Elias, P. Eng.
Senior Inspector
Environmental Control

FIELD TEST OF SIEBE GORMAN AERORLOX LIQUID OXYGEN BREATHING APPARATUS FOR ASBESTOS FIBRE CONCENTRATION

Introduction

This report briefly describes a number of tests used to determine whether the asbestos wool which is used to absorb the liquid oxygen in the evaporator is contaminating the breathing air of the Siebe Gorman Aerorlox Liquid Oxygen breathing apparatus used by the British Columbia Ministry of Mines and Petroleum Resources in mine rescue training, competitions and work.

Findings

The conclusion reached from the sampling results is that there is no health hazard in the use of the Aerorlox Liquid Oxygen Breathing Apparatus due to asbestos fibre contamination for the purpose that the equipment is designed.

Aerorlox Liquid Oxygen Breathing Apparatus

The "Aerorlox" is a two (three) hour, closed circuit liquid oxygen breathing apparatus which provides cool, dry air even when being used in a hot environment. Breathing resistance is so low that it is hardly noticeable under heavy work conditions. The rated duration of the "Aerorlox" is two (three) hours at hard work rate and a 2.5 kg charge of liquid oxygen. As the work rate decreases so the duration increases.

The apparatus is housed in a fibre glass case which protects breathing bag, liquid oxygen pack and absorbent canister and carried by a rucksack-type harness which ensures comfort in wear and quick-release action when adjusting or removing.

Technical Data

Weight of apparatus with liquid oxygen	14.1 kg
Dimensions - length	49.5 cm
- width	38.1 cm
- depth	15.9 cm
Liquid oxygen charge	2.5 kg
Absorbent charge (Soda-lime)	1.6 kg
Oxygen flow rate	6 - 12 l/min.

The Breathing Circuit

(a) The warm saturated air that is breathed out passes from the face piece through the exhalation valve housed in it towards the absorbent canister along the corregated tube.

(b) Any excess air present in the breathing circuit over 2 cm water gauge passes through the relief valve and escapes from the apparatus.

(c) The bulk of the exhaled air passes through the radial flow soda-lime canister which absorbes carbon dioxide.

(d) The purified air passes over one end of the liquid oxygen pack into the breathing bag.

(e) This cools the air and condenses the moisture which collects in the breathing bag.

(f) The heat from the purified air surrounding the liquid oxygen pack stimulates the evaporation of oxygen. The oxygen gas passes from the innermost container to and fro through the outer cases and by doing so slows down heat input to the liquid oxygen. As the cool gaseous oxygen flows out of the evaporating tube it mixes with the purified air in the breathing bag, reducing further the air temperature and condensing more of the moisture.

(g) Oxygen enriched air from the breathing bag passes over the liquid oxygen pack between the baffles to increase its path and in the process is further cooled.

(h) The now cool, fresh, dry air passes along the breathing tube and through the inspiratory valve into the face piece as the next breath is taken.

Sampling Apparatus

An in line sample holder (Monitor type) was manufactured using the following method and materials:- a 15 cm long clear acrylic extruded tube with inside diameter 6.5 cm and outside diameter 7.5 cm was used as the main cylindrical body. The base and cap were made of double thickness 7 mm thick clear acrylic sheeting, one thickness of each the base and cap to fit the inside and outside diameter of the cylinder respectively were glued together. The base was glued solidly into the cylinder to form a light seal. The cap was equipped with an

Sampling Apparatus (Cont'd.)

O-ring seal and closing clasps to facilitate accessibility.

The outlet and inlet from the base and cap respectively were made of 3.3 cm diameter nickel plated brass thin wall pipe. A brass "T" type fitting, adapted to accept a monitor type filter cassette, with copper tubing leading to the outside of the cylinder was mounted centrally 8 cm from the inlet end of the cylinder. The copper tube connection affords a means by which an air sample may be collected with the monitor type filter cassette with a pump and hose connection.

The sampling assembly was installed inline in the inhalation breathing tube, with hose clamps, between the face piece and outlet of the liquid oxygen evaporator.

A Millipore Aerosol type MAWG037AO filter with a 0.8 micron pore size was used to collect the samples. A battery operated M.S.A. Monitair pump calibrated at 2 litres per minute air flow with an American Wet (type) test meter was used to draw the sample through the filter.

Results of Sampling

Sample Number	Machine Number	Liquid O_2 Charged (kg)	Time Sampled (min)	Corrected Volume Sampled (liters)	Number of Fields Counted	Number of Fibers	Concentration Fibers per Milliliter
1	4	1.13	106	229	400	0	0
2	5	1.13	110	238	400	0	0
3	spare	1.36	120	259	400	1	0.00198
4	7 9 11	1.36 2.49 1.59	360	777	400	1	0.00066

Four blanks were counted, 400 field in each blank, the average fiber count per blank was 0.25 fiber. The result f/ml have been corrected.

Test Procedures

1. The pump batteries were fully charged.
2. Flow rates of the pumps were measured before and after the sampling procedure with an American Wet (type) test meter. The pumps were operated at approximately 2 litres per minute.
3. The "Aerorlox" soda-lime canister was charged, positioned and checked for tightness and correct positioning.
4. The Aerorlox was charged with 1.2 kg of liquid oxygen using a weighing scale.
5. The apparatus was then assembled in the fibre glass case and fitted to the wearer.
6. The sample pump was started and the time noted at the start and finish of each sampling period.
7. Six Aerorlox units were sampled for approximately a two hour period each.
8. Four filter samples were obtained. Three of individual machines; each for approximately 2 hours and One a composit filter sample of three sampling periods of two hours each with three different Aerorlox machines.
9. The filter samples were assessed using the U.S. Department of Health, Education and Welfare Membrane Filter Method for Evaluating Air Borne Asbestos Dust.
10. Four blank filters were assessed using the method in item #9 for control purposes.

Conclusions

During eleven hours and thirty six minutes of sampling time a total of 1503 liters of air was sampled. The fibre count on all samples combined was two fibers.

Four blanks were counted to eliminate the error or background contaminations. The fibre count was one fibre in the four blanks combined.

This indicates that in 1503 liters of air sampled one fiber was counted if the background error is subtracted. The fiber concentration would therefore be 0.00046 fibers per milliliter for the cambined sampling period.

Conclusions (Cont'd.)

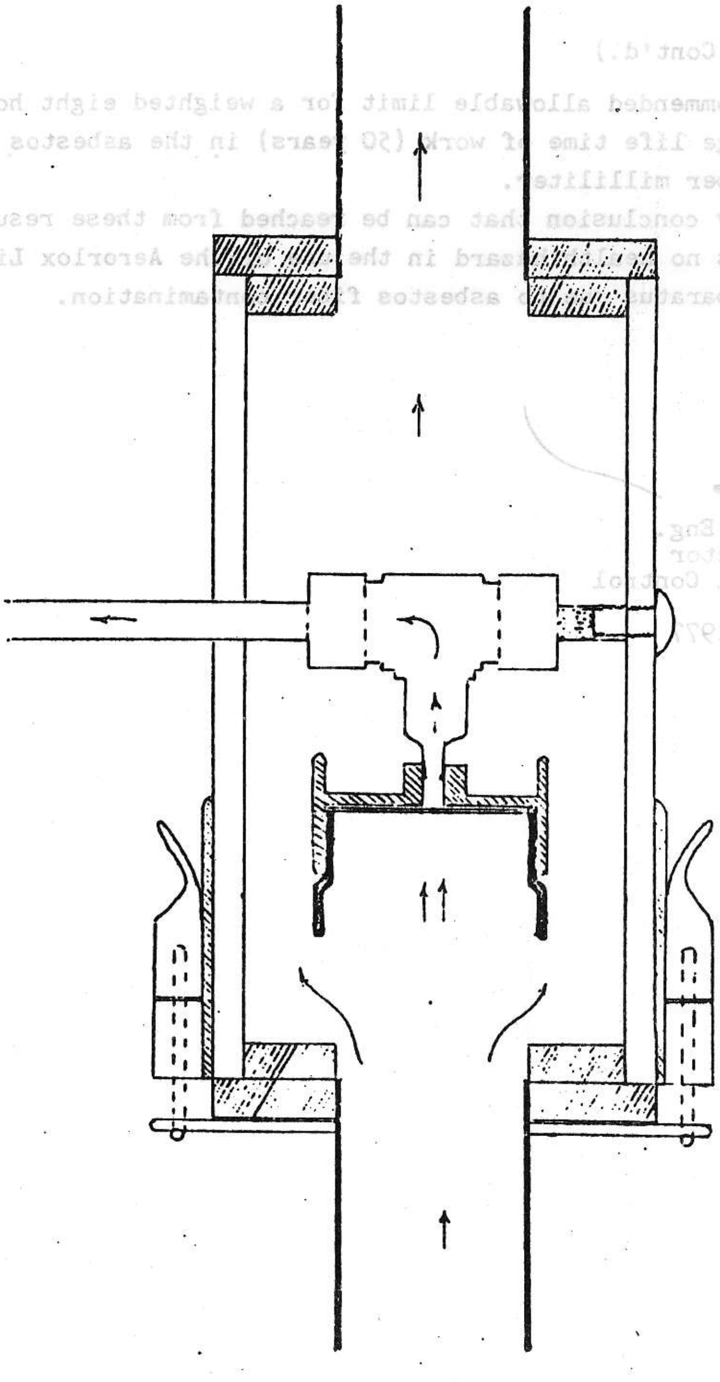
The recommended allowable limit for a weighted eight hour exposure for an average life time of work (50 years) in the asbestos industry is 2 fibres per milliliter.

The only conclusion that can be reached from these results is that there is no health hazard in the use of the Aerorlox Liquid Oxygen Breathing Apparatus due to asbestos fiber contamination.

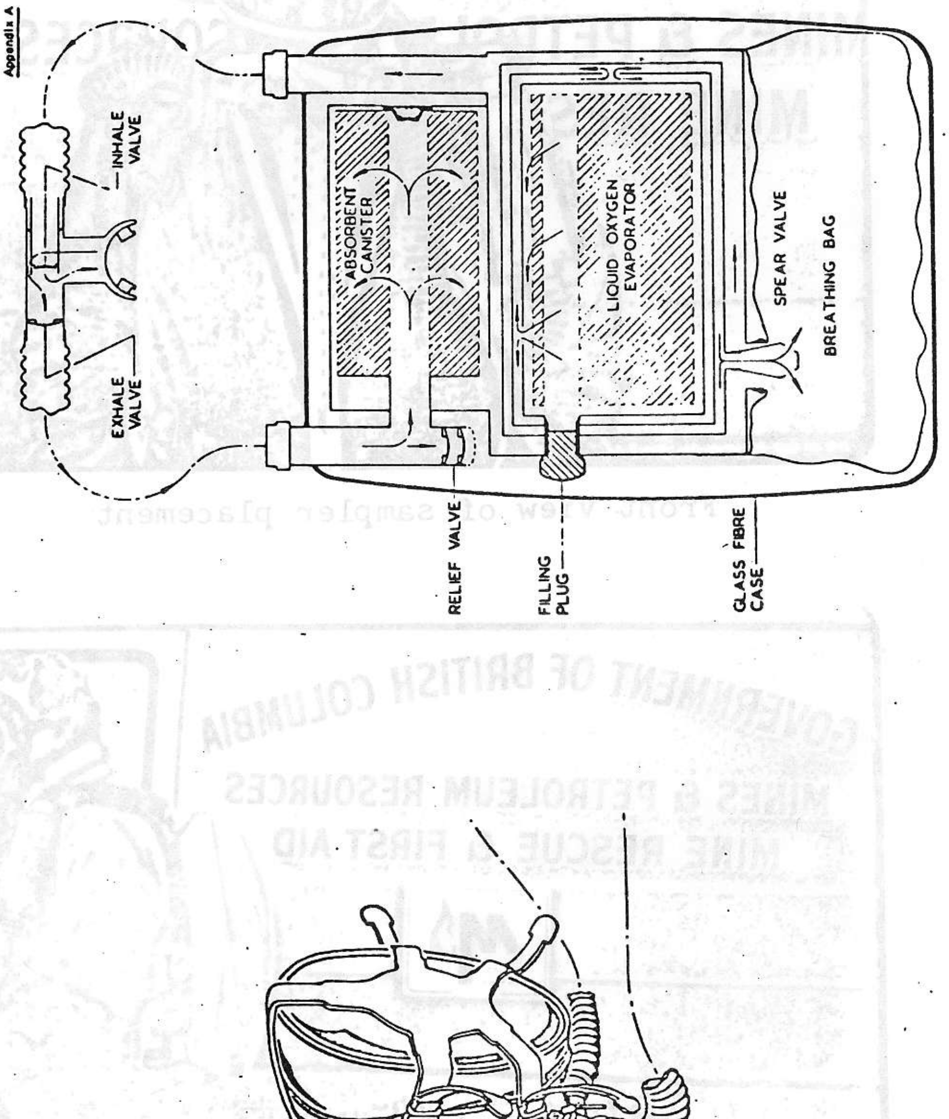
S. Elias

S. Elias, P. Eng.
Senior Inspector
Environmental Control

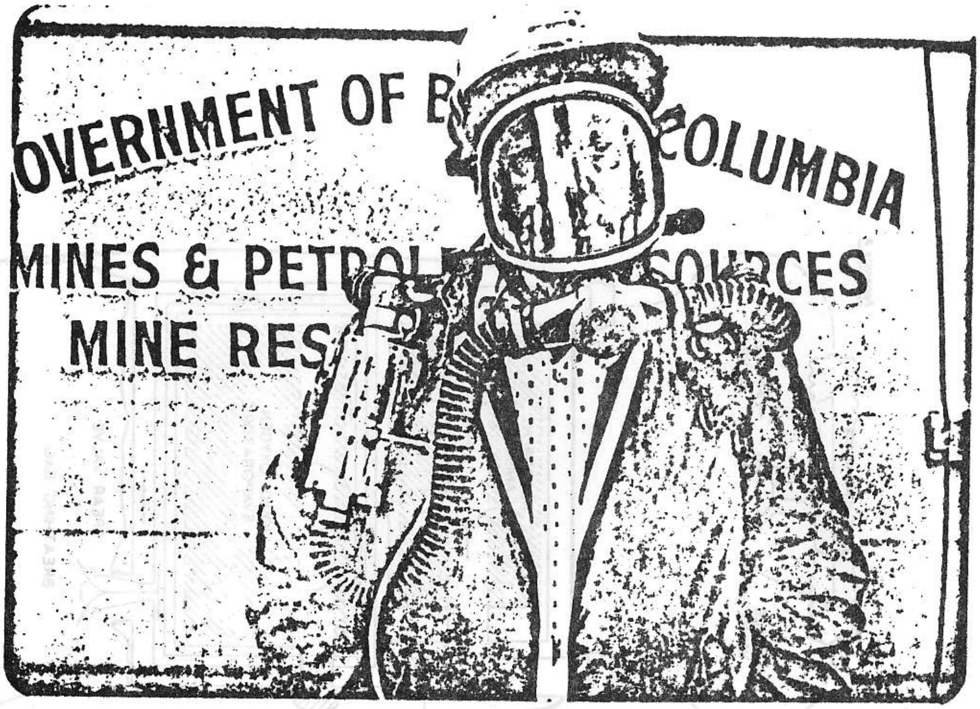
January 27, 1977



Schematic Drawing Of Inline Sampler

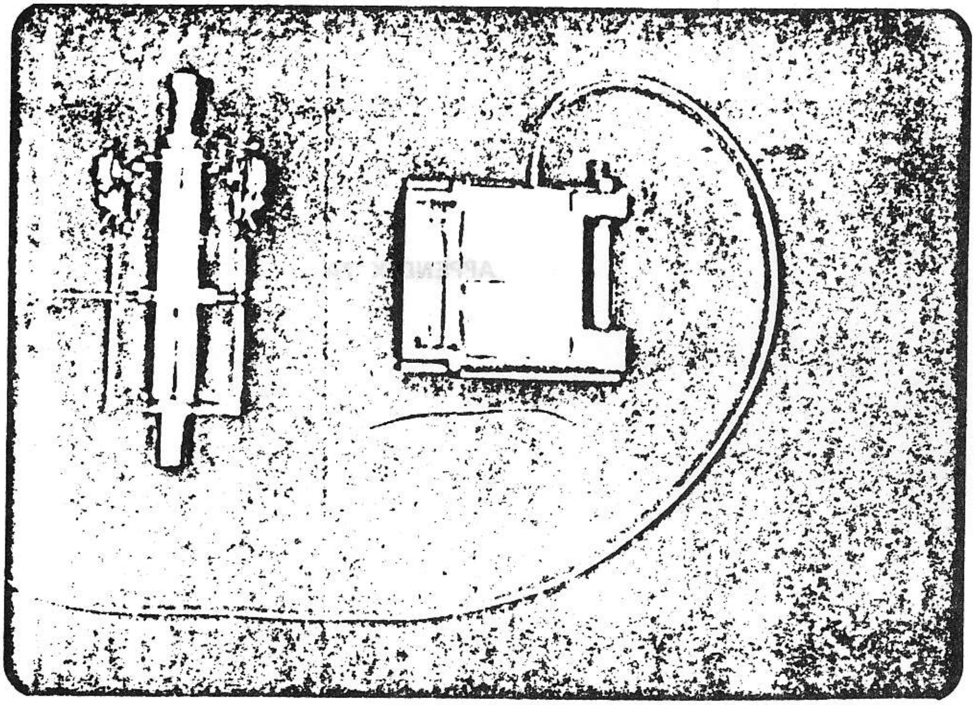


Schematic Drawing "Aerorlox"

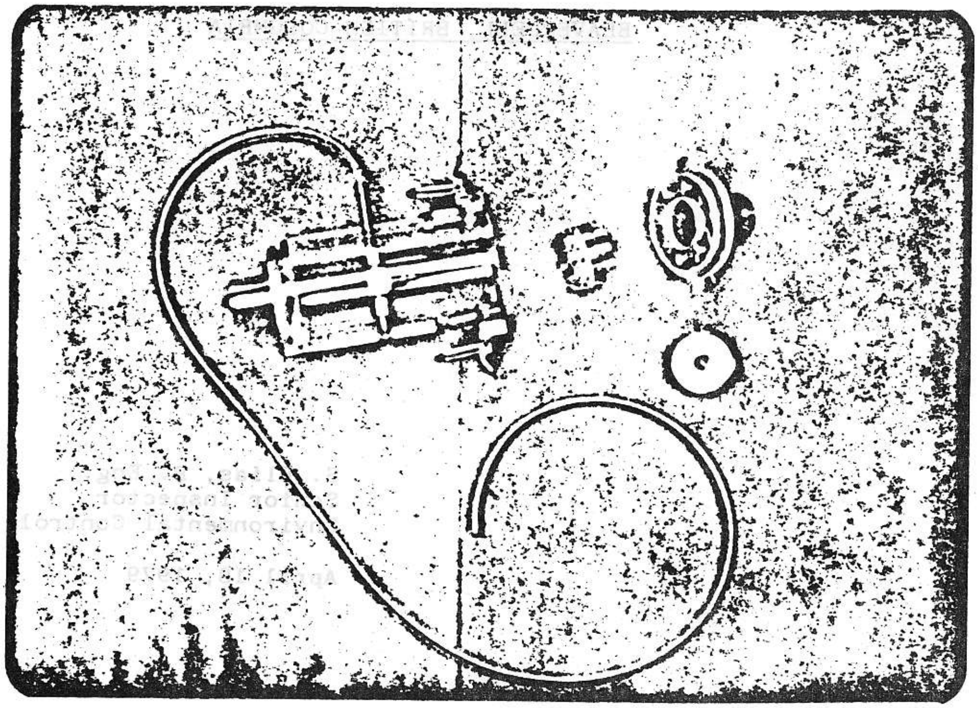


Front view of sampler placement

Side view of sampler placement



Sampler with pump assembly



View showing accessibility of filter

APPENDIX 7A

RADIATION SURVEY OF
P.N.C. EXPLORATIONS (CANADA) LIMITED
BEAVERDELL, BRITISH COLUMBIA

S. Elias, P. Eng.
Senior Inspector
Environmental Control

April 18, 1979

RADIATION SURVEY OF

P.N.C. EXPLORATIONS (CANADA) LIMITED

BEAVERDELL, BRITISH COLUMBIA

In the company with Wayne Bulmer, geologist and Takeo Obara, Mining Engineer for P.N.C. Explorations (Canada) Limited a radiation survey was made about the Cup Lake Lat. 49°35' Long. 118°53' property drill holes and core storage area. The equipment used was as follows:

Air samples were taken with an H & H Custom Work diaphram air pump with pulsation damper. The pump was calibrated at a flow rate of 8.8 liters per minute using a wet test meter. A Sartorius membrane filter, 25 mm in diameter with a 0.8 micron pore size was used to collect the sample. A ten minute sample was collected at each location. A Tri-Met Instruments Ltd., Model TM372A alpha counter equipped with a foil type open zinc sulphide detector was used to evaluate the radiation level. A certified AM-241 alpha standard was used to calibrate the Tri-Met alpha counter before and after the sampling project.

A Ludlum Model 19 Micro R meter, with an internally mounted 1" x 1" Na(Tl) scintillator to give optimum performance in counting low level gamma radiation provided with five ranges 0-25 Micro R/hr as the most sensitive and 0-5000 Micro R/hr on the highest range, was used to assess gamma radiation levels.

Following are the results of the survey:

Location	W.L. Radon Daughters	Micro R/hr Gamma Radiation
Open core box rack near storage shed	0.0005	10
Diamond drill hole No. 111, 47.6 m deep	0.0008	5
Diamond drill hole No. 110 in drill shack	0.0007	5
Diamond drill hole No. 107	0.0005	5
Background along roadway, at campsite	0.0005	6

Remarks

The company is engaged in an exploration diamond drilling program on the Cup Lake Lat. 49°35' Long. 118°53' property. The drilling contractor is Cameron McCutcheon Drilling Ltd., Vancouver, B. C. A Longyear Super 38 diamond drill was being used to drill. The drill was housed in drill shack approximately 4 meters square. The daily diamond drill was located in the drill shack. A Boyles 35A diamond drill was in the process of being set up in preparation to drill the

Remarks (Cont'd.)

next hole. The holes were being drilled in an unconsolidated conglomerate type of overburden.

The diamond drill core storage area at the campsite was an open air rack stationed beside a storage building.

The present program for sealing diamond drill holes is as follows:

All radioactive holes will be sealed with cement. (ie over 1000 cpm)

A. 1. If collared in basalt - plug the top with cement.
   2. If collared in overburden - then drilled into basalt below, plug with cement as far down as basalt.
   3. If drilled all the way in overburden fill with cement from bottom to top.

B. If hole is non-radioactive they intend to:-
   1. If in basalt leave open.
   2. If in overburden then basalt, let it cave in.
   3. If in overburden all the way, let it cave in.

C. If hole is producing water whether radioactive or not they will be treated as radioactive holes and plugged as in "A" above.

The company is requested to initiate a Radiation Dosimetry program using the Film Monitoring for measuring personal exposure to Gamma (Beta) radiation.

S. Elias

S. Elias, P. Eng.
Senior Inspector
Environmental Control

April 26, 1979

APPENDIX 7B

RADIATION SURVEY OF
NORCEN ENERGY RESOURCES LIMITED
BLIZZARD PROPERTY
BEAVERDELL, BRITISH COLUMBIA

S. Elias, P. Eng.
Senior Inspector
Environmental Control

April 18 and 19, 1979

RADIATION SURVEY OF

NORCEN ENERGY RESOURCES LIMITED

BLIZZARD PROPERTY

BEAVERDELL, BRITISH COLUMBIA

In the company with Jim Chapman, geologist and/or Eugene Larabie, manager at property for Norcen Energy Resources Limited a radiation survey was made about the Lassie Lake area drill holes and core storage area. The equipment used was as follows:

Air samples were taken with an H & H Custom Work diaphram air pump with pulsation damper. The pump was calibrated at a flow rate of 8.8 liters per minute using a wet test meter. A Sartorius membrane filter, 25 mm in diameter with a 0.8 micron pore size was used to collect the sample. A ten minute sample was collected at each location. A Tri-Met Instruments Ltd., Model TM372A alpha counter equipped with a foil type open zinc sulphide detector was used to evaluate the radiation level. A certified AM-241 alpha standard was used to calibrate the Tri-Met alpha counter before and after the sampling project.

A Ludlum Model 19 Micro R meter, with an internally mounted 1" x 1" Na(T1) scintillator to give optimum performance in counting low level gamma radiation provided with five ranges 0-25 Micro R/hr as the most sensitive and 0-5000 Micro R/hr on the highest range, was used to assess gamma radiation levels.

Following are the results of the survey:

Location	W.L. Radon Daughters	Micro R/hr Gamma Radiation
Gate Claim south center boundary of claim on roadway Percussion hole No. S.5 10 meters deep	0.0008	7
Gate Claim south center boundary of claim on roadway Percussion hole No. S.6 10 meters deep	0.0008	7
Gate Claim south center boundary of claim on roadway Percussion hole No. S.7 10 meters deep	0.001	7
Diamond drill core storage building at No. 23	0.011	15
Diamond drill core storage building at No. 24	0.013	100
Diamond drill core storage building at No. 26	0.010	15

Location	W.L. Radon Daughters	Micro R/hr Gamma Radiation
Background along roadway to property	0.0005	6

Gamma Radiation Survey about Diamond Drill Storage Building.

Location (see figure I)	Micro R/hr
No. 1	8
No. 2	22
No. 3	11
No. 4	7
No. 5	7
No. 6	9
No. 7	7
No. 8	7
No. 9	6
No. 10	5
No. 11	9
No. 12	6
No. 13	5
No. 14	5
No. 15	7
No. 16	5
No. 17	7
No. 18	7
No. 19	8
No. 20	50
No. 21	7
No. 22	11
No. 23	15
No. 24	100
No. 25	12
No. 26	15
No. 27	28
No. 28	90

Remarks

The company had stopped the drilling program until more favorable weather conditions will allow movement of drilling equipment.

All the diamond drill holes had been cemented. The drill holes that were tested were percussion holes drilled to a depth of 10 meters in overburden. The tests were taken at the collar of the hole in such a manner as to draw the sample from the drill hole proper without sealing the top. Water could be seen in all of the holes.

The diamond drill core storage building is of metal construction and is equipped with a man door, a large service door and roof ventilators. The diamond drill core boxes are stacked approximately 3 meters in height as illustrated in figure I. A work table was also located

Remarks (Cont'd.)

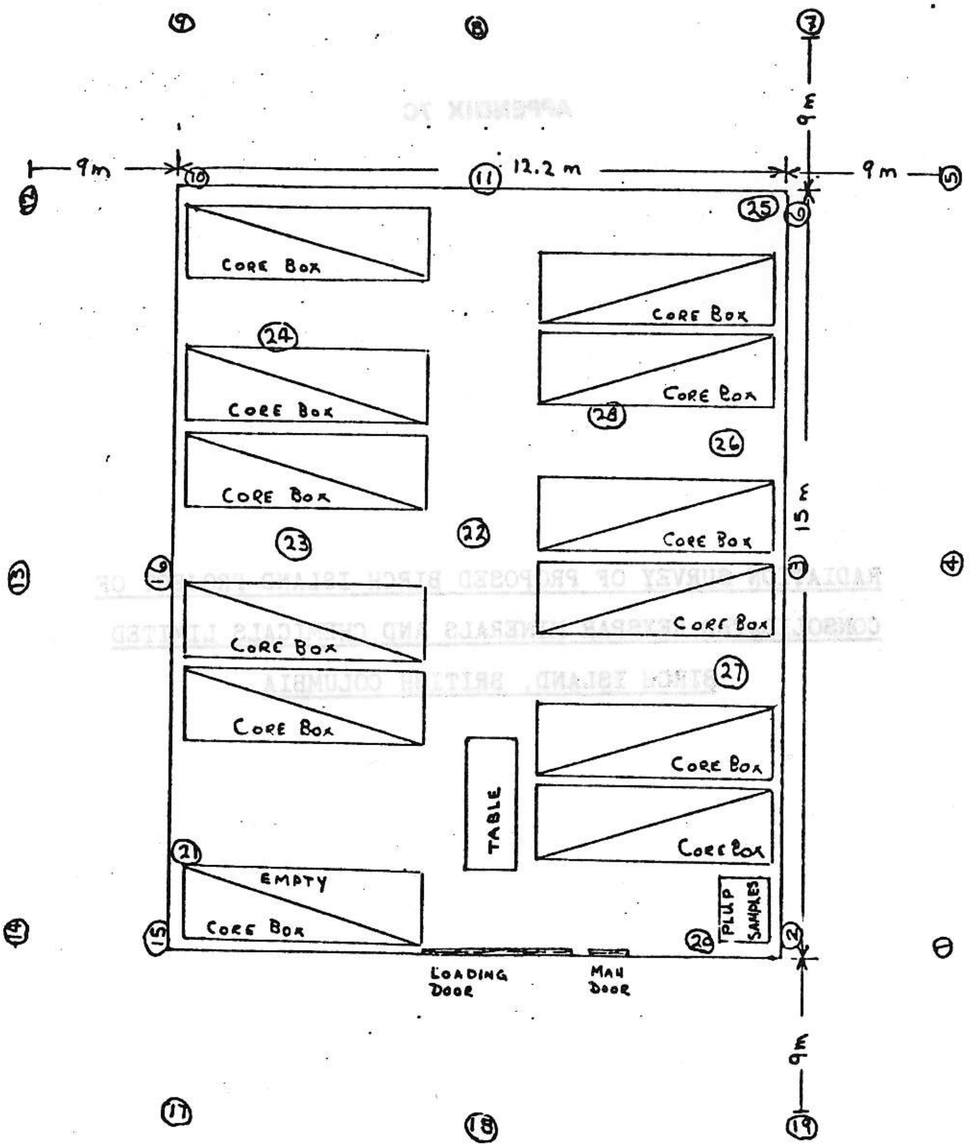
in the core storage area. A truck load of pulp samples and core samples being returned from the analysis laboratory was in the process of being moved into the storage building. A measurement taken in the truck was found to be 50 Micro R/hr gamma radiation.

A sign on the core storage building read as follows, "Uranium Bearing Drill Cores Radiation Level Less Than Ten (10) Micro-Rem per Hour".

The workers about the property are enrolled in the Radiation Dosimetry Film monitoring service of the A.E.C.B.

S. Elias, P. Eng.
Senior Inspector
Environmental Control

April 25, 1979



SCHEMATIC DIAGRAM SHOWING SAMPLE LOCATION OF GAMMA RADIATION AT NORCEN D.D. CORE STORAGE

FIGURE I

APPENDIX 7C

RADIATION SURVEY OF PROPOSED BIRCH ISLAND PROJECT OF CONSOLIDATED REXSPAR MINERALS AND CHEMICALS LIMITED BIRCH ISLAND, BRITISH COLUMBIA

Radiation Survey of Proposed Birch Island Project of Consolidated Rexspar Minerals and Chemicals Limited Birch Island, British Columbia

In company with Mr. Ron Ripley and Bert Haywood, residents in the Birch Island area, a radiation survey was made about the proposed Birch Island Project of Consolidated Rexspar Minerals and Chemicals Limited on May 30, 1978. The equipment used was as follows:-

Air samples were taken with a H & H Custom Work diaphram air pump with pulsation damper. The pump was calibrated at a flow rate of 8.8 liters per minute using a wet test meter. A Sarterius membrane filter, 25 mm in diameter with a 0.8 micron pore size was used to collect the sample. A Tri-Met Instruments Ltd., Model TM372A alpha counter equipped with a foil type open zinc sulphide detector was used to evaluate the radiation. A certified AM-241 alpha standard was used to calibrate the instrument before and after the sampling project. The Atomic Energy Control Regulations, Registration SOR/78-58, 16 January, 1978, Schedule 11, Maximum Permissible Doses and Exposures, Table Column II. Any Other Person, limit the radiation exposure in the home or in other non-occupational situations as follows: "the maximum permissible annual average concentration of radon daughters attributable to the operation of a nuclear facility shall be 0.02 W.L. (work level)." There were no concentrations found above this limit in the ambient air about the proposed site.

Following are the results of the survey:-

RADIATION SURVEY OF PROPOSED BIRCH ISLAND PROJECT

MAY 30, 1978

Sample No.	Time of Sample	Time of Reading (Δt)	Sampling Time (Min)	Counting Time (Min)	Number of Counts	Average Count	Location	W.L.
1	10:57	11:47 (50)	15	5	2	1,980	DDH alongside road. Hole caved 18" from collar. Pump sealed to hole.	0.05
2	12:48	1:38 (50)	5	0.1	5	424	10 ft. inside portal. "BD" Zone	1.6
3	1:09	1:59 (50)	10	1 5	1 1	321 1,700	DDH in middle of road 200' above portal. "A" Zone, Pump sealed to hole.	0.06 0.07
4	2:03	2:53 (50)	15	1 5	3 2	104 631	Old log core shack ¼ mile from U/G samples.	0.01 0.02
5	2:21	3:11 (50)	10	1	5	83	10' inside portal of 100' adit 200 yds. from core shack. Old Camp (Silver Mine Adit)	0.02
6	3:02	3:52 (50)	10	1	5	2,844	10' inside portal at top of mountain, access blocked by cave 100' from entrance. "A" Zone	0.56
7	3:27	4:17 (50)	10	1 5	3 1	24 139	DDH 400' above portal at top of mtn. Open hole, pump sealed to hole.	0.005 0.005
8	3:55	4:45 (50)	10	5	2	63	DDH 75-1 S.E. face of mtn. below road. Hole caved 1' down. Pump open to atm.	0.003

Sample No.	Time of Sample	Time of Reading (Δt)	Sampling Time (Min)	Counting Time (Min)	Number of Counts	Average Count	Location	W.L.
9	4:09	4:59 (50)	10	5	1	43	DDH 76-B-2 100' from DDH 75-1. Hole open. Pump open to atm.	0.002
10	4:26	5:16 (50)	15	5	2	39	Within 3 ft. radius of DDH 76-B-2 collar. (3 locations/5 min. each)	0.001
11	4:44	5:34 (50)	15	5	1	32	Within 2 ft. radius of DDH - 75-1. (3 locations/5 min. each)	0.001
12	5:57	6:42 (45)	15	5	1	14	Isolated corner of core shack in proposed tailings pond area.	0.0003
13.	6:15	6:50 (35)	15	5	2	12	Background sample. Open air sample in proposed tailings site	0.0003
14	8:19	9:09 (50)	15	5	3	7	Background sample. Little Fort Hotel parking lot.	0.0002
15	9:55	10:45 (50)	15	5	3	10	Background sample. Sagebrush Motel parking lot - Kamloops.	0.0003
16	-	-	-	5	3	11	Background sample. Blank filter calibration.	

SUMMARY OF BIRCH ISLAND RADIATION SURVEY MAY 30/78

(All Results in Working Levels)

DDH Pump Sealed to Hole	DDH Pump Open to Hole	DDH Vicinity -within 3 ft. of Open DDH	Inside old Core Shacks	Open Air Samples	10 Ft. Inside Accessible Portals
.05	.003	.001	.02	.0003	1.6
.07	.002	.001	.0003	.0002	.02
.005				.0003	.56
AVERAGES					
.04	.0025	.001	.012	.0003	.73

Underground

The adit entrance to the underground workings at the three adit locations had at one time been closed off to prevent inadvertent access by unauthorized persons. The fencing had been partially removed by persons unknown so that entry is possible by any person. This condition must be immediately corrected to prevent access to any of the underground workings by unauthorized persons.

The BD zone underground workings are all dead ends. This means that the only ventilation possible would be by convection due to temperature variance between the mine workings air and the ambient outside atmosphere. This means of air movement decreases in direct ratio with the length of the underground workings and temperature variance between the underground and ambient atmosphere temperature. There would only be minimal air movement from the underground workings proper to the outside atmosphere. The immediate portal area would be flushed by surface breezes. The high underground radon daughter concentrations can be attributed to the minimal air circulation and the long period of underground working dormancy. The radon gas and daughters that reach the outside atmosphere are very quickly diluted by natural air currents to levels well below the established permissible limits.

Following are the results obtained in the BD zone underground workings together with a sketch showing the location of the samples:-

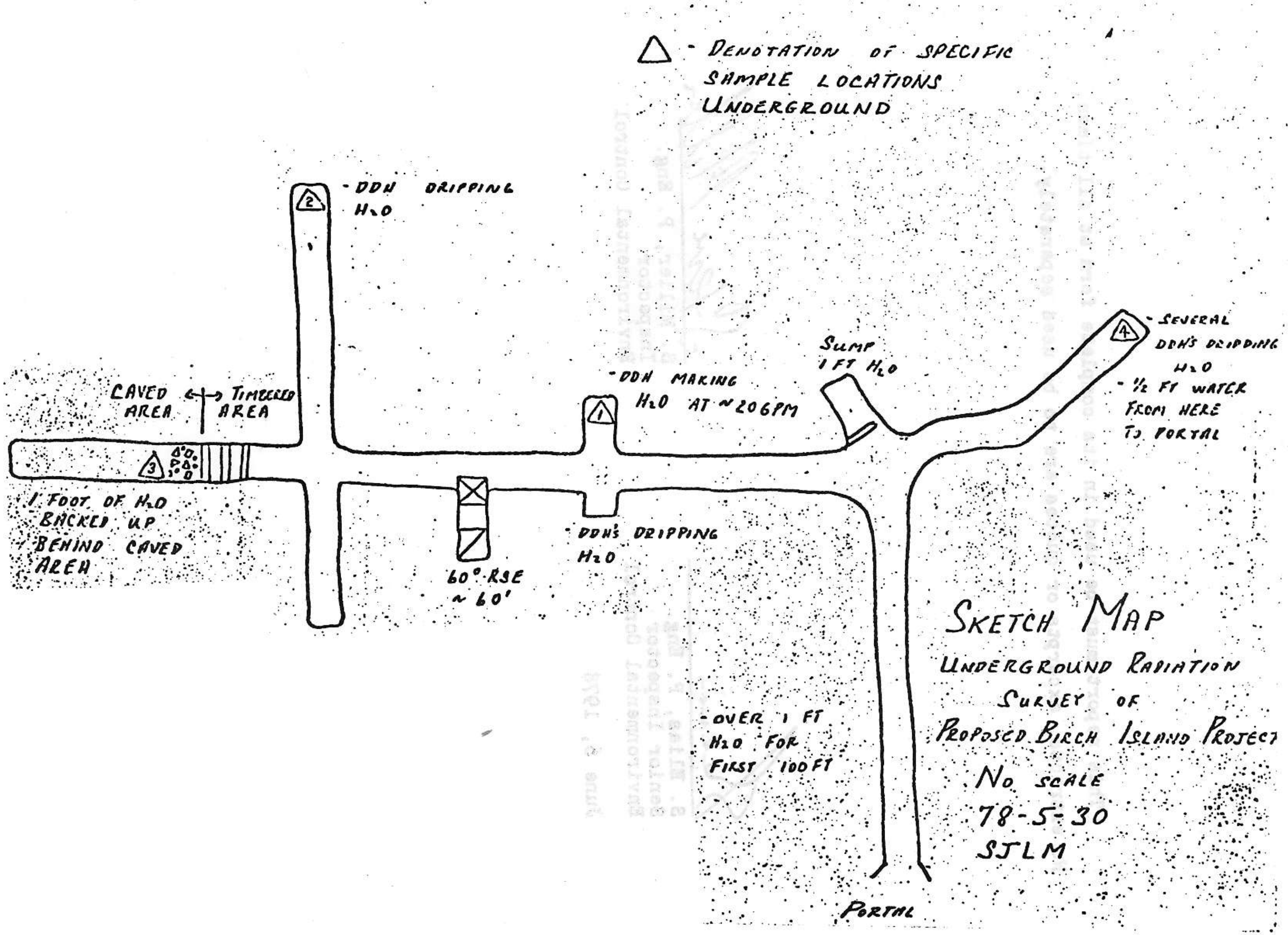
UNDERGROUND SAMPLES

Black Diamond Zone
RADIATION SURVEY OF PROPOSED BIRCH ISLAND PROJECT

MAY 30, 1978

Sample No.	Time of Sample	Time of Reading (Δt)	Sampling Time (Min)	Counting Time (Min)	Number of Counts	Average Count	Location	W.L.
U/G 1	12:04	12:54 (50)	10	0.1	4	46,485	D.D. station 250' from portal. DDH making 20 gpm water.	91
U/G 2	12:15	1:05 (50)	5	0.1	5	43,370	Dead end of crosscut. DDH's dripping water.	168
U/G 3	12:25	1:15 (50)	5	0.1	5	35,380	100' from end of drift. Caved material dams 1 foot of water.	137
U/G 4	12:35	1:25 (50)	5	0.1	5	20,360	End of drift, opposite side of portal, DDH's dripping H_2O.	79
							Average U/G Count	119

Consolidated Rexspar Minerals and Chemicals Limited has been ordered by the District Mines Inspector to effectively close all entrances to the underground workings to protect against inadvertent access by unauthorized personnel as per Section 12 (1) of the Mines Regulation Act.



SKETCH MAP
UNDERGROUND RADIATION SURVEY OF
PROPOSED BIRCH ISLAND PROJECT
NO SCALE
78-5-30
SJLM

This report must be used in its complete form at all times. No extracts, excerpts or quotes are to be used separately.

S. Elias, P. Eng.
Senior Inspector
Environmental Control

June 6, 1978

Steve Miller

S. Miller, P. Eng.
Inspector
Environmental Control

APPENDIX 8A

RADIATION SURVEY OF A NON-URANIUM MINE

ALWIN MINE, OK SYNDICATE

ASHCROFT, BRITISH COLUMBIA

S. Elias, P. Eng.
Senior Inspector
Environmental Control

July 9, 1979

RADIATION SURVEY OF A NON-URANIUM MINE

ALWIN MINE, OK SYNDICATE

ASHCROFT, BRITISH COLUMBIA

A preliminary radiation survey was made to assess the radon daughter and gamma radiation levels about representative work areas and exhaust airways of Alwin Mine, OK Syndicate, Ashcroft, B. C. during July 9, 1979. The equipment used was as follows:

Air samples were taken with an H & H Custom Work diaphram air pump with pulsation damper. The pump was calibrated at a flow rate of 8.8 litres per minute using a wet test meter. A Sartorius membrane filter, 25 mm in diameter with a 0.8 micron pore size was used to collect the sample. A 44.4 litre sample was collected at each location. A Tri-Met Instruments Ltd., Model TM372A alpha counter equipped with a foil type open zinc sulphide detector was used to evaluate the radiation level. A certified AM-241 alpha standard was used to calibrate the Tri-Met alpha counter before and after the sampling project.

A Ludlum Model 19 Micro R meter, with an internally mounted 1" x 1" Na(Tl) scintillator to give optimum performance in counting low level gamma radiation provided with five ranges 0-25 Micro R/hr as the most sensitive and 0-5000 Micro R/hr on the highest range, was used to assess gamma radiation levels.

Following are the results of the survey:

Location	W.L. Radon Daughters	Micro R/hr Gamma Radiation
Outside air at office.	0.0007	7
4980 - 4N crosscut, drilling, 49.7 m^3/min air flow.	0.0010	9
5130 - 41 decline No. 2 access, had been mucking.	0.0015	9
5130 - 50N crosscut, dead end.	0.0015	9
5130 level exhaust air from mine 1934 m^3/min flowing.	0.0016	7

Remarks

A preliminary evaluation was made to assess for the presence of hazardous concentrations of radon daughters and gamma radiation. On a preliminary survey representative headings of different types of workings, poorly ventilated areas and return airways only are sampled. If the preliminary survey does not show measurable concentrations of radon daughters or under 0.10 W.L. it can be assumed that the health hazard does not exist. Should results indicate 0.10 W.L. (work level) more sampling is done to further assess the potential hazard. If the sampling indicates any workers are exposed to an average full shift exposure of more than 0.30 W.L. (work level) enough sampling must be done to indicate individual exposure over a (3) three month period. If exposure exceeds 1 W.L.M. (work level month) over a three month period permanent records must be kept for all workers working in radiation areas of the mine, or until it can be shown that the health hazard no longer exists (less than 0.10 W.L. average exposure). When sampling indicates an inherent radon daughter hazard exists in any mine all standards applied normally to uranium mines shall be considered to be in force.

The radiation levels are well within the present permissible standards that are considered to present no occupational health hazard.

S. Elias, P. Eng.
Senior Inspector
Environmental Control

August 2, 1979

APPENDIX 8B

RADIATION SURVEY OF A NON-URANIUM MINE

CRAIGMONT MINES LIMITED

MERRITT, BRITISH COLUMBIA

S. Elias, P. Eng.
Senior Inspector
Environmental Control

July 10, 1979

RADIATION SURVEY OF A NON-URANIUM MINE

CRAIGMONT MINES LIMITED

MERRITT, BRITISH COLUMBIA

A preliminary radiation survey was made to assess the radon daughter and gamma radiation level about representative work areas and the exhaust airways of the Craigmont Mines Limited, Merritt, British Columbia during July 10, 1979. The equipment used was as follows:

Air samples were taken with an H & H Custom Work diaphram air pump with pulsation damper. The pump was calibrated at a flow rate of 8.8 litres per minute using a wet test meter. A Sartorius membrane filter, 25 mm in diameter with a 0.8 micron pore size was used to collect the sample. A 44.4 litre sample was collected at each location. A Tri-Met Instruments Ltd., Model TM372A alpha counter equipped with a foil type open zinc sulphide detector was used to evaluate the radiation level. A certified AM-241 alpha standard was used to calibrate the Tri-Met alpha counter before and after the sampling project.

A Ludlum Model 19 Micro R meter, with an internally mounted 1" x 1" Na(Tl) scintillator to give optimum performance in counting low level gamma radiation provided with five ranges 0-25 Micro R/hr as the most sensitive and 0-5000 Micro R/hr on the highest range, was used to assess gamma radiation levels.

Following are the results of the survey:

Location	W.L. Radon Daughters	Micro R/hr Gamma Radiation
3500 level exhaust air, NO + NO_2 = Nil (41,000 CFM) outcast 1161.1 m^3/min.	0.0015	8
3060 level exhaust air, NO + NO_2 = Nil (228,000 CFM) outcast 6457 m^3/min.	0.0009	12
2846 PD74 dead end in waste rock NO + NO_2 = 0.5 ppm.	0.0397	14
2780 PD68N in ore.	0.0008	14
2700 HD5 dead end, waste rock.	0.0008	11
2653 PD41 in ore NO + NO_2 = 1.5 ppm.	0.0006	12
2560 PD43 in waste.	0.0005	13
Mill grinding circuit at ball mill discharge.	0.0004	6
Outside air at 2400 elevation portal.	0.0003	10

Remarks

A preliminary evaluation was made to assess for the presence of hazardous concentrations of radon daughters and gamma radiation. On a preliminary survey representative headings of different types of workings, poorly ventilated areas and return airways only are sampled. If the preliminary survey does not show measurable concentrations of radon daughters or under 0.10 W.L. it can be assumed that the health hazard does not exist. Should results indicate 0.10 W.L. (work level) more sampling is done to further assess the potential hazard. If the sampling indicates any workers are exposed to an average full shift exposure of more than 0.30 W.L. (work level) enough sampling must be done to indicate individual exposure over a (3) three month period. If exposure exceeds 1 W.L.M. (work level month) over a three month period permanent records must be kept for all workers working in radiation areas of the mine, or until it can be shown that the health hazard no longer exists (less than 0.10 W.L. average exposure). When sampling indicates an inherent radon daughter hazard exists in any mine all standards applied normally to uranium mines shall be considered to be in force.

The radiation levels are well within the present permissible standards that are considered to present no occupational health hazard.

S. Elias, P. Eng.
Senior Inspector
Environmental Control

August 2, 1979

APPENDIX 8C

RADIATION SURVEY OF A NON-URANIUM MINE

DANKOE MINES LIMITED

KEREMEOS, BRITISH COLUMBIA

S. Elias, P. Eng.
Senior Inspector
Environmental Control

July 11, 1979

RADIATION SURVEY OF A NON-URANIUM MINE

DANKOE MINES LIMITED

KEREMEOS, BRITISH COLUMBIA

A preliminary radiation survey was made to assess the radon and gamma radiation level about representative work areas and the exhaust airways of Dankoe Mines Limited, Keremeos, B. C. during July 11, 1979. The equipment used was as follows:

Air samples were taken with an H & H Custom Work diaphram air pump with pulsation damper. The pump was calibrated at a flow rate of 8.8 litres per minute using a wet test meter. A Sartorius membrane filter, 25 mm in diameter with a 0,8 micron pore size was used to collect the sample. A 44.4 litre sample was collected at each location. A Tri-Met Instruments Ltd., Model TM372A alpha counter equipped with a foil type open zinc sulphide detector was used to evaluate the radiation level. A certified AM-241 alpha standard was used to calibrate the Tri-Met alpha counter before and after the sampling project.

A Ludlum Model 19 Micro R meter, with an internally mounted 1" x 1" Na(Tl) scintillator to give optimum performance in counting low level gamma radiation provided with five ranges 0-25 Micro R/hr as the most sensitive and 0-5000 Micro R/hr on the highest range, was used to assess gamma radiation levels.

Following are the results of the survey:

Location	W.L. Radon Daughters	Micro R/hr Gamma Radiation
26-88/66 stope, ore, blasted night shift, low volume ventilation.	0.0166	32
26-96/63 stope, ore, no blast for several days, low volume ventilation.	0.0109	34
21-10/52 stope dead end heading no ventilation.	0.0103	32
19-10/49 sub ore area.	0.0090	30
1700 level exhaust air.	0.0141	32
2200 level portal outside air.	0.0004	30
Mill grinding circuit at discharge end of ball mill.	0.0008	26
At office building.	0.0007	18

Remarks

A preliminary evaluation was made to assess for the presence of hazardous concentrations of radon daughters and gamma radiation. On a preliminary survey representative headings of different types of workings, poorly ventilated areas and return airways only are sampled. If the preliminary survey does not show measurable concentrations of radon daughters or under 0.10 W.L. it can be assumed that the health hazard does not exist. Should results indicate 0.10 W.L. (work level) more sampling is done to further assess the potential hazard. If the sampling indicates any workers are exposed to an average full shift exposure of more than 0.30 W.L. (work level) enough sampling must be done to indicate individual exposure over a (3) month period. If exposure exceeds 1 W.L.M. (work level month) over a three month period permanent records must be kept for all workers working in radiation areas of the mine, or until it can be shown that the health hazard no longer exists (less than 0.10 W.L. average exposure). When sampling indicates an inherent radon daughter hazard exists in any mine all standards applied normally to uranium mines shall be considered to be in force.

The radiation levels are well within the present permissible standards that are considered to present no occupational health hazard.

S. Elias, P. Eng.
Senior Inspector
Environmental Control

August 1, 1979

APPENDIX 8D

RADIATION SURVEY OF NON-URANIUM MINES

BEAVERDELL MINE

TECK CORPORATION LIMITED

BEAVERDELL, BRITISH COLUMBIA

S. Elias, P. Eng.
Senior Inspector
Environmental Control

July 12, 1979

RADIATION SURVEY OF NON-URANIUM MINES

BEAVERDELL MINE

TECK CORPORATION LIMITED

BEAVERDELL, BRITISH COLUMBIA

A preliminary radiation survey was made to assess the radon daughter and gamma radiation level about representative work areas and the exhaust airways of the Beaverdell Mine, Teck Corporation Ltd., Beaverdell, B. C. during July 12, 1979. The equipment used was as follows:

Air samples were taken with an H & H Custom Work diaphram air pump with pulsation damper. The pump was calibrated at a flow rate of 3.8 litres per minute using a wet test meter. A Sartorius membrane filter, 25 mm in diameter with a 0.8 micron pore size was used to collect the sample. A ten minute sample was collected at each location. A Tri-Met Instruments Ltd., Model TM372A alpha counter equipped with a foil type open zinc sulphide detector was used to evaluate the radiation level. A certified AM-241 alpha standard was used to calibrate the Tri-Met alpha counter before and after the sampling project.

A Ludlum Model 19 Micro R meter, with an internally mounted 1" x 1" Na(T1) scintillator to give optimum performance in counting low level gamma radiation provided with five ranges 0-25 Micro R/hr as the most sensitive and 0-5000 Micro R/hr on the highest range, was used to assess gamma radiation levels.

Following are the results of the survey:

Location	W.L. Radon Daughters	Micro R/hr Gamma Radiation
New Beaver crosscut, at face, had mucked round previous shift, dead end, vent. by fan with duct, fan off.	0.0158	42
New Beaver 01 crosscut, blasted two days previous, will be mucking, dead end, diesel haulage used, must be mechanically ventilated before using diesel.	0.0310	32
Sally, at face of heading, blasted previous dayshift, mucking dry muck, atomizer used ventilation fan & duct, end of duct too far from face (27 meters).	0.0038	38

Location (Cont'd.)	W.L. Radon Daughters	Micro R/hr Gamma Radiation
890 stope, blasted previous day shift, no atomizer used, dead end, will be scraping.	0.0653	46
3800 level (7 level) outcast air from mine.	0.0739	38
3550 level 3561 raise, drilling, dead end, ventilation duct 7 meters from collar of raise, raise advanced 8 meters.	0.0195	36
3550 level outcast air from level.	0.0771	34
3550 level portal area, outside ambient air.	0.0018	17
2905 level stope, dead end, no crew working on 2900 level.	0.0590	38
Mill building at grinding circuit, discharge end of ball mill.	0.0015	16

The exhaust air from 3800 and 3550 level are near the 0.10 W.L. at which point positive action must be taken to lower the radon daughter level to avoid a health hazard. It is strongly suggested that the ventilation be so planned and directed that the shortest distance from outside fresh air be used to supply the working areas to avoid a possible build up of radon and radon daughters in the main ventilation circuits. All headings must be positively ventilated either by a through flow of uncontaminated fresh air or via auxiliary ventilation using prime air. Diesels shall not be used in any heading where permit requirements are not subsistent at all times.

Remarks

A preliminary evaluation was made to assess for the presence of hazardous concentrations of radon daughters and gamma radiation. On a preliminary survey representative headings of different types of workings, poorly ventilated areas and return airways only are sampled. If the preliminary survey does not show measurable concentrations of radon daughters or under 0.10 W.L. it can be assumed assumed that the health hazard does not exist. Should results indicate 0.10 W.L. (work level) more sampling is done to further assess the potential hazard. If the sampling indicates and workers are exposed to an average full shift exposure of more than 0.30 W.L. (work level) enough sampling must be done to indicate individual exposure over a (3) three month period. If exposure exceeds 1 W.L.M. (work level month) over a three month period permanent records must

<u>Remarks</u> (Cont'd.)

be kept for all workers working in radiation areas of the mine, or until it can be shown that the health hazard no longer exists (less than 0.10 W.L. average exposure). When sampling indicates an inherent radon daughter hazard exists in any mine all standards applied normally to uranium mines shall be considered to be in force.

S. Elias, P. Eng.
Senior Inspector
Environmental Control

July 31, 1979

APPENDIX 8E

RADIATION SURVEY OF A NON-URANIUM MINE
INTERNATIONAL MARBLE AND STONE COMPANY LIMITED
SIRDAR, BRITISH COLUMBIA

S. Elias, P. Eng.
Senior Inspector
Environmental Control

July 17, 1979

RADIATION SURVEY OF A NON-URANIUM MINE

INTERNATIONAL MARBLE AND STONE COMPANY LIMITED

SIRDAR, BRITISH COLUMBIA

A preliminary radiation survey was made to assess the radon daughter and gamma radiation levels about representative work areas and exhaust airways of the International Marble and Stone Company Limited underground workings at Kootenay Bay, B. C. during July 17, 1979. The equipment used was as follows:

Air samples were taken with an H & H Custom Work diaphram air pump with pulsation damper. The pump was calibrated at a flow rate of 8.8 litres per minute using a wet test meter. A Sartorius membrane filter, 25 mm in diameter with a 0.8 micron pore size was used to collect the sample. A ten minute sample was collected at each location. A Tri-Met Instruments Ltd., Model TM372A alpha counter equipped with a foil type open zinc sulphide detector was used to evaluate the radiation level. A certified AM-241 alpha standard was used to calibrate the Tri-Met alpha counter before and after the sampling project.

A Ludlum Model 19 Micro R meter, with an internally mounted 1" x 1" Na(Tl) scintillator to give optimum performance in counting low level gamma radiation provided with five ranges 0-25 Micro R/hr as the most sensitive and 0-5000 Micro R/hr on the highest range, was used to assess gamma radiation levels.

Following are the results of the survey:

Location	W.L. Radon Daughters	Micro R/hr Gamma Radiation
South end of underground workings approximately 250 meters from surface, dead end working, large open stope type.	0.0041	7
Near portal entrance to underground general ambient air.	0.0024	7

Remarks

A preliminary evaluation was made to assess for the presence of hazardous concentrations of radon daughters and gamma radiation. On a preliminary survey representative headings of different types of workings, poorly ventilated areas and return airways only are sampled. If the preliminary survey does not show measurable concentrations of radon daughters or under 0.10 W.L. it can be assumed that the health hazard does not exist. Should results indicate 0.10 W.L. (work level) more sampling is done to further assess the potential hazard. If the sampling indicates any workers are exposed to an average full shift exposure of more than 0.30 W.L. (work level)

Remarks (Cont'd.)

enough sampling must be done to indicate individual exposure over a (3) three month period. If exposure exceeds 1 W.L.M. (work level month) over a three month period permanent records must be kept for all workers working in radiation areas of the mine, or until it can be shown that the health hazard no longer exists (less than 0.10 W.L. average exposure). When sampling indicates an inherent radon daughter hazard exists in any mine all standards applied normally to uranium mines shall be considered to be in force.

It would appear that there is no health hazard from radon daughters according to present established permissible standards. The mine is ventilated by mechanical means.

S. Elias, P. Eng.
Senior Inspector
Environmental Control

July 31, 1979

APPENDIX 8F

RADIATION SURVEY OF NON-URANIUM MINES
GOLD BELT MINES INCORPORATED
SALMO, BRITISH COLUMBIA

S. Elias, P. Eng.
Senior Inspector
Environmental Control

July 16, 1979

RADIATION SURVEY OF NON-URANIUM MINES

GOLD BELT MINES INCORPORATED

SALMO, BRITISH COLUMBIA

A preliminary radiation survey was made to assess the radon daughters and gamma radiation level about representative work areas and exhaust airways of Gold Belt Mines Incorporated, Salmo, B. C. during July 16, 1979. The equipment used was as follows:

Air samples were taken with an H & H Custom Work diaphram air pump with pulsation damper. The pump was calibrated at a flow rate of 8.8 litres per minute using a wet test meter. A Sartorius membrane filter, 25 mm in diameter with a 0.8 micron pore size was used to collect the sample. A ten minute sample was collected at each location. A Tri-Met Instruments Ltd., Model TM372A alpha counter equipped with a foil type open zinc sulphide detector was used to evaluate the radiation level. A certified AM-241 alpha standard was used to calibrate the Tri-Met alpha counter before and after the sampling project.

A Ludlum Model 19 Micro R meter, with an internally mounted 1" x 1" Na(Tl) scintillator to give optimum performance in counting low level gamma radiation provided with five ranges 0-25 Micro R/hr as the most sensitive and 0-5000 Micro R/hr on the highest range, was used to assess gamma radiation levels.

Following are the results of the survey:

Location	W.L. Radon Daughters	Micro R/hr Gamma Radiation
1850 level exhaust air from mine 480 m^3/min (16,900 CFM) air flowing.	0.0098	33
1435 W. drift, dead end, quartsite no crew, no ventilation.	0.0158	25
1100 level shaft sta. water down shaft.	0.0738	36
1100 level 41 raise, blasted two days previous, had been mucking wet muck.	0.0767	24
11 level 35 West drift, timber crew, no auxiliary ventilation.	0.0048	24
1850 level near portal, outside ambient air.	0.0007	17

Remarks

A preliminary evaluation was made to assess for the presence of hazardous concentrations of radon daughters and gamma radiation. On a preliminary survey representative headings of different types of workings, poorly ventilated areas and return airways only are sampled. If the preliminary survey does not show measurable concentrations of radon daughters or under 0.10 W.L. it can be assumed that the health hazard does not exist. Should results indicate 0.10 W.L. (work level) more sampling is done to further assess the potential hazard. If the sampling indicates any workers are exposed to an average full shift exposure of more than 0.30 W.L. (work level) enough sampling must be done to indicate individual exposure over a (3) three month period. If exposure exceeds 1 W.L.M. (work level month) over a three month period permanent records must be kept for all workers working in radiation areas of the mine, or until it can be shown that the health hazard no longer exists (less than 0.10 W.L. average exposure). When sampling indicates an inherent radon daughter hazard exists in any mine all standards applied normally to uranium mines shall be considered to be in force.

The mine is ventilated by natural means. Air enters the mine via the upper 600 level and flows downward via No. 2 and No. 1 shaft and is then outcast via 1850 level portal. The mine requires an adequate positive mechanical means of ventilation that will ensure a flow of prime air to all active working headings either by through air flow or auxiliary means.

S. Elias, P. Eng.
Senior Inspector
Environmental Control

July 31, 1979

APPENDIX 8G

RADIATION SURVEY OF NON-URANIUM MINES
SCRANTON PROPERTY, DAVID MINERALS INC.
AINSWORTH, BRITISH COLUMBIA

S. Elias, P. Eng.
Senior Inspector
Environmental Control

July 17, 1979

RADIATION SURVEY OF NON-URANIUM MINES

SCRANTON PROPERTY, DAVID MINERALS INC.

AINSWORTH, BRITISH COLUMBIA

A preliminary radiation survey was made to assess the radon daughters and gamma radiation levels about representative work areas and the exhaust airways of the Scranton Property, David Minerals Inc. Ainsworth, B. C. on July 17, 1979. The equipment used was as follows:

Air samples were taken with an H. & H Custom Work diaphram air pump with pulsation damper. The pump was calibrated at a flow rate of 8.8 litres per minute using a wet test meter. A Sartorius membrane filter, 25 mm in diameter with a 0.8 micron pore size was used to collect the sample. A ten minute sample was collected at each location. A Tri-Met Instruments Ltd., Model TM372A alpha counter equipped with a foil type open zinc sulphide detector was used to evaluate the radiation level. A certified AM-241 alpha standard was used to calibrate the Tri-Met alpha counter before and after the sampling project.

A Ludlum Model 19 Micro R meter, with an internally mounted 1" x 1" Na(Tl) scintillator to give optimum performance in counting low level gamma radiation provided with five ranges 0-25 Micro R/hr as the most sensitive and 0.5000 Micro R/hr on the highest range, was used to assess gamma radiation levels.

Following are the results of the survey:

Location	W.L. Radon Daughters	Micro R/hr Gamma Radiation
5700 level diamond drill cutout, dead end heading, making water, no ventilation.	0.0153	40
5700 level crosscut, at face, mucking wet muck, ventilation via fan & duct from surface.	0.0038	36
5700 level outcast air from mine.	0.0053	26
5700 level near portal, outside ambient air.	0.0020	21

Remarks

A preliminary evaluation was made to assess for the presence of hazardous concentrations of radon daughters and gamma radiation. On a preliminary survey representative headings of different types of workings, poorly ventilated areas and return airways only are sampled. If the preliminary survey does not show measurable concentrations of radon daughters or under 0.10 W.L. it can be assumed that the health hazard does not exist. Should results indicate 0.10 W.L. (work level) more sampling is done to further assess the potential hazard. If the sampling indicates any workers are exposed to an average full shift exposure of more than 0.30 W.L. (work level) enough sampling must be done to indicate individual exposure over a (3) three month period. If exposure exceeds 1 W.L.M. (work level month) over a three month period permanent records must be kept for all workers working in radiation areas of the mine, or until it can be shown that the health hazard no longer exists (less than 0.10 W.L. average exposure). When sampling indicates an inherent radon daughter hazard exists in any mine all standards applied normally to uranium mines shall be considered to be in force.

It would appear that there is no health hazard from radon daughters according to present established permissible limits.

S. Elias

S. Elias, P. Eng.
Senior Inspector
Environmental Control

July 31, 1979

APPENDIX 8H

RADIATION SURVEY OF NON-URANIUM MINES
SILVANA MINES INCORPORATED
NEW DENVER, BRITISH COLUMBIA

S. Elias, P. Eng.
Senior Inspector
Environmental Control

July 18, 1979

RADIATION SURVEY OF NON-URANIUM MINES

SILVANA MINES INCORPORATED

NEW DENVER, BRITISH COLUMBIA

In the company with Mr. W. Hogg, Mine Manager, Silvana Mines Incorporated a radiation survey was made to preliminary assess Gamma radiation and Radon Daughter levels in the general workings of the mine. The survey was made July 18, 1979. The equipment used was as follows:

Air samples were taken with an H & H Custom Work diaphram air pump with pulsation damper. The pump was calibrated at a flow rate of 8.8 litres per minute using a wet test meter. A Sartorius membrane filter, 25 mm in diameter with a 0.8 micron pore size was used to collect the sample. A ten minute sample was collected at each location. A Tri-Met Instruments Ltd., Model TM372A alpha counter equipped with a foil type open zinc sulphide detector was used to evaluate the radiation level. A certified AM-241 alpha standard was used to calibrate the Tri-Met alpha counter before and after the sampling project.

A Ludlum Model 19 Micro R meter, with an internally mounted 1" x 1" Na(Tl) scintillator to give optimum performance in counting low level gamma radiation provided with five ranges 0-25 Micro R/hr as the most sensitive and 0-5000 Micro R/hr on the highest range, was used to assess gamma radiation levels.

Following are the results of the survey:

Location	W.L. Radon Daughters	Micro R/hr. Gamma Radiation
4000 level Ruth at portal outside ambient atmosphere.	0.0128	15
4000 level #2 west lateral, development dead end heading, ventilation via duct approx. 30 meters from face, quantity insufficient to measure, mucking with mucking machine, muck wet.	0.0119	23
4000 level #1 west lateral #2 drill station dead end, drill holes making water.	0.1055	32
4000 level portal exhaust air from 4000 level workings - day shift	0.2005	23
outcast air volume (8,400 CFM) $237.8\ m^3/min$.		
ahead of Ruth - night shift	0.1834	24
after Ruth - night shift	0.3660	

Location (Cont'd.)	W.L. Radon Daughters	Micro R/hr. Gamma Radiation
Night Shift		
4000 level exhaust air from #2 W. lateral and haulageway at Silversmith fan location.	0.0997	42
4000 level air from Silversmith working being blown to #2 W. lateral face via ducting.	0.0143	40
4000 level Ruth mine water sump area.	0.4588	36
4625 level station of decline, exhaust air from development and mining.	0.0364	24
4585 level stub, dead end, scooptram dumping waste rock, no ventilation in this area.	0.013	22

Remarks

A preliminary evaluation was made to assess for the presence of hazardous concentrations of radon daughters and gamma radiation. On a preliminary survey representative headings of different types of workings, poorly ventilated areas and return airways only are sampled. If the preliminary survey does not show measureable concentrations of radon daughters or under 0.10 W.L. it can be assumed that the health hazard does not exist. Should results indicate 0.10 W.L. (work level) more sampling is done to further assess the potential hazard. If the sampling indicates any workers are exposed to an average full shift exposure of more than 0.30 W.L. (work level) enough sampling must be done to indicate individual exposure over a (3) three month period. If expcsure exceeds 1 W.L.M. (work level month) over a three month period permanent records must be kept for all workers working in radiation areas of the mine, or until it can be shown that the health hazard no longer exists (less than 0.10 W.L. average exposure). When sampling indicates an inherent radon daughter hazard exists in any mine all standards applied normally to uranium mines shall be considered to be in force.

It is evident from the results that conditions definitely require corrective action to insure that health hazards from radiation do not develop. The air volume to the 4000 level is not adequate and it is required that a complete evaluation be made of both the 4000 level and decline working area to insure that adequate ventilation is subsistent at all times to remove the radon daughters and supply adequate air for diesel operations.

Remarks (Cont'd.)

It is suggested that the connection to the Ruth mine should be bulkheaded off from the 4000 level mine workings and a method of pressurizing the Ruth workings instituted so that air would flow from the 4000 level to the Ruth mine. This would stop radon daughters emanating in the Ruth mine from entering the 4000 level ventilation circuit.

S. Elias, P. Eng.
Senior Inspector
Environmental Control

July 27, 1979

APPENDIX 8I

RADIATION SURVEY OF A NON-URANIUM MINE

ARLINGTON MINE

SLOCAN, BRITISH COLUMBIA

S. Elias, P. Eng.
Senior Inspector
Environmental Control

July 19, 1979

RADIATION SURVEY OF A NON-URANIUM MINE

ARLINGTON MINE

SLOCAN, BRITISH COLUMBIA

A preliminary radiation survey was made to assess the radon daughter and gamma radiation level about representative work areas and the exhaust airways of the Arlington Mine, Slocan, British Columbia on July 19, 1979. The equipment used was as follows:

Air samples were taken with an H & H Custom Work diaphram air pump with pulsation damper. The pump was calibrated at a flow rate of 8.8 litres per minute using a wet test meter. A Sartorius membrane filter, 25 mm in diameter with a 0.8 micron pore size was used to collect the sample. A ten minute sample was collected at each location. A Tri-Met Instruments Ltd., Model TM372A alpha counter equipped with a foil type open zinc sulphide detector was used to evaluate the radiation level. A certified AM-241 alpha standard was used to calibrate the Tri-Met alpha counter before and after the sampling project.

A Ludlum Model 19 Micro R meter, with an internally mounted 1" x 1" Na(T1) scintillator to give optimum performance in counting low level gamma radiation provided with five ranges 0-25 Micro R/hr as the most sensitive and 0-5000 Micro R/hr on the highest range, was used to assess gamma radiation levels.

Following are the results of the survey:

Location	W.L. Radon Daughter	Micro R/hr Gamma Radiation
"B" level subdrift approximately 14 meters down from level, had just finished drilling, getting ready to blast, air flow through stope.	0.0193	34
"A" level exhaust air from mine, natural air flow 324 m^3/min (11,400 CFM).	0.0521	26
"A" level near portal ambient outside air.	0.0101	24

Remarks

A preliminary evaluation was made to assess for the presence of hazardous concentrations of radon daughters and gamma radiation. On a preliminary survey representative headings of different types of workings, poorly ventilated areas and return airways only are sampled. If the preliminary survey does not show measurable concentrations of radon daughters or under 0.10 W.L. it can be assumed that the health hazard does not exist. Should results indicate

Remarks (Cont'd.)

0.10 W.L. (work level) more sampling is done to further assess the potential hazard. If the sampling indicates any workers are exposed to an average full shift exposure of more than 0.30 W.L. (work level) enough sampling must be done to indicate individual exposure over a (3) three month period. If exposure exceeds 1 W.L.M. (work level month) over a three month period permanent records must be kept for all workers working in radiation areas of the mine, or until it can be shown that the health hazard no longer exists (less than 0.10 W.L. average exposure). When sampling indicates an inherent radon daughter hazard exists in any mine all standards applied normally to uranium mines shall be considered to be in force.

It would appear that there is no health hazard from radon daughters according to present established standards with the present quantity of air flow through the mine. It is suggested that a means of mechanical ventilation should be installed to ensure an adequate air flow during all seasons of the year.

S. Elias, P. Eng.
Senior Inspector
Environmental Control

July 31, 1979

APPENDIX 8J

RADIATION SURVEY OF A NON-URANIUM MINE

HEWITT MINE

SILVERTON, BRITISH COLUMBIA

S. Elias, P. Eng.
Senior Inspector
Environmental Control

July 19, 1979

RADIATION SURVEY OF A NON-URANIUM MINE

HEWITT MINE

SILVERTON, BRITISH COLUMBIA

A preliminary radiation survey was made to assess the radon daughter and gamma radiation level about the mine workings and exhaust airways of the Hewitt Mine operated by Frank Pho of New Denver, B. C. during July 19, 1979. The equipment used was as follows:

Air samples were taken with an H & H Custom Work diaphram air pump with pulsation damper. The pump was calibrated at a flow rate of 8.8 litres per minute using a wet test meter. A Sartorius membrane filter, 25 mm in diameter with a 0.8 micron pore size was used to collect the sample. A 44.4 litre sample was collected at each location. A Tri-Met Instruments Ltd., Model TM372A alpha counter equipped with a foil type open zinc sulphide detector was used to evaluate the radiation level. A certified AM-241 alpha standard was used to calibrate the Tri-Met alpha counter before and after the sampling project.

A Ludlum Model 19 Micro R meter, with an internally mounted 1" x 1" Na(Tl) scintillator to give optimum performance in counting low level gamma radiation provided with five ranges 0-25 Micro R/hr as the most sensitive and 0-5000 Micro R/hr on the highest range, was used to assess gamma radiation levels.

Following are the results of the survey:

Location	W.L. Radon Daughters	Micro R/hr Gamma Radiation
10 level east, exhaust air from mine workings, air flow quantity too small to measure, water running out.	0.7551	36
11 level shaft station, dead end, used as pump station.	0.4959	24
10 level near portal, outside air.	0.0074	24

Remarks

A preliminary evaluation was made to assess for the presence of hazardous concentrations of radon daughters and gamma radiation. On a preliminary survey representative headings of different types of workings, poorly ventilated areas and return airways only are sampled. If the preliminary survey does not show measurable concentrations of radon daughters or under 0.10 W.L. it can be assumed that the health hazard does not exist. Should results indicate 0.10 W.L. (work level) more sampling is done to further assess the potential hazard. If the sampling indicates any workers are exposed to an average full shift exposure of more than 0.30 W.L. (work level) enough sampling must be done to indicate individual exposure over a (3) three month period. If exposure exceeds 1 W.L.M. (work level month) over a three month period permanent records must be kept for all workers working in radiation areas of the mine, or until it can be shown that the health hazard no longer exists (less than 0.10 W.L. average exposure). When sampling indicates an inherent radon daughter hazard exists in any mine all standards applied normally to uranium mines shall be considered to be in force.

The radiation levels are well above the permissible standards. The crew shall be immediately removed. Adequate positive mechanical ventilation is required before resuming any underground work.

The ventilation should be so designed that the fresh air flows into the mine via the shortest route to the working areas and the volume shall be adequate to dilute the radon daughters to below 0.10 W.L. at all times and at all working locations.

S. Elias, P. Eng.
Senior Inspector
Environmental Control

August 1, 1979

APPENDIX 8K

RADIATION SURVEY OF A NON-URANIUM MINE

NORTHAIR MINES LIMITED

SQUAMISH, BRITISH COLUMBIA

S. Elias, P. Eng.
Senior Inspector
Environmental Control

June 26, 27, 1979

RADIATION SURVEY OF

NORTHAIR MINES LIMITED

SQUAMISH, BRITISH COLUMBIA

A radiation survey for radon daughters was made about the active underground workings of Northair Mines Limited on June 26, 1979. The equipment used and the results obtained were as follows:

Air samples were taken with an H. & H. Custom Work diaphram air sampling pump with pulsation compensator powered by a lamp battery. The pump was calibrated at a flow rate of 8.87 liters per minute using a wet test meter. A sortorius membrane filter, 25 mm in diameter with a 0.8 micron pore size was used to collect the samples. A ten minute sample was collected at each location. A Tri-Met Instruments Ltd. Model TM372A alpha counter equipped with a foil type open zinc sulphide detector was used to evaluate the radiation level. A certified AM241 alpha standard was used to calibrate the Tri-Met alpha counter before and after sampling.

Following are the results of the survey:

Location	W.L. Radon Daughters
3260 E. drift, dead end, ground water entering.	0.00192
3000 W. sub, dead end, fairly dry area.	0.00245
2800 E. drift, dead end, high volume of ground water.	0.00374
32-1800 stope, open stope, backfilling with sand fill.	0.00738
2800 level portal, ambient air, background sample.	0.00066
Campsite elevation, at cookhouse, background sample.	0.00075

Remarks

There were not radon daughter exposures over the maximum permissible exposures according to the Atomic Energy Control Regulations.

Interpretation:-

"Radon daughters" means the following short-lived radioactive decay products of radon-222: polonium-218: (radium A), lead 214 (radium B) bismuth-214 (radium C) and polonium-214, (radium C').
"Working level" or "WL" means the amount of any combination of radon daughters in one litre of air that will release 1.3 x 10^5 mega electron volts of alpha particles energy during their radioactive decay to lead-210 (radium D).

Remarks (Cont'd.)

"Work level Month" or "WLM" means the exposure resulting from the inhalation of air containing one work level of radon daughters for one working month, where one working month equals 170 working hours.

Maximum Permissible Exposures to Radon Daughters (1)

Column I Atomic Radiation Worker		Column II Any other Person
WLM per quarter of a year	WLM per year	WLM per year (2)
2	4	0.4

(1) For exposures to radon daughters, the maximum permissible exposure (in working level months) apply instead of maximum permissible doses for lungs (in rems).

(2) The WLM unit is not appropriate for exposures in the home or in other non-occupational situations. In such situations, the maximum permissible annual average concentration of radon daughters attributable to the operation of a nuclear facility shall be 0.02 WL.

S. Elias, P. Eng.
Senior Inspector
Environmental Control

June 29, 1979

APPENDIX 9A

NOTES ON ENVIRONMENTAL CONDITIONS AT SULLIVAN MINE AND CONCENTRATOR - COMINCO LIMITED KIMBERLEY, BRITISH COLUMBIA

D. Murray, P. Eng.
Inspector
Environmental Control

S. Elias, P. Eng.
Senior Inspector
Environmental Control

March 20-28, 1979

NOTES OF ENVIRONMENTAL CONDITIONS AT

SULLIVAN MINE AND CONCENTRATOR - COMINCO LIMITED

KIMBERLEY, BRITISH COLUMBIA

Following are my notes on which the "Report of Inspector of Mines Environmental Control" inspection report is based. The notes pertain to the underground workings, underground crushing plants, conveyor galleries, assay grinding room and sink float plant. They were obtainted during the period of March 20-28, 1979 and include pertinent information received from staff and workers about the mine and concentration and are for the use of authorized Cominco Limited, Sullivan Mine and Concentrator staff only.

DUST CONCENTRATIONS North Section - March 21, 1979	No. of particles per c.c. of air
Q-22 Sub B, B-10-30, Ingersol Rand #58 CMM-BH down the hole drill, pulling drill stems, ventilation duct approximately 5 meters from drill, hose type muffler used, ear muff type ear protection	110 122
Q-21 Sub E, setting up slusher, will be drilling later, no ventilation duct installed. Air mover at heading.	148 166
39267 Sub P, R-10-1, scraping hot muck, ventilation past operator into sub 1.4 m/sec velocity, respirator used, no ear protection used, duct issues from slusher and contaminates air flow to Sub 5D, Sub 5F, no water spray used.	1436 1286
39-R-11 Sub E, R-10-1, scraping hot muck, ventilation past operator into sub 1.0 m/sec velocity, ear protection used, no water sprays used.	104 96
39-R-11 Sub 5D, scraping hot muck, ventilation past operator into sub 1.9 m/sec, respirator used, ear protection used-plugs, air is being contaminated from blow back at 39267 Sub P.	2000 2000
39-R-11 Sub 5F, R-10-1, at slusher operator, scraping hot muck, ventilation past operator into sub 1.5 m/sec (7X7) ear plugs used, air is contaminated by blow-back from 39267 Sub P	92 98
39-Q-18 Sub W slusher, scraping, muck dry, water spray used, no ear protection, ventilation past operator in sub 1.1 m/sec velocity.	102 90

North Section - March 21, 1979	No. of particles per c.c. of air
39-Q-18 Sub X at slusher operator, scraping, water spray used, ear muffs used, air flow past operator into slusher 1.4 m/sec velocity.	62 54
39-Q-18 Sub A, pipe fitters installing pipe, general air	124 106
39-Q-18 Sub 3F, crew installing pipe, will be placing slusher, no ventilation $NO+NO_2$= 8 ppm, crew removed.	88 112
3917 Drift North at mucking point, mucking wet muck with mucking machine, no water spray used, air flow past operator up draw point/raise	146 128
3941 Sub P R-11-1 Block long hole drill, TNT drilling, hose type muffler, ear muffs used, ventilation via plastic duct 3 meters from drill (2300 CFM) 65.7 m^2/min.	134 122
3941 Sub D crew cleaning up area, general air	98 92
3900 level 32 raise hoist room, general air	16 20
3911 cross cut between 17 and 18 drifts, cleaning ditches, general air	42 34
Q-21 Sub E drilling with two G.D. RB83 drills with steel mufflers, ear protection used, no ventilation to heading.	1290 1424

Mechanized Operations - March 22, 1979

3804 scram, mucking with ST5 scooptram, muck dry ventilation duct approximately 15 meters from face, $NO+NO_2$=6 ppm ventilation via 42 inch diameter duct 1026 m^2/min (36,300 CFM)	152 162
4010 scram, haulage $NO+NO_2$= 1.5 ppm, CO=Nil	-
3900 ramp, haulage $NO+NO_2$= 2.0 ppm, CO=Nil	-
4250 P scram scram drilling with three boom jumbo with GD 120 drills, ear muff used for ear protection hose type mufflers used, ventilation duct 30 meter back from face, diesel running to operate hydraulics air flow to face 1003 m^2/min (35,400 CFM) $NO+NO_2$=4 ppm, CO=Nil.	356 388
4410 scram at P-2 grizzly, timber crew working	74 86

Mechanized Operations - cont'd	No. of particles per c.c. of air
4150 - 3903-QZ scram drilling with down the hole I.R. CMM drill, ear muffs used, ventilation duct 5 meter from drill, hose type muffler used.	246 218
4250 P scram, ventilation duct approximately 20 meters from face volume at end of duct (3000 CFM) 83.3 m^2/min after "Y" tied off 119 m^2/min (4200 CFM) near fan 166.6 m^2/min (5900 CFM) crew ready to muck with 5 ST scooptram stopped.	78 86
0-2-30, 2N Panel, Jarvis Clark jumbo with two copco 120 drills, drilling, hose type mufflers, ear muffs used, thru flow ventilation 0.3 m/sec 441 m^2/min (15,600 CFM) #1 stope air flow to 2N	106 92
4700-B stope, mucking with 913 scooptram, water spray or muck pile, ventilation via 30 inch diameter duct to within 15 meters of face 523.7 m^2/min (18,500CFM) $NO+NO_2$= 4 ppm while mucking, haulage ramp (4700) $NO+NO_2$= 3 ppm at fan location.	228 212
3900 level mechanized section shop area, general air	24 22
39124 repair shop (drill) general air	16 18

Mechanized Operations - March 28, 1979

4350 Scram at P2 dump, scooptram muking $NO+NO_2$= 4 ppm	320 294
4350 P scram at Sub H, muck dry ventilation 840 m^3/min (29,700 CFM) auxiliary ventilation via 42 inch duct, 1120 m^3/min (39,500 CFM) $NO+NO_2$= 5 ppm, 2 scooptrams mucking, one ST5 and one ST2E. No water spray used.	168 184
4310 scram, ST5 scooptram mucking fairly wet muck, big chunks, and dumping into P2. $NO+NO_2$= 4.5 ppm. No water spray used.	124 144
4310 dump, STS scooptram dumping, $NO+NO_2$= 4 ppm mucking point, ventilation= 611 m^3/min, (21,600 CFM) exhaust air via ore dump, ventilation at dump 305 m^3/min (10,800) air flows up mucking points, no water spray used.	162 154

No. 1 & 2 Shaft Section - March 21, 1979

32118 Sub W, three timbermen installing yielding arch sets	162 124

No. 1 & 2 Shaft Section - cont'd	No. of particles per c.c. of air
32118 Sub Z one worker scaling in drawhole, ventilation 45.1 m^3/min (1590 CFM)	158 148
3218 Sub W, drilling with G.D. jackleg, machine muffled, ear muffs used, ventilation via 12" duct 2 m from face.	96 128
3126 Sub Z, slusher, scraping fairly dry muck, water spray used, ear muffs used	42 48
3134 Sub Y, miner had just blasted, smoke cleared, good ventilation, CO=Nil, NO+NO_2=Nil	168 176
2850 level, cleaning out ditch with a ditcher, (small backhoe attached to a mucking machine chassis)	32 28

No. 1 & 2 Shaft Section - March 22, 1979

3721 Sub D, scraping, muck fairly dry, operator wet it down with water hose, ear muffs used, ventilation up 3721 incline 446 m^3/min (15,800 CFM). Operator located over incline.	154 172
35217 Sub Z, scraping, muck dry, water spray used effectively, ear muffs used, ventilation past operator, velocity 0.95 m/sec.	94 128
35217 Sub Y, scraping, water spray used, ear muffs used, ventilation past operator, velocity 1.1 m/sec, 360 m^3min (12,700 CFM).	142 162
35204 Sub X, scaling in raise, at 2 m from face CO=10 ppm, NO+NO_2= 6 ppm, no ventilation to face, operator installed 12" duct and turned fan on when told to do so, atomizer used, blasted previous shift.	78 92
35204 Sub Y, two G.D. stopers drilling in ventilation raise, drills muffled, ear plugs used, auxiliary ventilation lm from face 12" duct.	122 136
3510 drift, backhoe cleaning out ditch, good through ventilation.	32 40
3510 drift, four workers mixing cement and pumping same thru pipe.	62 54
33126 Sub Y one worker preparing to blast down hang-up in draw hole.	102 114

Centre Section - March 23, 1979

38312 Sub B, GD 99 percussion long hole drill with hose muffler. Remote control drilling, two	132 148

Centre Section - cont'd	No. of particles per c.c. of air
workers 15m from drill, ear muffs used by one man, ear plugs by other, ventilation via 12" plastic duct at drill connected to air mover, 30.5 m^3/min (1080 CFM)	
3820.4 Sub 2A, two workers cleaning out for slusher hoist, blow pipe used until stopped by shift boss, ventilation via 12" plastic duct connected to fan 4 m from working place, 22.9 m^2/min. (808 CFM).	294 342
36204 Sub L, GD99 percussion longhole drill with hose muffler, ear plugs used, ventilation via 12" duct and air mover to operator's station, 20.4 m^3/min. (720 CFM).	136 154
36204 Sub L, TNT longhole drill with hose type muffler, ear muff used, ventilation via 12" duct and air mover 21.6 m^3/min (763 CFM)	128 134
In ramp at entrance to 38203 Sub W ambient air CO=Nil NO+NO2= 2 ppm. No diesel around at time of sample	- -
38203 Sub W two workers drilling, G D stoper equipped with Integral muffler, joy jackleg equipped with Integral muffler, ear muffs used, ventilation from 3900 ramp via 18" duct 6m from face 64.0 m^3/min (2260 CFM). A few holes in the ducting.	350 322
203 Sub Y, drilling, G.D. stoper muffled, ear plugs used, ventilation via 12" duct at drill, hole cut in duct at drill and remainder of air flows to other drill 5 m away at end of drift, 37.8 m^3/min (1330 CFM)	164 184
As above at end of drift, drilling lifters, ear muffs used. GD stoper equipped with integral muffler.	124 138
3600 ramp after St 5 had passed up ramp CO=Nil, NO+NO2= 4.0 ppm. Air flow up ramp 566 m^3/min. (20,000 CFM).	- -
38203 Sub C two workers had just finished installing eye bolt with Roc-loc for a cable barricade, ventilation at bottom of raise 6 m from work place via 12" plastic duct, 37.8 m^3/min (1330 CFM) measured air duct near fan, CO=Nil NO+NO_2=Nil	72 64
Centre Section - March 26, 1979	
#2 Shaft Hoistroom. Clean, dry. Ventilation in via 8" metal duct. Quantities of air in = 25.3 m^3/min (893 CFM). Exhaust ventilation via 18" metal duct. Volume of air out = 143 m^3/min (504 CFM). Hoistman has electric fan blowing over his area.	24 18

Centre Section - cont'd	No. of particles per c.c. of air
#25 Shaft Station 3900 level, ambient air	42 36
38231 - Sub U. Preparing to scrape muck from last round from raise above.	162 148
38231 - Sub F. Miners had just finished scraping out round and were preparing to drill. Atomizer used after blast. Auxiliary ventilation via 18" ducting, at face when drilling. Volume of air = 78.9 m^3/min. (2790 CFM).	140 124
38231 - Sub W. Drilling with Gardner Denver stoper, equipped with integral muffler. Operator wearing ear plugs. Auxiliary ventilation via 12" metal duct 20 m. from face. Should be closer. Driller added length of plastic duct when told to do so, then ventilation was within 8 m. of face. Dust sample taken when plastic ducting added. Volume of air = 96.3 m^3/min (3400 CFM).	184 210
38231 - Sub V. Drilling with Gardner Denver stoper, muffled. Operator wearing ear muffs. Auxiliary ventilation via 12" metal duct, 18 m. from face (when dust sample taken). Driller added length of plastic duct, to within 7 m. of face, when told to do so. Volume of air = 78.8 m^3/min (2780 CFM)	352 368
36223 - Sub B. Slushing, water spray used. Muck fairly dry. Operator wearing ear muffs. Air flow past operator 1.2 m/sec. velocity.	54 48
36219 - Sub Z. Slushing, water spray used. Operator had no ear protection. Air flow past operator 0.9 m/sec. velocity.	58 68
38207 - Sub U, at slusher. Not scraping, waiting to blast. Operator had ear muffs. Air flow past operator 0.4 m/sec. velocity.	44 56
38207 - Sub V, at slusher. Not scraping, waiting to blast. Air flow part operator not enough to measure.	62 68
3800 level, #2 shaft station.	52 48
3650 level, #2 shaft station.	44 40

Centre Section - March 28, 1979

3900 level, 501 dumps, train dumping damp muck.	68 74

Mine Air Temperatures North Section	Degree Celsius Wet Bulb	Degree Celsius Dry Bulb	Per Cent Relative Humidity
39-Q-22 Sub B	12.0	13.0	89
39-Q-21 Sub E	14.0	15.0	90
39267 Sub P	8.5	9.5	88
39-R-11 Sub E	9.5	10.0	94
39-R-11 Sub 5F	8.0	8.5	94
39-R-11 Sub 5D	8.5	9.5	88
39-Q-18 Sub W	6.5	7.0	93
39-Q-18 Sub X	6.5	7.0	93
39-Q-18 Sub 3F	15.0	16.0	90
3917 D.N.	10.0	11.0	88
3941 Sub P R-11-1	18.0	20.0	83
Mechanized Operations			
3804 scram	10.0	12.5	74
4250 P scram	8.5	9.0	94
4410 scram	7.0	7.5	93
4150, 3903 Q - Z scram	12.0	12.5	94
Q-21 Sub E	11.0	11.5	94
0-2-30, 2N Panel	8.3	9.0	94
4700 B stope	9.0	11.0	77
No. 1 & No. 2 Shaft Section			
32118 Sub W	9.5	10.0	94
32118 Sub Z	8.2	10.2	76
3818 Sub W	9.6	10.2	93
3126 Sub Z	9.8	11.8	78
3134 Sub Y	7.4	9.2	78
3721 Sub D at face	19.5	21.0	87
3721 Sub D at slusher	8.0	10.2	74
35217 Sub Z	8.6	11.0	73
35217 Sub Y	7.8	9.8	76
35204 Sub X	9.5	10.5	88
35204 Sub Y	9.5	11.0	83
33126 Sub Y	8.5	10.0	82
Centre Section			
38312 Sub	14.5	15.5	90
38204 Sub 2A	20.0	23.0	76
36204 Sub L	12.8	14.2	85
38203 Sub W	10.0	11.5	82
38203 Sub Y	9.5	12.0	73
38203 Sub C	10.0	11.5	82
#2 Shaft hoist room	14.0	23.0	36
3900 level #2 shaft station	10.5	12.0	83
38231 Sub U	9.0	10.0	88
38231 Sub F	11.0	12.5	83
38231 Sub W	11.5	14.0	74
38231 Sub V	11.0	12.0	89
38223 Sub B	10.0	12.5	73
36219 Sub Z	10.0	13.0	69
38207 Sub U	8.0	9.5	82
38207 Sub V	9.0	10.0	82

3800 Level Crushing Plant - Afternoon Shift March 26, 1979	No. of particles per c.c. of air
At operator's position in control booth	78 82
No. 101 Jaw Crusher, on walkway beside feeder	134 162
No. 101 Jaw Crusher, at back end, lower floor	174 188
Along No. 111 conveyor, at operator's position	130 138
Along No. 111 conveyor at discharge point of jaw crusher	132 142
Beside splitting chute over screens (101 & 102)	182 170
Adjacent to 101 screen, inspection port open	112 124
Adjacetn to 102 screen	148 150
Beside No. 111 Symons cone crusher, feed elevation	128 116
Beside No. 112 Symons cone crusher, feed elevation	160 144
Adjacent to 111 Symons cone crusher, at exhaust duct	158 176
Adjacent to 112 Symons cone crusher at exhaust duct	202 186
No. 120 conveyor tail pulley	406 438
Along 113 conveyor gallery	682 762
Halfway along 120 conveyor at take-up pulley	432 466

2800 Level Crushing Plant - Afternoon Shift March 26, 1979	No. of particles per c.c. of air
At operator's position feed to jaw crusher	240 252
Top floor, at head of stairway	280 262
Middle floor, front of jaw crusher	242 218
Bottom floor, at bottom of stairway	88 72
Along No. 9 conveyor, at feed box	116 94
Beside No. 9 conveyor or discharge point to chute	110 124
Bottom floor, beside chute to fine ore bin	86 92
Top of incline, air to crushing plant	62 58
Adjacent to dust control fan, fan isolated from plant information sample only	284 268
Along No. 8 conveyor at feed discharge point	184 162
At operator's poistion at feeder to No. 8 conveyor	192 220
3902 Conveyor Galleries - Afternoon Shift March 26, 1979	
At tail pulley of 112 conveyor	524 462
No. 3 Conveyor discharge to chute feeding 112 conveyor new duct installed, blow pipe used to clean chute	545 482
Halfway along No. 3 conveyor gallery	284 322
At transfer point of No. 4 to No. 3 conveyor, new duct installed	494 624
Halfway along No. 4 conveyor gallery	362 340
At transfer point of No. 5 to No. 4 conveyor new duct installed	320 282

3902 Conveyor Galleries - cont'd
Afternoon shift
Mar. 26/79 cont'd

	No. of particles per c.c. of air
Halfway along No. 5 conveyor gallery manway slippery in some areas - muddy	244 218
At transfer point of No. 6 to No. 5 conveyor new duct installed	310 288
Halfway along No. 6 conveyor gallery gallery muddy in sections - clean-up required	282 264
At transfer point of No. 7 to No. 6 conveyor	198 144
Halfway along No. 7 conveyor gallery clean-up required	162 152
At transfer point of No. 8 to No. 7 conveyor	224 238
Halfway along No. 8 conveyor gallery	- -
Sink Float Plant- Graveyard Shift March 26, 1979	
Between feeders under 131 bin along 201 conveyor	166 196
Discharge of 201 to 210 conveyor, at 201 head pulley	142 134
Along 210 conveyor gallery at discharge point of 201 conveyor	176 160
At transfer point of 210 to 212 conveyor	54 66
Adjacent to 212 conveyor head pulley	186 214
At transfer point of 212 to 213 conveyor	198 228
Mezzanine floor, between 2100 and 2200 screens	218 202
In operator's control room	98 86
On main floor between 215 and 216 screens	172 186
Adjacent to Oliver filter, discharge side	210 198

Sink Float Plant - cont'd Graveyard Shift Mar. 26/79 cont'd	No. of particles per c.c. of air
At transfer point of 218 to 220 conveyor	126 120
Main floor of building adjacent to boiler shop	154 162
Main floor of building adjacent to pipe shop entrance	84 78
Assay Grinding Room - March 27, 1979	
Pulverizing samples and cleaning pulverizer with compressed air	98 110 168 182 112 156 208 164
Screening, rolling and bagging mill pulp samples and cleaning rolling bench with compressed air and brush	146 166 120 186 156 206 86 112 134 176
Crushing sample in rolls and splitting in riffles	130 320 160 138
Adjacent to table used to place hot mill samples	214 192 246 162
Mill Building - March 27, 1979	
At discharge end of #301 rod mill	116 126
At discharge end of #302 ball mill	120 128

Mill Building - cont'd
Mar. 27/79 - cont'd

	No. of particles per c.c. of air
At discharge end of #316 ball mill	112 102
At discharge end of #313 ball mill	106 122
Between #411 and #412 flotation banks	128 96
Between #422 and #423 flotation banks	150 136
Between #427 and #428 flotation banks	74 82
Between tin tables, at centre	106 84
Operator's station tin plant laboratory test area	58 62
Discharge end of #501 Oliver filter	44 50
Discharge end of #502 Oliver filter	110 104
Discharge end of zinc dryer	30 24
Between #404 and #405 flotation banks	76 80

VENTILATION

Air Volumes

Mechanized Section - March 28, 1979	M^3/min.	CFM
3900 Ramp, Sta. #1	2,010	71,100
3900 Ramp, Sta. #2	1,770	62,500
3900 Ramp, Sta. #3	977	34,500
4010 Scram #5	138	4,860
3900 Ramp, Sta. #4	2,010	70,900
3900 Ramp, Sta. #7	815	28,800
3901 Ramp, Sta. #8	3,210	113,000
4253 D.S.	4,790	169,000
3900 Ramp, Sta. #10	2,030	71,600
40-M-14 Sub A #11	1,010	35,800
3901 Winze #12	678	23,900
3901 Ramp Sta. #14	2,600	91,800
4310 Ramp, Sta. #15	1,920	67,800
4000 Scram, Sta. #17	Nil	Nil
3800 Ramp, Sta. #18	2,350	83,100
Dump, Sta. #19	1,120	39,400
3903 Ramp Sta. #20	158	5,590
4267 XC Sta. #22	1,330	47,000
39-P-2 Mechanized Ore Dump in 4251 DS Sta. #23	2,000	70,700

VENTILATION - cont'd

1. Intakes

A. Forced by intake fans and pulled by exhaust fans:

		m^3/min.	kPa	kw
1.	#1 shaft	2,970	0.23	37.3
2.	#24 shaft	7,930	0.88	223.8
3.	#41 shaft	8,920	1.22	447.6
4.	4400 Portal	2,830	0.05	74.6
5.	R -8 Cave	1,700	0.12	56.0
	Total	24,350		839.3

B. Pulled by exhaust fans only:

		m^3/min.
1.	4800 Portal (south end)	1,270
2.	4250 Level (south end)	780
3.	4150 Level (south end)	283
4.	42-P-2 Raise (north end)	283
5.	3900 Portal	283
6.	3700 Portal	849
	Total	3,679 m^3/min.

C. Total compressed air liberated: 566 m^3/min.

D. Total fugitive air pulled by exhaust fans: 2,830 m^3/min.

Total useful air A + B 28,029 m^3/min.

Total flow A + B + C + D 31,425 m^3/min.

2. Exhausts

		m^3/min.	kPa	kw
1.	#23 Shaft fan	3,400	0.62	93
2.	#26 Shaft fans	4,390	1.41	224
3.	#29 Shaft fan	3,960	0.70	149
4.	#33 Shaft fan	1,980	0.46	112
5.	#39 Shaft fan	4,530	0.88	149
6.	#40 Shaft fan	3,260	0.98	112
7.	#42 Shaft fans	12,320	1.18	448
	Total Exhaust Flow	33,840		1,287

VENTILATION - cont'd

3. Secondary Booster Fans - Conventional Section

Location	m3/min.	kw	Duty
4250XC	991	14.9	Intake
Q-10-1 Block	991	44.8	Intake
R-10-1 Block	991	43.3	Intake
T-9-31 Block	708	18.7	Intake
T-9-31 Block	991	14.9	Intake
S-11-31 Block	991	14.9	Intake
U-13-30 Block	849	43.3	Intake
501 Dumps	2,265	44.8	Exhaust
39100 D.N.	3,540	93.3	Exhaust
3865 XC	3,398	111.9	Exhaust
3810 D.N.	2,407	56.0	Exhaust
3800 Dumps	991	37.3	Exhaust
2-07 Block	991	43.3	Exhaust
2-21 Block	566	18.7	Exhaust
3500 Dumps	566	7.5	Exhaust
33240 Raise	1,416	37.3	Exhaust
30036 Sub A	1,133	37.3	Exhaust
5, 6 - 32 42 Block	1,416	37.3	Exhaust
7 - 32 Block	708	37.3	Exhaust
3811 D.S.	1,416	74.6	Intake
3800 c.c.	849	74.6	Exhaust
	1,076	29.8	Exhaust
2850 c.c.	1,133	37.3	Exhaust
	566	44.8	Exhaust
Total	30,949	1,017.9	

4. Secondary Booster Fans - Mechanized Section

Location	m3/min.	kW	Duty
4350 P Scram	991	14.9	Exhaust
	991	37.3	Intake
4250 P Scram	991	37.3	Intake
4250 Spiral	991	44.8	Intake
3801 Ramp	991	44.8	Intake
3802 Ramp	1,133	56.0	Intake
3804 Ramp	1,416	44.8	Intake
L-11-30 Ramp	1,416	44.8	Intake
4700 Ramp	849	41.8	Intake
4700 Ramp	708	7.5	Exhaust
4800 Doors	283	3.7	Exhaust
0-2-30 Stope	566	22.4	Intake
0-2-30 Stope	566	22.4	Intake
Total	11,892	422.5	

VENTILATION - cont'd

5. Heating Plants

Location	$m^3/min.$	Maximum Input	
		Watts	$m^3/hr.$ Gas
No. 1 Shaft	2,265	1.61×10^6	147
No. 24 Shaft	7,929	4.78×10^6	439
No. 41 Shaft	8,920	5.86×10^6	538
4400 Portal	2,832	1.47×10^6	136
Total	21,946	13.72×10^6	1,260

Heating season is approximately from October 15th to April 15th.

Remarks

North Section

The average dust concentration about the active workings of the North Section of the Mine was 373 particles per c.c. of air.

The conditions that require corrective action are as follows:

39-Q-21 Sub E requires suitable ventilation during all phases of work.

39267 Sub P, R-10-1 Block, hot muck sub, blow back of dust to the operator's position is very hazardous to the operator and is contaminating the Sub 5D and Sub 5F areas as well. It appears that when the muck raise is at a certain level and the 39-R-11 Sub E slusher is operated this hazardous condition is most likely to happen. The scraping in the subs must be scheduled to avoid this condition or the ventilation must be corrected.

39-Q-18 Sub 3F, sub was not ventilated $NO+NO_2$= 8 ppm, requires suitable ventilation during all phases of work.

Mechanized Operations

The average dust concentration about the active workings of the mechanized section of the mine was 158 particles per c.c. of air.

The conditions that require correction are as follows:

38D4 scram, $NO+NO_2$= 6 ppm when the haulage trucks were stationed at 501 ore dump, this contaminates all the air flow to 3800 ramp and the 3600 ramp areas. A means of controlling mechanized units must be established to avoid this condition. There were two ST5 scooptrams, the oil supply truck and a jumbo (drill) in the ramp at one time.

4250 P scram, ventilation is not adequate to operate ST5 scooptram, must be corrected before mucking or drilling.

A generalized concept of the mechanized section ventilation is; The intake air ways to the mechanized section include 4400 level portal, 4250 level portal, 42177 XCW, No. 33 shaft, No. 41 shaft and 3900 DN. The exhaust airways include No. 31 shaft, 4251 DS, No. 39 shaft, No. 26 shaft, 4200 "B" raise, dump at 3902 ramp, dump at 4310 scram and leakages at various points to the conventional mining areas that includes 3800 and 3600 levels. The fresh air flows along the main ramps to the production scrams and development headings. Fabric duct with auxiliary fans are used to

Remarks - cont'd

Mechanized Operations - cont'd

ventilate individual production and/or development headings that do not have through ventilation.

There are a number of ventilation conditions that require high priority revaluation when using diesel equipment underground.

1. The toal prime air requirement for the mechanized section should be a minimum of 20 per cent more than air requirements for all diesel equipment in use.
2. Air used to ventilate areas where diesel powered equipment is used must be on a one pass system - that is, it may be used only once, it cannot be used to ventilate a second heading in series - it must flow directly to an exhaust circuit from the heading and shall not flow back into the fresh air circuit.
3. The air requirements for service, production and development diesel powered vehicles must be subsistent at all times whenever these vehicles are operated in any ramp or other type of heading e.g. there are five vehicles in the immediate 3901 and 3800 ramp area at one time (plus an unknown number above the 3900 level) this resulted in $NO+NO_2$= 6 ppm in the duct supplying 3804 scram. It is evident that permit requirements were not being followed. Gas tests taken in development and production areas illustrate that contaminated air is being used as prime air to ventilate e.g. 38203 Sub Y and Sub W air in sub 4 ppm NO_x and 3 ppm NO_x in the supply duct, this was during drilling operations !!
4. Ore passes cannot be considered as exhaust air ways, this is not an acceptable means due to unstable conditions that result when dumping and the differences in the amount of ore in the raise may change air flow conditions e.g. 4310 scram.
5. Control doors are not being kept in the predetermined positions e.g. 3900, 3800 and 3600 level.
6. All dead end dormant headings must either be fenced or roped off and marked "no entry" or adequately ventilated to prevent build up of gases. If fenced or roped off ventilation must be restored before re-entry.
7. The air requirement shall never be less than 15 m^3/min. per square meter of face area or cross section of the heading in any development or production heading.

Remarks - cont'd

No. 1 and No. 2 Shaft Sections

The average dust concentration about the active workings of the No. 1 and No. 2 shaft sections of the mine was 107 particles per c.c. of air.

The conditions that require corrective attention are:
35204 Sub X, auxiliary ventilation must be installed before working at the face.

Centre Section

The average dust concentration about the active workings of the Centre section was 130 particles per c.c. of air.

The conditions that require corrective action are:
38204 Sub 2A, blow pipe being used to muck, blow pipes shall not be used to muck.

38231 Sub W, ventilation duct must be kept to within 15 meters of the working locations, at drilling locations it should be extended to the immediate staging.

38231 Sub V, same as 38231 Sub W applies.

38207 Sub V, ventilation past slusher operator shall not be less than 0.25 m/sec velocity.

3800 Level Crushing Plant

The average dust concentration found about the 3800 level crushing plant while crushing fairly damp run-of-the-mine ore was 223 particles per c.c. of air. For comparison the average in September 1978 was 119 particles per c.c. of air.

The conditions in the plant during the survey were as follows: the dust control units were in operation; the feed to the plant was damp; the housekeeping in the plant was good; the inspection ports at the front end of 101 and 102 screens were open and the curtain enclosure was open. Clean up along 120 conveyor was poor. Door to 3700 level manway was open.

2800 Level Crushing Plant

The average dust concentration found about the 2800 level crushing plant was 150 particles per c.c. of air. For comparison the average in September 1978 was 140 particles per c.c. of air. There appears to be an upward trend in dust concentrations in this plant. This should be checked to avoid any further elevation.

3902 Conveyor Gallery

The average dust concentration found about the 3902 conveyor galleries was 301 particles per c.c. of air. For comparison the dust

Remarks - cont'd

3902 Conveyor Gallery - cont'd

concentration in September 1978 was 470 particles per c.c. of air. This is an improvement. The dust control system servicing the 3902 conveyor galleries has been replaced, but foggy conditions are still evident about the upper sections.

The housekeeping along the 3902 conveyor galleries has been improved but still requires attention.

Assay Grinding Room

The average dust concentration about the assay grinding room was 164 particles per c.c. of air. For comparison the average was 183 particles per c.c. of air in September 1978.

It has been previously suggested that an exhaust hood over the steel table used for the hot mill samples removed from the dryers would be benificial. The recommendation is still valid.

Sink Float Plant

The average dust concentration about the sink float plant and feed conveyors was 161 particles per c.c. of air. For comparison the average in September 1978 was 177 particles per c.c. of air. This is an improvement.

The conditions in the plant during the survey were as follows: the clean-up was still poor along 201, 210, 212, and 213 conveyor galleries the dust control systems were in operation.

Noise Control

It was noted that all hand held drills were equipped with integral mufflers and that all long hole machines were equipped with suitable hose type noise attenuation devices. The majority of workers were wearing muff type ear defenders. A separate report on noise control has been made.

Summary

Mine Averages	No. of particles per c.c. of air
Mine average (drilling and others)	192
Drilling locations only	342
Exclusive of drilling only	170
3800 level crushing plant	223
2800 level crushing plant	150
3902 conveyor galleries	301

Dust Concentrations by Sections

Sample Classification	Number of particles per c.c. of air Mechanized Section	North Section	Centre Section	No. 1 & 2 Shaft Section	Averages
Primary air	-	-	44	-	44
Slushers	-	552	57	125	285
Development	227	747	225	109	272
Stopes	179	-	-	-	179
Blast Hole Drills	232	122	139	-	149
Miscellaneous	40	73	53	84	67
No. of Samples	26	32	42	28	128
Averages	158	373	130	107	192

Concentrator Averages	No. of particles per c.c. of air
Sink Float plant	161
Assay grinding room	164
Mill building	93

Clean-up required along 201, 210 and 212 conveyor galleries.

Hood should be installed over steel table used for hot mill samples.

Underground Mine

1. The fresh air requirements for service, production and development diesel powered vehicles must be subsistent at all times.

Summary - cont'd

Underground Mine - cont'd

2. Control doors must be kept in the predetermined positions.

3. Auxiliary ventilation must be installed before working at the face.

4. Blowpipes must not be used for mucking.

5. Clean-up is required along 120 conveyor.

S. Elias, P. Eng.
Senior Inspector
Environmental Control

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D. J. Murray, P. Eng.
Inspector
Environmental Control

APPENDIX 9B

NOTES OF ENVIRONMENTAL CONDITIONS AT
KAISER RESOURCES LIMITED
SPARWOOD, BRITISH COLUMBIA

D. J. Murray, P. Eng.
Inspector
Environmental Control

S. Elias, P. Eng.
Senior Inspector
Environmental Control

November 20 - 29, 1978

NOTES OF ENVIRONMENTAL CONDITIONS AT
KAISER RESOURCES LIMITED
SPARWOOD, BRITISH COLUMBIA

A survey was made of the environmental conditions in the active underground workings of Balmer North Mine, Hydraulic Mine, No. 4 Rock Tunnel (Panel 6), No. 1 Rock Tunnel (Panel 6), open pit mine, Elkview coal processing plant and Michel By-Products plant of Kaiser Resources Limited, Sparwood, British Columbia during November 20 - 29, 1978.

The sampling method used to evaluate environmental conditions in the coal getting operations, the coal processing plant and By-Products plant was Personal Gravimetric dust samplers. The Threshold Limit Value (TLV) is currently 3 mg/m^3 for coal dust containing less than 5% quartz. In January 1979 it is intended to change the TLV to 2 mg/m^3, Mine Research Establishment (MRE) standards.

Konimetry was the sampling method used in the rock mining operations in the open pit. The TLV for siliceous dusts containing less than 30% silica, SiO_2, is 300 particles per c.c. of air.

The results obtained and the information received were as follows:

DUST CONCENTRATIONS

Rock Mining Operations

Open Pit Mine, Harmer Ridge November 25/78	No. of particles per c.c. of air.
Harmer 2 60R Bucyrus Erie drill No. 403, drilling water used, windows closed, skirting not let down on front, cab pressurizing fan requires repairs.	180 206 166 188
Harmer 2 60R Bucyrus Erie drill No. 404, drilling water used, windows closed, skirting not let down on front, cab pressurizing fan on. Two cracked windows in cab. one in door to drill, one on right side next to door.	162 148 158 172
Harmer 2 PH 2800 shovel No. 313, loading damp rock, window open 18" on right side. Cab clean inside.	92 104 122 116
Harmer 2 D9 Caterpillar No. 580, pushing rock over dump, cab pressurizer not used.	114 90 96 86
"G" Pit PH 2800 shovel No. 312, all windows closed, loading dry rock. Top left side window cracked. Cab fairly clean, some grease and dust on outside of windows.	214 232 246 224

Rock Mining Operations

Open Pit Mine, Harmer Ridge Nov. 25/78 (Cont'd.)

	No. of particles per c.c. of air.
"G" Pit PH 2100 shovel No. 334, windows closed, loading dry material, mixture of coal and waste rock.	174 196 206 188
"G" Pit D9 Caterpillar No. 579 pushing rock at dump. Cab pressurizer fan on.	146 160 172 156
"G" Pit PH 2100 shovel No. 336, loading truck with dry rock, windows closed. Small crack in left side window. Windows clean, cab fairly clean, but pile of rags on floor.	54 44 60 48
"G" Pit D9 Caterpillar No. 573 levelling pit floor pushing rock and snow, cab in poor condition, cab pressurizer not working.	62 56 52 66
"G" Pit 60R Bucyrus Erie drill No. 401, drilling water used, windows closed, cab pressurizing unit operating, front skirting up.	322 304 328 314
29 South PH 2100 shovel No. 335, loading a mixture of rock and coal, windows closed, operator's cab in poor condition.	70 56 58 62
29 South D9 Caterpillar No. 574, pushing coal and rock at dump site, operator cab in poor condition, cab pressurizing unit requires repairs.	362 326 354 388
29 South GD 120 drill No. 409, drilling, water used, windows closed, cab pressurized, skirting at front of drill up.	78 90 82 106

Coal Getting Operations

Open Pit Mine, Harmer Ridge Nov. 25/78

Gravimetric dust samples were taken at various operations about the coal getting sections. The samples are classified as to various operations as follows:

No. 589 Dart loader. Sampler in cab with operator.	2.01 mg/m^3 (MRE equiv.)
No. 590 Dart loader. Sampler in cab with operator.	1.72 mg/m^3 (MRE equiv.)

Coal Getting Operations

Open Pit Mine, Harmer Ridge Nov. 25/78 (Cont'd.)

Caterpillar No. 576. Sampler in cab with operator.	2.30 mg/m^3 (MRE equiv.)
Lectra-Haul truck No. 266. Sampler in cab with operator.	1.87 mg/m^3 (MRE equiv.)
Lectra-Haul truck No. 268. Sampler in cab with operator.	2.16 mg/m^3 (MRE equiv.)
Breaker Station. Sampler worn by clean-up worker.	7.91 mg/m^3 (MRE equiv.)

Open Pit Mine

The average dust concentrations at rock mining operations in the open pit mine were as follows:

	No. of particles per c.c. of air.
Drilling operations	188
Shovel operators	128
Caterpillar operators	168

The skirting is not being let down at the front of the drill on some of the drills when drilling.

No. 335 PH 2100 shovel operator's cab is in poor condition. The left side window is badly cracked, the windows will not close tightly and the door is not sealed properly.

Cab pressurizing units on all equipment must be properly maintained and repaired when necessary.

The breaker station dust control system is not adequate. The dust concentration as sampled by one of the clean-up workers was 7.91 mg/m^3 of air, which is well over the standard. The adverse conditions must be corrected.

Balmer North Mine

Location of operation: 303 panel, No. 4 entry. Lee Norse No. 3990 Continuous Miner with No. 6 and No. 7 Joy shuttle cars, No. 7 shuttle car was hauling and dumping into No. 6 shuttle car, which was dumping into the belt. Rock bolt and strapping roof support is used. On the miner, thirty-two water sprays are used at the cutter head. The three water sprays at the dump point onto the belt, and the three water sprays at the first transfer point on the belt were shut off because the belt drive pulley would start to slip with them turned on. A more efficient belt scraper is needed to alleviate this problem. At the third transfer point the ends of two of the three water sprays were broken off.

Balmer North Mine (Cont'd.)

Three Gardner Denver stopers, type RB 83, numbered 9, 13 and no number were found stored in No. 2 rock tunnel. All had damaged mufflers that require repair.

Dust Concentrations

Milligrams per cubic meter of air (Equivalent to MRE instrument)

Location and Date	CM #1 Operator	CM #2 Operator	Shuttle Car #1 Oper.	Shuttle Car #2 Oper.	Intake Air	Remarks
L.N. 3990 CM 303 panel Nov.20/78	10.12	5.06	5.98	9.96	7.42	Production 469 tons. On bottom coal

Ventilation Nov. 20/78	m^3/min.	CFM
Intake air along 304 incline (9 a.m., main fan on)	536	18,900
(2 p.m., main fan off)	135	4,770
Fresh air past 3990 CM (main fan off)	340	12,000
Return airway 303 panel, from 3990 CM (main fan off)	800	28,300
Intake air No. 2 rock tunnel (main fan off)	2934	103,600

CH_4 = 0.2% at face.
Air temperature W.B. = 5.5°C, D.B. = 6.0°C RH = 93%

In No. 2 Rock tunnel, WB = 7.0°C, D.B. = 14.5°C RH = 30%

There was no auxiliary ventilation to the face at CM 3990, since they were taking up bottom coal, and the air flow was directly past the operator.

At the main intake fan house, the manometer was empty. The Carbon Monoxide Alarm had not been checked on the day of inspection.

There was much dust on the roadways and in places along the belt roadways.

Balmer North Mine Ventilation

The general mine ventilation is as follows: Air enters the mine via No. 1 and No. 2 rock tunnels, flows along numbers 2, 3, 4 and 5 mains then to 302 and 303 panel areas. The return air exits via the upper workings to the 16 foot diameter exhaust air shaft to surface. There is a 400 h.p. Joy exhaust fan on surface at the top of the shaft.

The fresh air to the working areas flows along the supply road and the belt road, and this air is being contaminated by dust from the belt transfer points and from dust stirred up by supply vehicles. The deep dust on the roadways must be cleaned up and the roadways kept damp, possibly by the use of water sprays or atomizers at strategic locations.

Mine Fans in Use:

1 - 400 H.P. Joy Fan on surface at exhaust shaft.
1 - 100 H.P. Joy Fan on surface with heater. (No. 2 Rock tunnel)
2 - 30 H.P. Joy Auxiliary Fans.

The 400 H.P. fan was off from 9:30 a.m. till the end of the shift on the day of inspection because of an overheated bearing.

Hydraulic Mine

No. 611 C.M., Panel 5.
Roof support consists of steel arches with timber lagging. The miner is equipped with 14 water sprays, and works with a Goodman loader, which dumps the coal into a flume for transportation out to surface. Auxiliary ventilation to 611 CM via 36 inch diameter duct was 308 m^3/min. (10,000 CFM).

Dust Concentrations

Milligrams per cubic meter of air - Equivalent to MRE instrument

Location and Date	CM #1 Operator	CM #2 Operator	Faceman	Faceman	Fresh Air Intake	Remarks
No.611 CM Panel 5 Nov.21/78	6.41	8.05	13.31	5.91	4.90	15 ft. advance

Monitor, Nov. 27/78 0.78 mg/m^3.

At miner, CH_4 = 0.1%

Air temperatures in No. 1 Rock tunnel, DB = 10.0°C, WB = 8.5°C, RH = 82%

Main Air Flows	m^3/min.	CFM
No. 1 Flume road, intake air	814	28,700
No. 1 Belt road, intake air	1920	67,800
No. 1 Rock tunnel, exhaust air	1156	40,800
13 Adit, exhaust air	1822	64,600
Total air in	2734	96,500
Total air out	2978	105,400

Air Flows	m^3/min.	CFM
30 Entry, hydraulic station	622	23,400
31 Entry, intake air	Not enough	to measure
32 Entry, air in 36 in. dia. duct	343	12,100
33 Entry, air in 36 in. dia. duct	343	12,100
Aux. air to 611 CM, via 36 in. dia. duct	308	10,900
Air down ore supply road	2677	94,500

In No. 1 Rock tunnel, after diesel powered Hunslett MT60 had just passed by, going up.

$$NO + NO_2 = 1.0 \text{ ppm}$$

$$CO = 0$$

Hydraulic Mine - Ventilation

The general ventilation of the Hydraulic mine is as follows: Air enters the mine via the hydraulic test mine portals and travels along No. 1 flume road and No. 1 belt road. The exhaust airways are No. 1 rock tunnel and No. 13 adit. Auxiliary fans with 36 inch diameter ducts are used to ventilate CM development headings, and monitor headings.

A Hunslet MT60 is used for transporting supplies. This vehicle requires 637 m^3/min (22,500 CFM) of fresh air to operate.

The intake air is being contaminated by deep dry dust especially in No. 2 entry. This dust must be cleaned up, and the roadway kept damp to prevent further dust. It was very dry and dusty in front of the auxiliary fresh air fan to the CM, and men walking through this entry stirred up much dust.

Fans in Use:

1 - 100 H.P. Joy fan on surface with heater.

5 - 30 H.P. Joy auxiliary fans.

Balmer South

No. 4 Rock Tunnel - Panel 6

No. 843 Continuous Miner was operating in 06005 roadway, with a Joy shuttle car used to haul the coal about 400 ft. to the dump raise. Steel arches with wooden plank lagging are used for roof support. The miner is equipped with 18 water sprays. Auxiliary ventilation to the face was via 36" diameter duct, 55 ft. from the face. The distance from the 75 H.P. Joy fan to the end of the duct was 415 ft. The air flow was 326 m^3/min (11,500 CFM) at the end of the duct. Approximately half the shift was spent timbering. The miner advanced 10 ft. and 77 tons of coal was mined.

Air temperature at miner: WB = 7.5°C, DB = 9.0°C, RH = 82%

At face, CH_4 = 0.1%

Air temperature at vent. sta. 2, No. 4 Rock tunnel: DB = 18°C, WB = 7.5°C, RH = 16%

Dust Concentrations

Milligrams per cubic meter of air - Equivalent to MRE instrument

Location and Date	CM #1 Operator	CM #2 Operator	Shuttle Car Operator	Faceman	Faceman	Intake Air	Remarks
CM 843 06005 Roadway Nov.22/78	6.24	5.42	6.44	2.63	2.63	1.81	Advance 10 ft. 77 tons mined

Location and Date	CM #1 Operator	CM #2 Operator	Shuttle Car Operator	Faceman	Faceman	Remarks
CM 765 06006 Belt roadway Nov.27/78	5.09	1.81	7.39	1.64	2.14	80 tons mined

CH_4 = 0.05% at face.

Air temperature, DB = $10.0^{o}C$, WB = $8.0^{o}C$, RH = 76%

No. 4 Rock Tunnel (Panel 6) - Ventilation

Air Flows	m^3/min.	CFM
Fresh air in 36 inch dia. duct to 843 CM (Reading taken 30 m. from fan)	326 411	11,500 14,500
06005 Roadway, HW entrance to 843 machine entry	1513	53,400
06006 Belt roadway, return air	1581	55,800
06006 Belt roadway, fresh air intake in 30 inch dia. spiral duct	190	6,700
Access No. 4 Rock tunnel, fresh air intake	1905	67,300
Leakage between airlock doors	237	8,350

The main 100 H.P. fan is at a static pressure of 2.5 inches W.G.

Fans in Use:

1 - 100 H.P. Joy Fan (on surface with heater).

2 - 75 H.P. Joy auxiliary fans.

1 - 5 H.P. auxiliary fan.

Balmer South

No. 1 Rock Tunnel, Panel 6

Air Flows	m^3/min.	CFM
Intake Air, No. 1 Entry	2742	96,800
Return Air, No. 2 Entry, flume road	3397	112,000
No. 3 Rock tunnel, intake air	4221	149,000
No. 3 Rock tunnel, at #1 Entry to dewatering plant	3535	125,000
No. 1 Entry, lower 36" dia. duct, 50' from CM 764		
Rdg. taken near end	267	9,440
Rdg. taken near fan	377	13,300
No. 1 Entry, upper 36" dia. duct, at CM 764		
Rdg. taken near end	274	9,690
Rdg. taken near fan	411	14,500
Total auxiliary fresh air to CM 764	541	19,130
Auxiliary fresh air to No. 2 Entry, 860 CM		
Upper 36" dia. duct at CM 860,		
Rdg. taken 30' from end	274	9,690
Rdg. taken 20' from fan	446	15,700
Lower 36" dia. duct at CM 860,		
Rdg. taken 30' from end	178	6,300
Rdg. taken 20' from fan	343	12,100
Total auxiliary fresh air to CM 860	452	15,990

CH_4 = 0.4% at face, near CM 764.

Air temperature, DB = 10.0°C, WB = 7.5°C, RH = 71%

Re the auxiliary air into No. 1 entry, there were many holes in the ducting, especially near the fans. These holes should be repaired by patching, and not stitched up with haywire.

Gardner Denver stoper, No. 7 was stored at the top of the raise in No. 1 entry. The muffler was damaged on this machine.

75 H.P. Joy fans were used for auxiliary ventilation. 40 tons of coal were mined with CM 764.

Drager tests taken near the supply vehicle, on Eimco 975 in No. 1 entry gave:

$$NO + NO_2 = 0.5 \text{ ppm}$$

$$CO = 0$$

The air flow was 96,800 CFM.

Dust Concentrations

Milligrams per cubic meter of air - Equivalent to MRE instrument

Location and Date	CM #1 Operator	CM #2 Operator	Faceman	Faceman	Faceman	Fresh Air Intake	Remarks
Joy CM 764, Panel 6, No. 1 Entry Development Nov.23/78	5.84	4.87	3.89	1.95	12.02	3.33	40 tons mined

No. 2 Entry, Panel 6

Dust Concentrations

Milligrams per cubic meter of air - Equivalent to MRE instrument

Location and Date	CM #1 Operator	CM #2 Operator	Faceman	Faceman	Mechanic	Return Air	Remarks
CM 860 No.2 Entry 06002 Nov.24/78	5.78	6.71	10.58	9.30	4.02	4.17	100 tons mined, advance 15 ft. Away from face abou 40 mins. repairing flume

CH_4 = 0.9% at face.

Air temperature, DB = 10.2^{o}C, WB = 8.2^{o}C, RH = 76%

Miners were wearing dust masks, type 3M 8500.

Elkview Coal Processing Plant Nov. 26/78

The coal processing plant has been described previously. Gravimetric samplers were worn by the following workers as indicated by occupation.

Dust Concentrations in milligrams per cubic meter of air.

Raw coal silo operator	2.82
Plant feed, top floor	2.44
Clean coal silo operator	0.58
Dryer helper operator	1.73
Lower floor	8.87 (Sample interrupted)
Loading train	0.52

Elkview Coal Processing Plant (Cont'd.)

Clean up in the plant could be much improved, especially when the plant is not running, as when awaiting coal train, e.g. Nov. 26/78 (Sunday).

In the sample treatment lab, the splitter and pulverizer should be hooded and connected to an exhaust fan.

Diesel Exhaust Fumes (from CPR diesel locomotives)

At loading station North $CO = 50$ ppm
$NO + NO_2 = 8$ ppm

At loading station, oil pump elevation $CO = 50$ ppm
$NO + NO_2 = 9$ ppm

Michel By-Products Plant Nov. 28/78

The By-Products plant produces 500 tons of metallurgical coke per day. The other two products are gas, which is used by the plant, and tar.

Gravimetric samplers were worn by the following workers as indicated by occupation.

Dust Concentrations - milligrams per cubic meter of air.

Lorryman	4.11
Loaderman	0.66
Clean-up man	6.57

Drager tests taken at the lorryman's location gave $CO = 8$ ppm
$NO + NO_2 = 0$

Noise Control

All the mufflers on the stopers used underground were damaged. The mufflers must be repaired immediately or the drills shall be removed from the underground workings. It was noted that some workers did not wear ear protection when required, e.g. shuttle car operator in No. 4 rock tunnel working with CM 843. The dump raise was near two 75 H.P. fans and therefore a noisy location. Ear protection must be worn in all noisy locations.

SUMMARY

Dust Concentrations - Gravimetric Sampling

Milligrams per cubic meter of air - MRE Equivalent

Operation Area, Open Pit Mine Nov. 25/78	Truck #266 Operator 1.86	Truck #268 Operator 2.15	Dart #589 Operator 2.01	Dart #590 Operator 1.73	Cat. #576 Operator 2.30	Breaker Clean-up Crew 7.91
Underground Balmer North LN 3990 CM Nov. 20/78	CM #1 Operator 10.12	CM #2 Operator 5.06	Shuttle Car #1 Operator 5.98	Shuttle Car #2 Operator 9.96	Intake Air 7.42	(Main fan off)
Hydraulic Mine CM 611 Joy Nov.21/78	6.41	8.05	Faceman 13.31	Faceman 5.91	4.90	Monitor 0.78 Nov.27/78
No. 4 Tunnel Joy 843 CM Nov.22/78	6.24	5.42	Shuttle Car 6.44	2.63	Faceman 2.63	Intake Air 1.81
No. 4 Tunnel Joy 765 CM Nov.27/78	5.09	1.81	7.39	1.64	2.14	
No.1 Rock Tunnel Joy 764 CM Nov.23/78	5.84	4.87	Faceman 3.89	1.95	12.02	3.33
No.1 Rock Tunnel Joy 860 CM Nov.24/78	5.78	6.71	10.58	9.30	Mechanic 4.02	Return Air 4.17
Elkview Coal Processing Plant Nov.26/78	Raw Coal Silo 2.82	Clean Coal Silo Oper. 0.58	Dryer Helper Operator 1.73	Plant Feed 2.44	Train Loading 0.52	Plant, Low Floor Sample Interrupted
BP Plant Nov.28/78	Lorryman 4.11	Loaderman 0.66	Clean-up Worker 6.57			

SUMMARY (Cont'd.)

Dust Concentrations - Konimetry

Open Pit Mine	No. of particles per c.c. of air.
- drilling operations	188
- shovel operators	128
- Caterpillar operators	168

Open Pit Mine:

1. The dust control system at the breaker station requires corrective attention to lower dust concentrations to within the standard.
2. The skirting is not being let down at the front of some of the drills while drilling.
3. No. 355 PH 2100 shovel operator's cab is in poor condition.
4. The cab pressurizing units on all equipment must be properly maintaine and repaired if necessary.

Underground:

1. The Gardner Denver stoper with damaged mufflers must either be repaire immediately or removed from service.
2. Ear protection must be used at all drilling and coal cutting operatior
3. All excessive dust in the belt and supply roadways must be cleaned up and water applied to suppress any remaining dust.
4. A method of ventilation that will reduce the dust concentration to within the standards at continuous miner operation must be instituted without any further delay.
5. The holes in the ventilation ducts to CM 764 and CM 860 must be patched to prevent leakage.
6. In No. 4 tunnel the main air doors should be made more airtight to reduce leakage of fresh air.
7. In Balmer North Mine water sprays must be used at all belt transfer points.
8. The exhaust gases of diesel-powered equipment shall be sampled at least twice per week for carbon monoxide and oxides of nitrogen, as per CMRA, 95 (b)(iii)(A). This test should be done on surface.

Elkview Coal Processing Plant:

1. In the sample preparation laboratory the splitter and pulverizer must be hooded and dust control installed.
2. Clean-up about the plant and silos must be improved.
3. CPR diesel exhaust fumes are above the TLV's in loading stations. This condition must be corrected.

S. Elias, P. Eng. Senior Inspector Environmental Control	DMurray D. J. Murray, P. Eng. Inspector Environmental Control

APPENDIX 9C

NOTES OF THE ENVIRONMENTAL CONDITIONS AT
GIBRALTAR MINES LIMITED
McLEESE LAKE, BRITISH COLUMBIA

D. J. Murray, P. Eng.
Inspector
Environmental Control

August 15, 16, 1979

NOTES OF THE ENVIRONMENTAL CONDITIONS AT

GIBRALTAR MINES LIMITED

McLEESE LAKE, BRITISH COLUMBIA

A survey of the environmental conditions was made in the open pit mine, primary and secondary crushing plants, fine ore reclaim conveyors and assay grinding room at Gibraltar Mines Limited, McLeese Lake, B. C. during August 15 and 16, 1979. The results obtained and information received were as follows:

Primary Crusher Aug. 15/79	No. of particles per c.c. of air.
In control room, truck dumping fairly dry muck. One side window in room open.	56 74
At base of gyratory crusher.	230 216
Rock box elevation, beside inspection doors. Some dust on floor in front of doors.	322 354
Along No. 1 conveyor, discharge point from feeders.	310 360
No. 2 conveyor tail pulley.	262 284
Along No. 2 conveyor gallery at mid point. Exhaust system operating.	86 124
Secondary Crusher Aug. 15/79	
No. 2 conveyor discharge point to primary screen, at head pulley.	314 284
Along No. 6 conveyor gallery at feeders discharge point.	228 242
Along No. 5 conveyor gallery at feeders discharge point.	260 254
No. 6 conveyor head pulley, discharge to No. 3 and No. 4 secondary crushers.	316 276
No. 5 conveyor head pulley, discharge to No. 1 and No. 2 secondary crushers. Inspection port closed.	240 212
Between splitter feed chutes to secondary cone crushers. Inspection port closed.	224 196
Between No. 3 and No. 4 secondary cone crushers, feed elevation.	218 248

Secondary Crusher (Cont'd.)	No. of particles per c.c. of air.
Between No. 1 and No. 1 secondary cone crushers, feed elevation.	268 294
In operator's booth, control room, outside window open.	32 22
Between No. 1 and No. 2 primary screens, feed ends, deck elevation.	232 254
No. 1 screen discharge end at inspection door, maintenance floor.	208 194
No. 2 screen discharge end at inspection door, maintenance floor.	192 180
Between No. 2 and No. 3 cone crushers, base elevation.	164 178
Maintenance floor elevation at No. 2 cone crusher rock box inspection door.	310 298
Between No. 3 and No. 4 screens, No. 4 screen not operating.	286 260
Between No. 1 and No. 2 screens.	316 328
Adjacent to No. 3 conveyor, mid point. Some dust on floor.	294 322
Adjacent to No. 7 conveyor, mid point.	184 204
Beside No. 4 conveyor tail pulley.	324 362
Along No. 8 conveyor gallery, mid point.	184 218
No. 8 to No. 9 conveyor transfer point.	192 182
Along No. 9 conveyor at dump point to fine ore bin, dust skirting removed.	402 390

Fine Ore Reclaim Conveyors Aug. 15/79	No. of particles per c.c. of air.
No. 10 conveyor discharge point.	160 152
No. 12 conveyor discharge point.	104 108
No. 15 conveyor discharge point.	122 94
No. 13 conveyor discharge point.	132 78
No. 19 conveyor, mid point.	102 124
No. 20 conveyor, mid point.	174 142

Assay Grinding Room Aug. 16/79

Using a dried tailings sample dust spots were taken in the operator's breathing zone during the following regular bucking operations:

Pulverizer, equipped with dust hood and ducting attached to exhaust fan.	74 58 38 44
Rolling and bagging samples under dust hood.	54 32 24 40
Splitting of sample in riffle. Equipped with dust control hood and ducting.	204 168 142 150

Open Pit Mine Aug. 15/79

In cab of No. S1 P & H 2100B electric shovel on 3500 bench Gibraltar East pit. Lower and top front windows missing, both side windows open. Loading fairly dry waste.	104 56 42 74
In cab of No. D10 Bucyrus Erie drill on 3500 bench. Windows all closed and intact. Front door was open, we closed it. Pressurizing fan working. Front skirting was tied in up position. Water used for dust control.	182 148 136 102

Open Pit Mine (Cont'd.)	No. of particles per c.c. of air.
In cab of No. S3 P & H 2100B electric shovel on 3500 bench loading fairly damp rock. Front window open, most of the side windows cracked, side windows open.	48 56 60 44
In cab of No. D12 Marion M4 drill. All windows closed and intact. Both doors closed. Skirting in good condition.	108 74 82 94
In cab of No. S5 P & H 2100BL electric shovel loading dry ore on 3680 bench. Front and side windows open.	120 64 72 80
In cab of No. 65 D8 caterpillar, at waste dump. Back window and both doors open. No pressurizing system in cab. Operator wearing ear muffs.	164 182 148 120

REMARKS

Open Pit Mine

The average dust concentration about the drilling operations was 116 particles per c.c. of air. The dust concentration at all other locations was 90 particles per c.c. of air.

All drills are equipped with a double filter system on the unit used to pressurize the cabs. The filters are cleaned at the beginning of each shift.

Primary Crushing Plant

The average dust concentration about the primary crushing plant was 223 particles per c.c. of air and 65 particles per c.c. of air in the operator's control room.

Secondary Crushing Plant

The average dust concentration about the secondary crushing plant was 245 particles per c.c. of air and 27 particles per c.c. of air in the operator's control room. The outside window was open in the control room.

Fine Ore Reclaim Conveyors

The average dust concentration about the fine ore reclaim conveyors was 124 particles per c.c. of air.

Assay Grinding Room

The average dust concentration in the assay grinding room while samples were being prepared was 86 particles per c.c. of air. The equipment is equipped with dust hoods connected to ducting and an exhaust fan.

SUMMARY

The average dust concentrations found at the various operations were:

		No. of particles per c.c. of air.
Open Pit Mine	- drilling	116
	- at all other locations	90
Primary Crushing Plant	- operator's control booth	65
	- overall plant average	223
Secondary Crushing Plant	- operator's control booth	27
	- overall plant average	245
Assay Grinding Room		86
Fine Ore Reclaim Conveyors		124

Skirting on the drills must be let down to control the dust.

DJ Murray

D. J. Murray, P. Eng.
Inspector
Environmental Control

September 17, 1979

THE GOVERNMENT OF
THE PROVINCE OF BRITISH COLUMBIA

DEPARTMENT OF MINES
AND PETROLEUM RESOURCES

REPORT OF INSPECTOR OF MINES

(Issued pursuant to sections 5 and 6 of the Coal Mines Regulation Act and sections 6 and 7 of the Mines Regulation Act.)

ENVIRONMENTAL CONTROL

Name of property .... Locality McLeese Lake

Owner or operator GIBRALTAR MINES LIMITED

Manager Mr. J. D. Wright Address Box 130 McLeese Lake, B. C.

Portions inspected and conditions found: Open Pit Mine, primary and secondary crushing plants, fine ore reclaim conveyors and assay grinding room.

	No. of particles per c.c. of air.
Open Pit Mine - drilling	116
- all other operations	90
Primary crushing plant	
- operator's control booth	65
- overall plant average	223
Secondary crushing plant	
- operator's control booth	27
- overall plant average	245
Assay grinding room	86
Fine ore reclaim conveyors	124

Remarks: Skirting on the drills must be let down to control the dust.

Certificates of fitness, either temporary or annual, must be obtained before a man works underground or in any of the other specified categories of work which require such a certificate. Temporary certificates are good for two months. Annual certificates are good for a period of one year.

Number of workmen that have the required certificates of fitness ....

Number of workmen that do not have the required certificates of fitness ....

The following workmen require certificates of fitness:

Checked March 1979

MINISTRY OF ENERGY,
MINES AND PETROLEUM RESOURCES
103 - 2747 E. HASTINGS STREET
VANCOUVER, B.C. V5K 1Z8
(Address.)

D. J. Murray, P. Eng., *Inspector, Environmental Control.*

Date of inspection August 15, 16, 1979

APPENDIX 10

SUMMARY OF ENVIRONMENTAL CONTROL AT BRITISH COLUMBIA MINES DURING THE YEAR 1979

S. Elias, P. Eng.
Senior Inspector
Environmental Control

CONTENTS Page

APPENDIX

PREFACE

The Ministry of Energy, Mines and Petroleum Resources, Environmental Control Inspectors are trained to control adverse effects in the mining industry related to silicosis, pneumoconiosis (black lung), asbestosis, hearing loss and other mining environmental related industrial hazards. Inspection surveys are conducted at metal, coal, asbestos, industrial minerals, structural minerals, uranium exploration mining and/or exploration operations about the British Columbia provincial mining industry. The inspection surveys include siliceous dust control sampling, coal dust sampling, asbestos fibre control sampling, mineral dust sampling, welding fumes sampling, ventilation air movements, hazardous gases sampling, ionizing radiation sampling, heat stress evaluation, noise level surveys, hearing conservation programs, ensuring that "dust exposure occupations" maintain valid medical certificates of fitness, assure that audiometric tests for hearing acuity are maintained, training audiometric technicians, and training dust control technicians.

The permanent staff establishment for the Environmental Control Division consists of: Senior Inspector, two Inspectors on dust control and related hazards, an Inspector Technician on noise control surveys, and an Inspector Audiologist on hearing conservation programs. There were no staff changes during the 1979 year. Environmental Control inspection procedures require the use of a variety of instrumentation that must be kept in perfect calibration at all times to give accurate results, all personnel require an extensive training period before they are able to carry out their duties effectively. Of particular importance is the fact that the inspector must be aware of the physiological effects of a multitude of potentially hazardous compounds and conditions. A broad spectrum of professional disciplines are required that include engineering, physics, chemistry and toxicology to evaluate the probability that a hazardous situation does or might exist. Other aspects are the identification and quantification of exposure levels, application of realistic methods of evaluating the work environment, and selecting options for control or lessening of exposure.

INTRODUCTION

The dust sampling strategy is based on a number of short term samples taken to determine a workers relative exposure for silicosis, pneumoconiosis and for engineering control purposes in the areas that are regularly traversed by the worker for operational control. It has been shown that it is more meaningful to collect random samples of short term duration throughout a working day than to collect one long term (total sampling time equal to more than half of a working day), sample. The short term samples are better because the longer term environmental fluctuations during the working day are "averaged out" and therefore do not show the trouble spots. Although the long term samples indicate the same relative health hazards in the same manner as a short term sample averages the engineering control aspect is lost in the long term sampling procedures. The workers in plants do not remain at any specific site for extended periods unless there is some operational malfunction. Therefore the average of the short term sampling is considered to give a relative health hazard especially when years of sampling results are available for statistical interpretation. The individual dust concentrations about a plant as tabulated in the inspection notes cannot be taken out of text to represent worker exposure. It is further noted that silicosis takes many years to develop and that the standards set are predicated on historical and medical experience and represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse health effects. However due to wide variations in individual susceptibility a small percentage of workers may develop some occupational illness. It is fully realized that the ultimate standard to strive for is zero contamination. Hygiene health standards should be used as GUIDES in the control of health hazards not as a very fine dividing "safe" from "dangerous" concentrations. The findings from years of systematic dust studies have shown useful correlation with the incidence and progression of silicosis and pneumoconiosis among exposed workers, and in programmes of dust-control the measured reduction in dustiness has been followed by a parallel decrease in disease incidence. This can be shown by combining silicosis pension statistics with the average dust concentrations at mining operations over a period of 42 years in British Columbia.

ENVIRONMENTAL CONTROL AT
BRITISH COLUMBIA MINES DURING THE YEAR 1979

SUMMARY

A total of 145 surveys of environmental conditions were made at 84 operations during 1979. The surveys were made at lode mines both underground and open pit operations, rock quarries, gravel pits, asbestos mine, uranium exploration sites and coal mines.

31 surveys were made at operations of 22 underground mines;
25 surveys were made at operations of 13 open pit mines;
54 surveys were made at operations of 42 quarry and gravel pit operations;
2 surveys were made at operations of 1 asbestos mine;
3 surveys were made at operations of 3 collieries;
3 surveys were made at operations of 3 open pit coal mines;
27 surveys were made for radiation at 20 mining and/or exploration properties.

10 noise surveys were made at 10 underground mines;
6 noise surveys were made at 6 open pit mines;
21 noise surveys were made at 21 quarry and gravel pit operations;
2 noise surveys were made at 2 coal mining operations.

A total of 549 locations were assessed for noise hazards.

Supervisors and workers must be educated to the fact that dust control is one of a sequence of procedures equal in priority to any other sequence in the mining cycle. Failure to apply this strategy results in health hazards not only to the worker failing to comply but to other workers about the operation. Sixty-five percent of the surveys at underground drilling operations gave averages of less than 300 particles per c.c. of air.

The "all other" locations represents the locations where the majority of workers are working. When ventilation and dust control rules are complied with the health hazard risks are reduced that nearly all workers may be repeatedly exposed day after day without adverse effects. Ninety-three percent of the surveys gave averages of less than 300 particles per c.c. of air.

This year ninety-one percent of the survey averages were less than 300 particles per c.c. of air about the underground crushing plants. Operator failure, maintenance and improperly designed dust control systems remain culprits that prevent reaching the desired standards.

SUMMARY (Cont'd.)

Assay grinding rooms dust control systems that are experiencing lack of maintenance cause dust problems. Ninety-three percent of the surveys were less than 300 particles per c.c. of air. Two operations did not meet this standard.

Drilling operations at open pit mines have upgraded from eighty percent in 1978 to eighty-six percent this year meeting the 300 particles per c.c. of air or less standard. Again lack of maintenance and failing to comply with known preventative methods foil the attempt to have all operations within desired standards.

The "all others" category in the open pit mines were again one hundred percent less than 300 particles per c.c. of air. When proper operating methods and dust control is practiced it is evident that the health hazard can be reduced to minimal in this category.

Crushing plants at open pit operations must be equipped with excellently designed dust control systems and high priority maintenance schedules to maintain dust controls that will meet suitable standards. This year there were seven surveys out of thirty that gave unsatisfactory results, corrective action has been taken. Seventy-seven percent of the surveys were less than 300 particles per c.c. of air.

At structural and industrial mineral operations the surveys at drilling were one hundred percent less than 300 particles per c.c. of air; all others were one hundred percent less than 300 particles per c.c. of air; crushing and screening were eighty-one percent less than 300 particles per c.c. of air and about the operators booth were eighty-six percent less than the standard. Portable crushing and screening plants, poor maintenance, design and operator failure are the problem areas.

Ninety-eight percent of the locations sampled about coal mines were under the established standard as sampled with personnel respirable gravimetric dust samplers. One hundred percent of the samples taken at rock moving operations by konimetry were less than the allowable standard. Operators are aware of the corrective means on hand that will reduce dust health hazards and are using many effectively.

At asbestos mining operations ninety-seven percent of the samples taken were under 5 fibres per millilitre of air, eighty-seven percent were under the 2 fibres per millilitre of air standard that comes into effect January 1, 1980. Renovations are progressing in all areas of the plant that should reduce all locations to within the standard when completed. The dryer section is presently being renovated and is scheduled for completion late in 1980.

SUMMARY (Cont'd.)

Thirty-nine noise surveys were made about the underground and open pit mines, quarries and gravel pits and coal mining operations. Ninety-eight percent of the workers had received audiometric tests. Seventy-four percent at metal mining operations wore the required ear protection. In the industrial and structural minerals sixty-two percent wore the required ear protection when required. This year the audiometric test data was computerized; this will give industry valuable information so that corrective procedures may be instituted to reduce hearing loss to workers.

Radiation surveys were made for radon daughters and gamma radiation at twenty mining operations. Two non-uranium mining operations were closed down until corrective measures were taken to lower the radon daughter concentrations.

Certificates of fitness were checked at mining operations as per Section 18 of the CMRA and MRA. The results were as follows:

Lode Mines - 99% had the required certificates of fitness;
Coal Mines - 99% had the required certificates of fitness;
Asbestos Mine - 100% had the required certificates of fitness.

Drilling Operations Underground

Dust control at drilling operations may be divided into two categories - development mining drilling and production drilling. Dust produced at drilling operations can be controlled by using the proper distribution of fresh ventilating air either by the use of auxiliary ventilation or through air flows of the regular circuit, an adequate water supply and good mining practices in general. This year eight averages out of 23 surveys at underground mining operations gave dust concentrations over 300 particles per c.c. of air. The causes were one or more of the following: no ventilation to the heading; ventilation fan turned off; end of ventilation duct too far from face; insufficient air volume and ventilation distribution in stoping areas. In all but one location where the high dust concentrations were noted the means of correcting the adverse condition was immediately possible by the worker if established rules were followed. When insufficient air volume is the cause the company is required to install suitable equipment that will satisfy dust control standards. The minimum auxiliary ventilation that should be considered is the greater of - diesel powered equipment permit requirements and/or 15 m^3/min. per square metre of face area or cross section of the working area with the end of the ventube not more than 10 metres from the working area.

The results dating back to 1975 are given below for comparison:

Year	Number of Surveys	Percentage of Surveys Below 300 particles per c.c. of Air
1975	17	77
1976	8	88
1977	5	100
1978	17	82
1979	23	65

All Other Underground Locations

The term "All Other Underground Locations" represents the dust concentrations in the general working areas where no drilling is being done, such as - stopes, slushers, haulage operations, draw points, mucking, etc. and the general mine atmosphere. Two average dust concentrations at two mining operations gave dust concentrations over 300 particles per c.c. of air. The causes were: fresh air circuit contaminated from mucking operations on a lower level; insufficient air volume being supplied by the auxiliary ventilation system and no direct auxiliary ventilation to a working area. To correct these adverse conditions one company has installed larger ventilation fans and redesigned the distribution and the other company is keeping a close watch on workers to ensure that proper auxiliary ventilation systems are utilized as required. Strict control of diesel powered units usage is being enforced. Any diesel powered units operating contrary to permit requirement is stopped and removed from the location until permit requirements are met.

The percentage of surveys that have averages meeting the standard for the past five years are listed for comparison:

Year	Number of Surveys	Percentage of Surveys Below 300 particles per c.c. of Air
1975	17	82
1976	10	90
1977	7	100
1978	21	100
1979	28	93

Crushing Plants At Underground Operations

Adequate properly designed dust control systems are required at all crushing and screening operations. The dust control measures at underground mine crushing plants include: use of water to wet freshly broken rock and/or ore to prevent further dust release; confine dusty operations by isolation; remove dust that cannot be confined by dust control systems and dilute dust that has escaped capture with fresh make-up air. Dust control systems require constant maintenance to ensure a high degree of efficiency. Worn ducts, hoods and leaving inspection ports open upsets the balance of the dust control system and thereby decreases the efficiency and causes higher than normal dust concentrations in the plants. A properly designed and maintained dust control system will achieve a standard within the required limits.

Twenty-three surveys were made this year, two surveys gave dust concentrations over the 300 particles per c.c. of air standard. The causes were corrected by redesigning the dust control system and installing a new dust collector at one location.

The number of surveys in crushing plants that were below the 300 particles per c.c. of air standard for the past five years are listed for comparison:

Year	Number of Surveys	Percentage of Surveys Below 300 particles per c.c. of Air
1975	14	79
1976	8	63
1977	10	60
1978	17	76
1979	23	91

Assay Grinding Rooms - Underground and Open Pit Mines

All assay grinding rooms used for sample preparation for assay purposes that crush and pulverize samples require a suitable dust control system. All the equipment must have hoods. The hood face velocity should be between 75 - 150 metres per minute to effectively capture the dust from the operations. This year two surveys out of twenty-seven were over the standard. The causes were in one case the ducts system at one operation was broken down and at the second location it was a deterioration of the complete dust control system. Both systems have been overhauled.

For comparison the last five years results are listed:

Year	Number of Surveys	Percentage of Surveys Below 300 particles per c.c. of Air
1975	20	95
1976	17	71
1977	12	58
1978	21	100
1979	27	93

Drilling Operations at Open Pit Mines

All drilling operations at open pit operations require suitable dust control devices e.g.: drills equipped with cabs that are pressurized with fresh filtered air; must use either an acceptable dust collector with filter unit or drill with water. There are still a number of drills that do not have their cabs pressurized with fresh air and are deficient in maintaining skirting about the drill stem.

There were two surveys out of fourteen where dust concentrations were over the 300 particles per c.c. of air standard. The cause at one drill was a plugged filter of the cab pressurizing unit, a clean filter corrected the condition. The second operation did not have the cabs pressurized with fresh air and the drill steel was plugged therefore no water was getting down the drill hole. The company will be installing cab pressurizing units and stepping up maintenance.

For comparison the last five years results are listed:

Year	Number of Surveys	Percentage of Surveys Below 300 particles per c.c. of Air
1975	12	67
1976	4	75
1977	7	100
1978	15	80
1979	14	86

All Other Operations in Open Pit Mines

This category includes all the workers in the open pit exclusive of drilling operations: e.g. shovel operators, truck drivers, loader operators, caterpillar operators, blast hole loaders, etc. The majority of the trucks, shovels, caterpillar tractors, and front end loaders are being equipped with noise attenuated cabs with fresh air pressurizing units. Adverse conditions may be realized whenever an operator does not utilize the control at hand or when an older piece of equipment is being used that is not equipped with suitable controls.

The percentage of surveys below 300 particles per c.c. of air are listed below for comparison:

Year	Number of Surveys	Percentage of Surveys Below 300 particles per c.c. of Air
1975	13	85
1976	4	100
1977	9	89
1978	16	100
1979	21	100

Crushing Plants at Open Pit Mines

All open pit mine crushing plants require suitable dust control systems. Many of the open pit operations have increased production after original plant design. The result is renovation of the crushing plant and related facilities to accommodate the increased production. To achieve this more machinery is installed in buildings that were not originally designed to accommodate this increase. This effectively increases production but the dust control system is just extended and crowded to service the additional crushing machinery; this leads to poor design and maintenance problems and inadequate dust control. Other factors that contribute are: no central vacuum systems for clean-up purposes, large tonnages of dry ore being handled on open belt systems, etc.

There were seven surveys out of thirty that gave unsatisfactory results. The causes can be contributed to: inadequate control system, poor clean-up, dust control system not receiving proper maintenance and in one case the operator's booth pressurizing fan was not being used. In all cases the companies are taking corrective action that includes redesigning complete dust control systems.

For comparison the past five years of surveys are listed below:

Year	Number of Surveys	Percentage of Surveys Below 300 particles per c.c. of Air
1975	22	36
1976	6	83
1977	13	54
1978	25	76
1979	30	77

Structural and Industrial Minerals

Dust surveys were made at forty-two plants that produce structural or industrial minerals. A summary of the conditions is as follows:

Operation	No. of Surveys		Percentage of Surveys Below 300 particles per c.c. of Air	
	1978	1979	1978	1979
Drilling	11	16	91	100
All Others	7	15	100	100
Crushing & Screening	41	52	73	81
Operators Control Booths	-	14	-	86

The dust control about gravel pits and quarries crushing and screening plants has improved. Ten surveys out of 52 gave dust conditions about the plants that were over the 300 particles per c.c. of air standard. Three of these plants are operated by a front end loader operator that is not exposed to the high dust concentrations and one plant was closed down. Two plants have renovated the plant dust control system. One plant was waiting for parts to repair a bag filter unit, and the remaining three plants require an improvement in maintenance and dust control generally such as the use of water sprays, operator control booth improvements, etc.

Portable crushing and screening units that are moved from area to area as required by contractors to fulfill a contract cause regulation enforcement problems. These plants are moved interprovincially and the operators are not or indicate they are not aware of the required standards. When confronted with the standards they either move or stop operations.

Coal Mines

Personnel respirable gravimetric dust samplers are used to assess the dust conditions at all coal mining operations and Konimetry is used to assess all rock removal operations. At underground operations auxiliary ventilation to the working heading and the use of water sprays are the main means of dust control. The most successful ventilation method is the overlap system. This combines the advantages of having good scouring action at the face from the forcing system and the removal of high dust concentrations from the operators' locations at the face and along the entries by the exhausting system.

In the open pit mines all new vehicles are required to have operator's cabs pressurized with fresh filtered air. Many of the older units have been renovated at overhaul time to conform. This has reduced both the dust and noise hazards.

Following are the results for comparison:

Year	Gravimetric No. of Samples	Konimetry Surveys	Percentage of Samples &/or Surveys Less Than Allowable Standards
1973	44	-	63
	-	4	75
1975	44	-	59
	-	3	67
1977	47	-	83
	-	2	100
1978	48	-	40
	-	1	100
1979	51	-	98
	-	3	100

Asbestos Mining

The Membrane Filter Method is used to assess the asbestos fibre health hazard. The standard is being changed January 1, 1980 from 5 fibres to 2 fibres per cubic centimetre greater than 5 microns in length as determined with a phase contrast illuminated microscope at 625X magnification.

The overall arithmetical average was 1.1 fibres per millilitre. This is well within the present standard.

Following is a summary of the results obtained by membrane filter method of assessment for several years:

Year	Number of Samples	Percentage of Samples Under 5 Fibres per Millilitre of Air
1975	158	19
1977	56	45
1978	71	96
1979	76	97
		87 percent meets the 2 fibres/ml. standard

There were 10 sample locations that were over 2 fibres per millilitre out of the 76 samples taken and two of these samples were over 5 fibres per millilitre.

Renovations are progressing in all areas of the plants. The dryer section is presently receiving priority.

The medical preventative program has been extended to include lung function tests to augment the regular manditory "certificate of fitness" requirements as per M.R.A. Section 18. A change house provides clean and work clothes areas to ensure that all workers change to street clothes before going home; this prevents home contamination.

One hundred percent of the workers had the required certificates of fitness as required per M.R.A. Section 18.

Noise Control

Sound surveys and audiometric inspections were made as follows:

10 surveys were made at operations of 10 underground mines;
6 surveys were made at operations of 6 open pit mines;
21 surveys were made at operations of 21 quarry and/or gravel pit operations;
2 surveys were made at operations of 2 coal mines.

A total of 549 locations were assessed for noise hazards.

The total number of sound surveys made was 39. In the mining industry 98 percent of the checked personnel subjected to noise levels over 85 dBA are receiving regular audiometric checks for hearing acuity.

A summary of the past five years results are shown for comparison:

Metal Mining Operations	1975	1976	1977	1978	1979
Workers wearing ear protection	76%	78%	88%	41%	74%
ear muff type protection	64%	67%	75%	53%	56%
ear insert type protection	36%	33%	25%	47%	44%
Drills tested that were muffled	100%	100%	100%	100%	100%
Drills tested that were not muffled	0%	0%	0%	0%	0%
Total number of operations	15	18	3	11	16
Structural Minerals Operations					
Workers wearing ear protection	83%	83%	89%	44%	62%
ear muff type protection	87%	85%	50%	100%	69%
ear insert type protection	13%	15%	50%	0%	31%
Total number of operations	12	11	4	7	23

Noise Control (Cont'd.)

Audiometric Program:

In 1979 the computer system to handle industrial audiometric data was designed and became operational last October, generating monthly and year-end reports to mines who submitted data in 1979.

The Industrial Audiometry Training Manual was written and a training course designed to certify Industrial Audiometric Technicians. At present we have 65 certified Industrial Audiometric Technicians, 60 of whom are actively testing in B. C. and 5 from the Northwest Territories.

In summary for 1979:

3,762 1979 data forms were processed;
3,592 data forms from prior to 1979 processed;
7,354 total hearing tests submitted by industry and processed.

Twenty-three mines regularly submit audiometric data to our system.

Computer printouts sent to the mines on a monthly and year-end basis include:

schedules for hearing testing;
reports for quality control of hearing tests;
insufficient ear protection reports; and
monthly and yearly summary statistics.

Radiation Surveys of Non-Uranium Mines and Uranium Exploration

Surveys were made for Radon Daughters and Gamma radiation at twenty mining operations. The results of these surveys are tabulated in the appendix. The results are given as the average radiation level using an arithmetical average and do not represent actual exposure to individual workers. Two non-uranium mining operations were closed down until corrective measures were taken to lower the radon daughter concentration.

S. Elias, P. Eng.
Senior Inspector
Environmental Control

January 29, 1979

Underground Lode Mines

MINE NO.	MONTH IN 1979	PARTICLES PER CUBIC CENTIMETRE OF AIR BY KONIMETRY					
		UNDERGROUND		CRUSHING PLANTS		ASSAY GRINDING ROOM	
		DRILLING	ALL OTHERS	NO. 1	NO. 2	NO. 1	NO. 2
1	Mar.	342	170	223	150	164	---
	Nov.	169	166	162	160	132	---
12	June	436	130	---	---	---	---
21	June	275	143	157	---	---	---
	Dec.	265	141	143	---	---	---
55	Sept.	---	112	---	---	154	---
92(a)	June	259	---	---	---	---	---
115	June	---	187	---	---	---	---
180	Jan.	203	91	174	150	109	---
	July	106	208	---	265	278	---
187	June	287	113	233	---	---	---
	Dec.	---	85	221	---	---	---
203	June	---	124	---	---	---	---
215	Jan.	1526	463	426	---	---	---
	Aug.	297	144	254	---	91	---
218	Sept.	204	147	202	---	---	---
218(c)	Sept.	195	98	---	---	---	---
218(d)	Sept.	54	59	---	---	---	---
236	Feb.	296	155	223	154	122	---
	Dec.	80	229	184	---	184	---
241	Aug.	---	184	---	---	---	---
263	July	339	120	---	---	---	---
	Oct.	---	271	---	---	---	---
277	June	83	277	133	---	589	---
	Nov.	332	333	173	---	---	---
294	Feb.	378	197	205	---	120	---
	June	353	135	156	---	104	---
295	June	235	---	---	---	---	---
303	Aug.	---	123	---	---	---	---
323	June	407	297	422	---	135	---
334	June	---	---	123	---	---	---

Surface Lode Mines

MINE NO.	MONTH IN 1979	PARTICLES PER CUBIC CENTIMETRE OF AIR BY KONIMETRY					
		OPEN PIT MINE		CRUSHING PLANTS		ASSAY GRINDING ROOM	
		SURFACE DRILLING	ALL OTHERS	NO. 1	NO. 2	NO. 1	NO. 2
179	Jan.	92	56	338	---	86	---
	Oct.	---	154	559	---	134	---
	Nov.	---	---	560	---	---	---
180	Jan.	---	---	110	---	---	---
	July	---	---	157	---	---	---
215(a)	Aug.	---	65	---	---	---	---
235	Mar.	---	49	---	---	68	---
	Aug.	---	31	280	470	---	---
238	Jan.	43	46	138	---	---	---
	Oct.	---	63	103	---	39	---
252	Mar.	336	93	106	334	74	---
	Sept.	289	149	278	291	107	---
257	May	281	124	813	---	214	---
	June	---	---	247	---	---	---
258	June	---	38	105	279	---	---
	Dec.	92	70	---	227	---	---
262	May	136	137	222	---	204	---
	Sept.	134	109	127	---	73	---
286	Mar.	132	97	299	263	516	---
	Aug.	116	90	223	245	86	---
290	Mar.	596	55	222	326	110	---
	Aug.	---	70	---	279	102	---
300	Jan.	44	76	213	---	91	---
	Oct.	213	143	173	166	131	---
C-1	Apr/ May	92	84	---	---	---	---

PARTICLES PER CUBIC CENTIMETRE OF AIR BY KONIMETRY

COMPANY NUMBER	MONTH 1979	QUARRY DRILLING	QUARRY ALL OTHERS	SCREENING and/or CRUSHING	OPERATORS BOOTH CRUSHING	WAREHOUSE LOADING BAGGING
SM-1a	June	---	214(U/G)	---	---	---
SM-6	Apr.	31	85	---	---	310
	Oct.	47	105	130	---	---
SM-7	May	---	---	413	---	---
SM-11	Apr.	55	---	106	---	21
	Oct.	98	33	98	---	---
SM-12	Apr.	35	---	27	---	77
	Oct.	42	39	59	---	---
SM-13	Apr.	32	134	45	---	---
	Oct.	35	56	---	---	---
SM-14	Mar.	---	---	644	43	---
SM-19	Feb.	---	---	51	---	---
SM-20	May	---	---	332	---	---
SM-25	May	---	---	161	---	---
SM-30	Aug.	---	---	447	331	---
	Sept.	---	---	199	140	---
SM-32	Jan.	112	108	171	109	---
	Nov.	110	175	138	147	---
SM-34	Sept.	---	---	271 388	---	287
SM-35	Sept.	249	50	---	---	---
	Nov.	252	93 139	---	---	---
SM-37	June	157	53	128	---	---
	Nov.	238	103	95	---	---
SM-39	May	---	---	332	87	---
SM-46	June	---	---	237	27	---
	Nov.	---	---	205	111	---
SM-47	Feb.	---	---	78	---	---
SM-48	June	---	---	164	---	---
	Nov.	---	---	264	---	---
SM-49	Jan.	---	---	567 24	---	---
SM-50	May	---	---	261	83	---
SM-57	Oct.	65	83	157	192	---
SM-65	Aug.	---	---	145	---	---
SM-69	Feb.	---	---	176	---	---
SM-72	May	---	---	133	---	---
	Nov.	---	---	245	---	---
SM-75a	Apr.	---	---	169	---	---

Structural Minerals and Industrial Minerals (Cont'd.)

PARTICLES PER CUBIC CENTIMETRE OF AIR BY KONIMETRY

COMPANY NUMBER	MONTH 1979	QUARRY DRILLING	QUARRY ALL OTHERS	SCREENING and/or CRUSHING	OPERATORS BOOTH CRUSHING	WAREHOUSE LOADING BAGGING
SM-76	Apr.	---	---	92	---	---
SM-78	Feb.	---	---	237	---	---
SM-79	May	---	---	43	---	---
SM-83	Feb.	---	---	305	35	---
SM-84	Apr.	---	---	151	---	---
SM-85	May	79	---	281	79	---
SM-87	Feb.	---	---	566	408	---
SM-89	Apr.	---	---	127	---	---
SM-92	Nov.	---	---	64	---	---
SM-96	Apr.	---	---	38	---	---
SM-97	Apr.	---	---	69	---	---
	Oct.	---	---	102	---	---
SM-98	May	---	---	377 117	53	---
	Nov.	---	---	139	---	---
SM-99	May	---	---	152	---	---
SM-101	May	---	---	82	---	---
SM-102	Sept.	---	---	153	---	---

Coal Mining - Underground/Open Pit Mines

Dust Concentrations - Gravimetric Sampling

Mine No.	Milligrams per cubic metre of air - MRE Equivalent					
C-1 CM 3990 Apr. 24/79	CM#1 Operator	Shuttle Car #6	Faceman	Faceman	Return Air	Intake Air
	0.96	1.44	0.75	1.28	0.59	0.28
C-2a 860 CM Apr. 25/79	CM#1 Operator	CM#2 Operator	Faceman	Faceman	Faceman	Return Air
	0.81	0.96	2.41	1.93	4.79	1.23
C-2 Mine CM611 Apr. 26/79	CM#1 Operator	CM#2 Operator	Faceman	Facemen	Monitor	Monitor
	1.60	2.89	1.60	1.93	1.53	1.92
C-2a 765 CM Apr. 27/79	CM#1 Operator	CM#2 Operator	Shuttle Car Operator	Faceman	Faceman	Intake Air
	0.96	0.77	1.15	0.82	1.64	0.18
C-1 Plant Processing Apr. 29/79	Raw Coal Silo Operator	Clean Coal Silo Operator	Dryer Operator	Plant Top Feed Floor	Plant Feed Lower Floor	Train Loading
	1.44	2.07	1.72	2.42	1.02	1.04
B.P. Plant Apr. 30/79	Lorryman	Loaderman				
	1.91	1.91				
C-6 Open Pit Apr. 28/79	Breaker St. Control Room	Breaker St. Cherry Picker	Cat#578 Operator	Dart#591 Operator		
	2.56	1.83	1.81	1.40		
C-11 Open Pit May 2/79	#450 Truck Operator	#311 Loader Operator	#455 Truck Operator	#442 Truck Operator	Wash Plant Control Room	
	1.60	2.01	1.42	1.36	0.96	
C-9 Open Pit Feb. 22/79	No. 2 Loader Operator	No. 3 Loader Operator	No. 21 Truck Operator	#23 Cat. Operator	#5 Cat. Operator	
	0.59	0.83	1.87	0.15	0.17	
Coal Processing Plant Feb. 23/79	No. 1 Plant Operator	Dryer Operator	No. 1 Flotation Operator	Breaker St. Operator	Loader Operator	
	2.57	2.69	0.33	0.84	0.34	

Coal Mining (Cont'd.)

Dust Concentrations - Konimetry

NUMBER OF MINE	MONTH IN 1979	NUMBER OF PARTICLES PER CUBIC CENTIMETRE OF AIR				
		DRILLING OPERATIONS	LOADER & SHOVEL OPERATIONS	CATERPILLAR OPERATIONS	PORTABLE CRUSHING PLANT	
					PLANT	OPERATOR
C-1	May	92	89	59	-	-
C-11	May	74	39	-	-	-
C-9	Feb.	42	107	36	206	112

Membrane Filter Sampling Method

COMPANY NUMBER	MONTH 1979	LOCATION	FIBRES PER MILLILITRE MORE THAN 5 MICRONS IN LENGTH		
			ARITHMETICAL AVERAGE	NO. OF LOCATIONS OVER 5 f/ml	NO. OF LOCATIONS UNDER 5 f/ml
SM-1	June	Open Pit Drilling	0.6	0	1
		Open Pit Loading and Haulage	0.4	0	4
		Open Pit Tramline Loading and Crushing	0.6	0	11
		Tramline Unloading and Concentrator	1.09	0	8
		Dryer Circuit	3.1	1	6
		Mill Building	1.15	1	37
		Mill Air Building	0.18	0	5
SM-1a	June	Underground Tunnel	0.25	0	2

NOISE SURVEYS

MINE NO.	MONTH 1979	EAR PROTECTION				AUDIOMETRY		NUMBER OF DRILLS TESTED									TOTAL SURVEYS
		Both	Muff	Plug	None	Yes	No	J'leg	Stoper	Leyner	D.D.	Surface	Loaders Shovels	Cat; Trks	Concentrator	Misc.	
UNDERGROUND																	
1	Mar.	-	18	2	3	636	-	2	4	-	2	-	-	-	20	11	42
SM-1a	June	-	3	2	-	10	-	1	-	-	1	-	-	-	-	-	2
21	Dec.	-	3	1	1	38	-	2	-	-	-	-	-	-	2	5	9
180	Nov.	-	4	1	5	-	-	-	-	2	-	-	-	-	12	3	17
187	Dec.	-	-	-	1	-	42	-	-	-	-	-	-	-	2	3	5
218	Sept.	1	7	1	4	216	-	4	1	1	-	-	-	-	5	6	18
236	May	1	2	1	3	-	-	-	-	-	-	-	1	2	8	14	25
294	July	-	2	2	2	120	-	1	1	-	-	-	-	-	10	4	16
316	June	-	2	-	-	-	-	1	-	-	-	-	-	-	-	1	2
323	June	-	1	6	-	-	-	1	4	-	-	-	-	-	5	2	12
OPEN PIT																	
179	Oct.	-	1	2	1	360	-	-	-	-	-	1	1	1	8	9	22
238	Oct.	-	1	2	7	560	-	-	-	-	-	1	3	2	9	1	18
257	June	1	4	7	1	310	-	-	-	-	-	2	3	5	15	6	32
258	Dec.	-	-	3	4	470	-	-	-	-	-	1	2	1	6	7	20
262	Sept.	-	4	11	2	842	-	-	-	-	-	2	1	3	10	18	32
300	Oct.	-	-	2	-	-	-	-	-	-	-	1	1	2	-	1	5
STRUCTURAL & INDUSTRIAL MINERALS																	
SM-1	June	-	19	2	14	582	-	-	-	-	-	1	1	3	5	49	62
SM-6	Nov.	-	1	2	1	28	-	-	-	-	-	2	-	1	-	6	9
SM-7	May	-	-	-	-	4	-	-	-	-	-	-	1	-	-	2	3
SM-11	July	-	2	4	-	-	-	-	-	-	-	2	2	2	-	6	12
SM-12	Nov.	-	1	-	4	18	-	-	-	-	-	-	-	-	-	3	3
SM-13	July	-	2	1	1	42	-	-	-	-	-	2	1	2	-	2	7
SM-14	Mar.	-	-	-	1	-	-	-	-	-	-	-	-	-	-	4	4
SM-19	Feb.	-	1	-	-	4	1	-	-	-	-	-	-	-	-	5	5
SM-20	May	-	-	-	-	-	10	-	-	-	-	-	-	-	-	2	2
SM-30	June	-	1	-	-	6	-	-	-	-	-	-	-	-	-	6	6
SM-39	May	-	-	-	-	-	6	-	-	-	-	-	-	-	-	4	4
SM-47	Feb.	-	1	-	-	6	-	-	-	-	-	-	-	-	-	5	6
SM-57	Nov.	1	-	-	-	23	-	-	-	-	-	1	-	-	-	3	4
SM-69	Feb.	-	-	-	-	14	-	-	-	-	-	-	-	-	-	6	6
SM-78	Feb.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4
SM-83	Feb.	-	1	-	-	5	-	-	-	-	-	-	-	-	-	4	4
SM-85	May	-	1	1	1	-	4	-	-	-	-	1	-	-	-	5	6
SM-86	Mar.	-	-	-	-	-	3	-	-	-	-	-	-	-	-	7	7
SM-87	Feb.	-	1	-	-	-	2	-	-	-	-	-	-	-	-	2	2
SM-93	Mar.	-	-	-	-	-	2	-	-	-	-	-	-	-	-	3	3

NOISE SURVEYS (Cont'd.)

MINE NO.	MONTH 1979	EAR PROTECTION				AUDIOMETRY		NUMBER OF DRILLS TESTED									
		Both	Muff	Plug	None	Yes	No	J'leg	Stoper	Leyner	D.D.	Surface	Loaders Shovels	Cat; Trks	Concentrator	Misc.	TOTAL SURVEYS
STRUCTURAL & INDUSTRIAL MINERALS (Cont'd.)																	
SM100	Mar.	–	–	–	–	–	3	–	–	–	–	–	–	–	–	4	4
C-6	Aug.	–	8	6	10	439	–	–	–	–	–	1	3	3	–	57	64
C-9	Aug.	–	–	2	4	–	–	–	–	–	–	2	5	5	–	32	45

TOTAL LOCATIONS: 549

RADIATION SURVEYS - URANIUM AND NON-URANIUM MINES

Mine Number	Month in 1979	Exhaust Airway		Working Headings		Dead End Workings		Ambient Outside Atmosphere		Crushing Plants		Mill Buildings		Remarks
		W.L.	Gamma	W.L.	Gamma	W.L.	Gamma	W.L.	Gamma	W.L.	Gamma	W.L.	Gamma	
C-1	Nov.	0.002	-	0.004	-	0.002	-	0.0017	-	-	-	-	-	
C-2	Nov.	0.0017	-	0.0017	-	-	-	0.0017	-	-	-	-	-	
C-4a	Nov.	0.0034	-	0.0034	-	-	-	-	-	-	-	-	-	No dead end
C-5	Nov.	0.0017	-	-	-	-	-	-	-	-	-	-	-	Panel 6
C-5	Nov.	0.0017	-	-	-	-	-	-	-	-	-	-	-	Panel 5
SM2	July	0.0024	7	0.0041	7	-	-	-	-	-	-	-	-	
1	Nov.	0.011	-	0.014	-	0.018	-	0.0017	-	0.012	-	0.007	-	
12	July	0.01	33	0.052	28	0.016	25	0.0007	17	-	-	-	-	
SM35	Sept.	-	-	-	-	0.082	5	0.0007	7	-	-	-	-	
SM35a	Sept.	-	-	0.008	2	0.048	3	0.007	12	-	-	-	-	
	Nov.	-	-	0.009	-	-	-	0.006	-	-	-	-	-	
61	July	0.755	36	-	-	0.496	24	0.007	24	-	-	-	-	Mine closed.
	Nov.	-	-	0.044	-	0.075	-	-	-	-	-	-	-	Intake air 0.002 WL ventilation had been reversed.
92a	July	0.005	26	0.0038	36	0.0153	40	0.002	21	-	-	-	-	
215	Aug.	0.002	13	0.0043	21	1.072	35	0.0008	9	-	-	0.0006	5	No one working in dead, Ventilation required immediately.
	Sept.	0.039	19	0.046	25	0.013	30	0.002	10	-	-	-	-	
180	July	0.0012	10	0.0006	12	0.0203	13	0.0003	10	-	-	0.0004	6	
203	July	0.0521	26	0.0193	34	-	-	0.0101	24	-	-	-	-	
277	July	0.2499	24	0.0131	32	0.2821	34	0.0128	15	-	-	-	-	Ruth, work stopped
	July	0.0364	24	-	-	0.013	22	-	-	-	-	-	-	Silversmith.
	Nov.	0.1738	-	0.033	-	-	-	-	-	-	-	-	-	Ruth, not working.
	Nov.	0.031	-	0.035	-	-	-	-	-	-	-	-	-	Silversmith.

W.L. = Working level, an atmosphere concentration of radon (Rn-222) daughters which will deliver 1.3×10^5 MeV of alpha energy per litre of air in decaying through RaC'(Po-214).

Gamma = Gamma radiation measured in Micro Rem per hour (2500 Micro R/hr per 40 hr week for 52 weeks = 5.2 Rem per year exposure).

RADIATION SURVEYS - URANIUM AND NON-URANIUM MINES (Cont'd.)

MINE NO.	Month in 1979	Exhaust Airway		Working Headings		Dead End Workings		Ambient Outside Atmosphere		Crushing Plants		Mill Buildings		Remarks
		W.L.	Gamma	W.L.	Gamma	W.L.	Gamma	W.L.	Gamma	W.L.	Gamma	W.L.	Gamma	
294	June	-	-	0.0074	-	0.0027	-	0.0007	-	-	-	-	-	
303	Aug.	0.0017	22	0.0017	33	0.0012	24	0.0017	22	-	-	-	-	
		D.D. Holes Emination		D.D. Core Storage										
324	Apr.	0.0009	7	0.011	17	-	-	0.0005	6	-	-	-	-	Drill Location
	Aug.	0.0011	19	-	-	-	-	0.0008	18	-	-	-	-	Drill Location
328	Apr.	0.0007	5	0.0005	10	-	-	0.0005	6	-	-	-	-	Drill Location
	Aug.	0.133	9	-	-	-	-	0.0012	17	-	-	-	-	Drill Location
	Oct.	0.073	12	-	15	-	-	0.001	17	-	-	-	-	Drill Location

W.L. = Working level, an atmosphere concentration of radon (Rn-222) daughters which will deliver 1.3×10^5 MeV of alpha energy per litre of air in decaying through RaC' (Po-214).

Gamma = Gamma radiation measured in Micro Rem per hour (2500 Micro R/hr per 40 hr week for 52 weeks = 5.2 Rem per year exposure).

LODE MINES

Mine No.	Name of Mine
1	Sullivan Mine & Concentrator, Cominco Limited
12	Gold Belt Mine Incorporated
21	Beaverdell Mine, Teck Corporation Limited
55	Scottie Gold Mines Limited
92(a)	Scranton Property, David Minerals
115	Ottawa Mine, Slocan Development Corporation Limited
179	Bethlehem Copper Corporation Limited
180	Craigmont Mines Limited
187	Dankoe Mines Limited (N.P.L.)
203	Arlington Mine
215	Boss Mountain Division, Noranda Mines Limited
218	Western Mines Limited
235	Endako Mines Limited
236	Wesfrob Mining Division, Falconbridge Nickel Mines Ltd.
238	Lornex Mining Corporation Limited
241	York-Hardy Mine - Climax Molybdenum Corporation of B.C.
252	Granisle Mine, Babine Division, Noranda Mines Limited
257	Similkameen Division, Newmont Mines Limited
258	Brenda Mines Limited
262	Island Copper Mine, Utah Mines Limited
263	Alwin Mine, Dekalb Mining Corporation
277	Silvana Mines Incorporated
286	Gibraltar Mines Limited
290	Bell Copper Division, Noranda Mines Limited
294	Northair Mines Limited
295	Table Top Mountain Mines Limited, White Mine Development
300	Afton Mines Limited
303	Mosquito Creek Gold Mining Company Limited
323	Erickson Creek Gold Mining Corporation
324	Norcen Energy Resources Limited
328	PNC Explorations (Canada) Limited
334	Selmon Resources

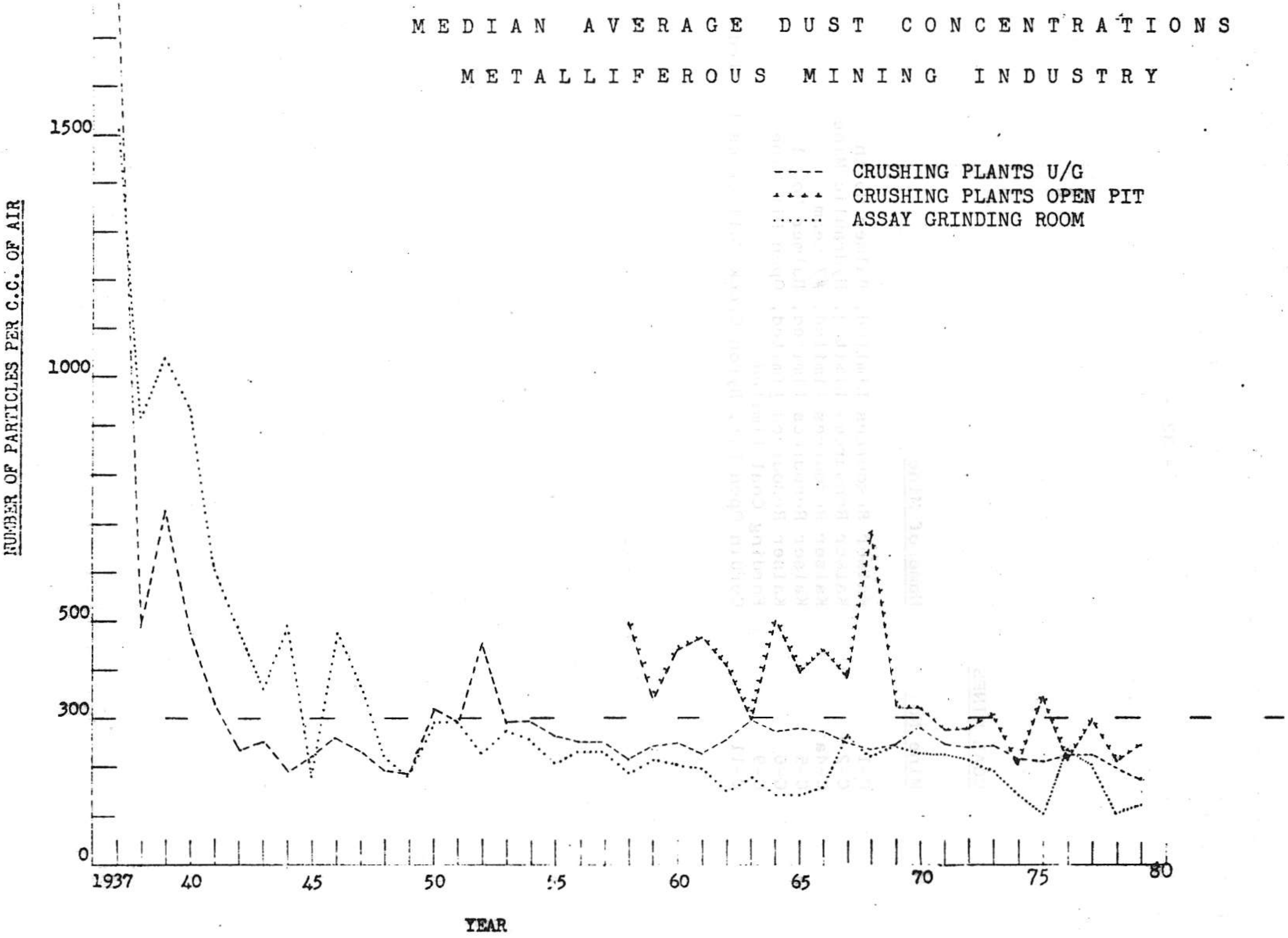
STRUCTURAL MINERALS AND INDUSTRIAL MINERALS

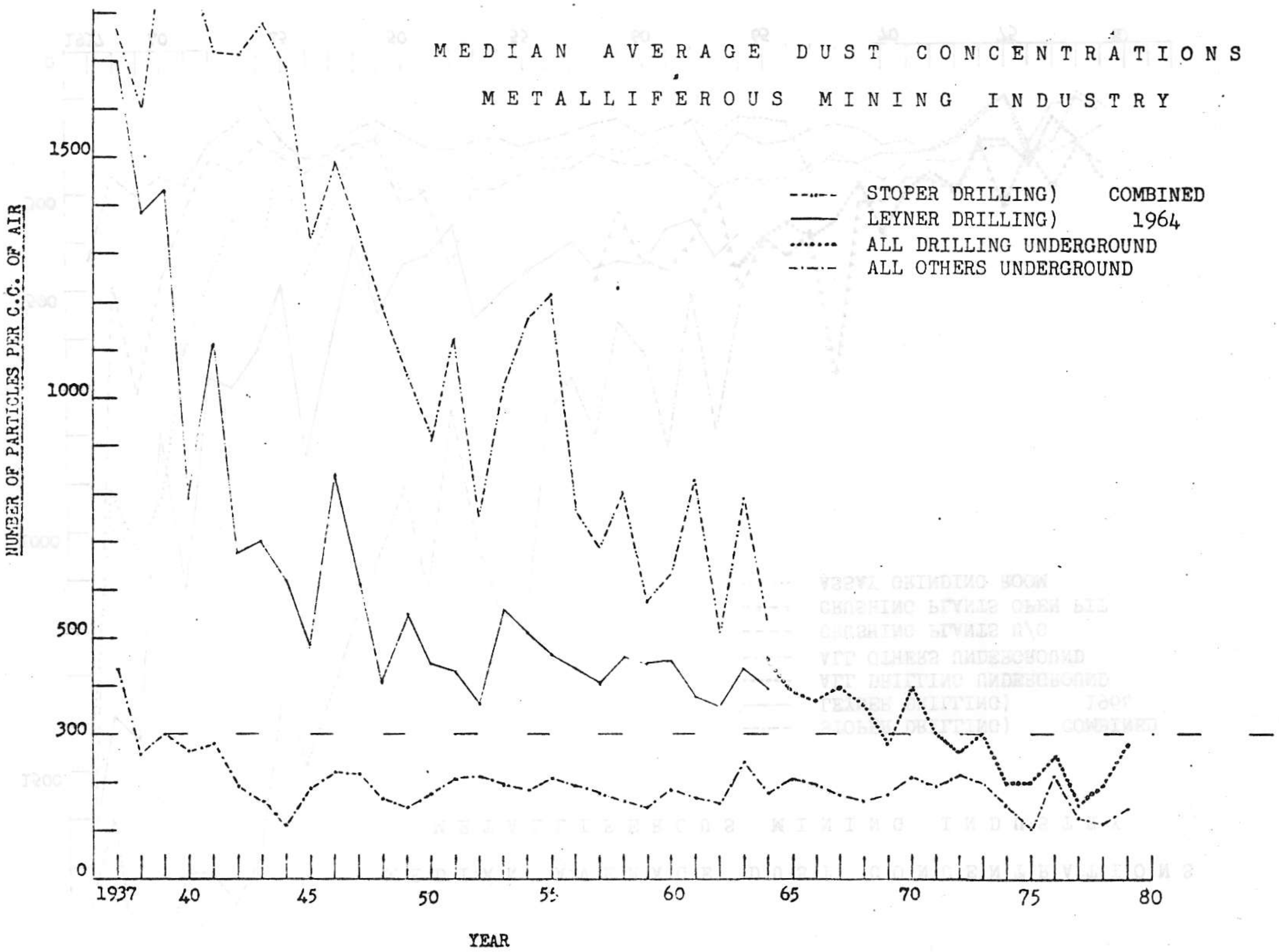
Mine No.	Name of Company
SM-1	Cassiar Asbestos Corporation Ltd., Open Pit & Concentrator
SM-1a	Cassiar Asbestos Corporation Limited, Exploration Tunnel
SM-6	Plant No. 15A, Canada Cement Lafarge Limited (Texada)
SM-7	Valley Rite Mix Limited
SM-11	Domtar Chemcials Limited
SM-12	Imperial Limestone Company Limited
SM-13	Ideal Basic Industries
SM-14	Jack Cewe Limited
SM-19	Blackham's Construction Limited
SM-20	Kirkpatrick Sand and Gravel Limited
SM-25	McGauley Ready-Mix Company Limited
SM-30	Allard Contractors Limited
SM-32	Canada Cement Lafarge Limited - Plateau Construction Ltd.
SM-34	Westroc Industries Limited - Invermere Plant and Quarry
SM-35	Brisco Barite Mine, Mountain Minerals Limited
SM-35(a)	Parson Barite Mine, Mountain Minerals Limited
SM-37	British Columbia Cement Company Limited
SM-39	Mamquam River Pit, Coast Aggregates Limited
SM-46	Producer Pit, Construction Aggregates Limited
SM-47	Western Paving Limited, Highland Pit
SM-48	Armour and Saunders Limited
SM-49	Dolan's Limited
SM-50	Hub City Paving
SM-57	Steel Brothers Canada Limited
SM-65	Bulkley Valley Concrete Company Limited
SM-69	Surrey Pit, Lafarge Concrete Limited
SM-72	Parksville Sand & Gravel (1975) Limited
SM-75(a)	Argus Aggregates Limited, Sechelt
SM-76	L & H Swanson Limited
SM-78	Central Aggregates Limited
SM-79	Dolowhite Mine Limited, Rock Creek Operations
SM-83	Valley Gravel Sales Limited
SM-84	Hillside Pit, Construction Aggregates Limited
SM-85	Watts Point Quarry, C.R. Aggregate Sales Limited
SM-86	Kitsul Land Development Company Limited
SM-87	Krahn Gravel and Contracting
SM-89	Premier Sand and Gravel Limited
SM-92	Island Ready Mix
SM-93	Fraser Valley Aggregates Limited
SM-96	Yukon Gravel Pit
SM-97	Hawkins Sand and Gravel
SM-98	Uplands Excavating (1971) Limited
SM-99	Valley Paving (1973) Limited
SM-100	Keny-Lin Pit
SM-101	Korpack Cement Products Limited
SM-102	Penresh Explorations Limited

COAL MINES

Mine No.	Name of Mine
C-1	Kaiser Resources Limited, Balmer North
C-2	Kaiser Resources Limited, Hydraulic Mine
C-4a	Kaiser Resources Limited, #7 seam
C-5	Kaiser Resources Limited, Balmer No. 1
C-6	Kaiser Resources Limited, Open Pit Mine
C-9	Fording Coal Limited
C-11	Corbin Open Pit, Byron Creek Collieries Limited

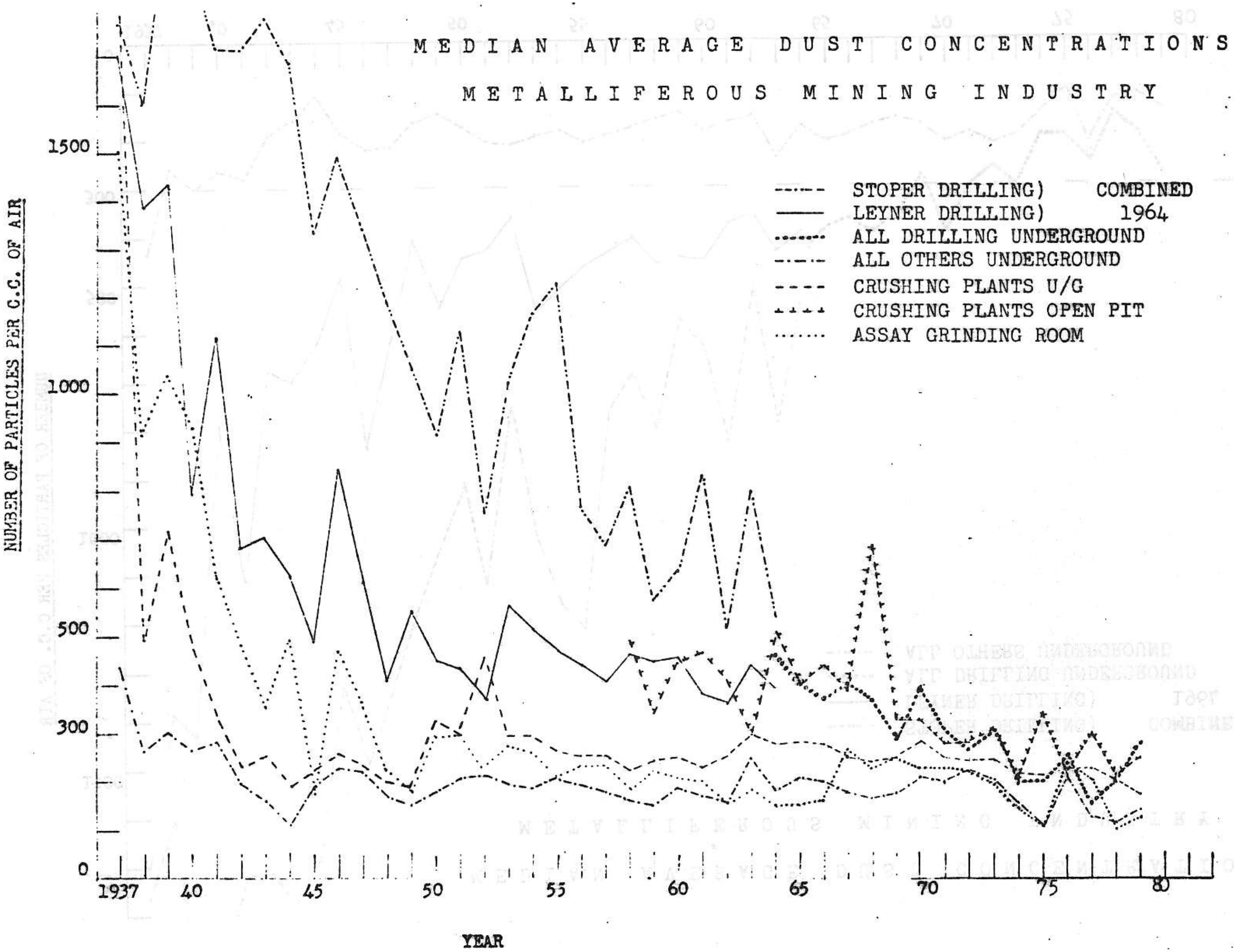
MEDIAN AVERAGE DUST CONCENTRATIONS
METALLIFEROUS MINING INDUSTRY





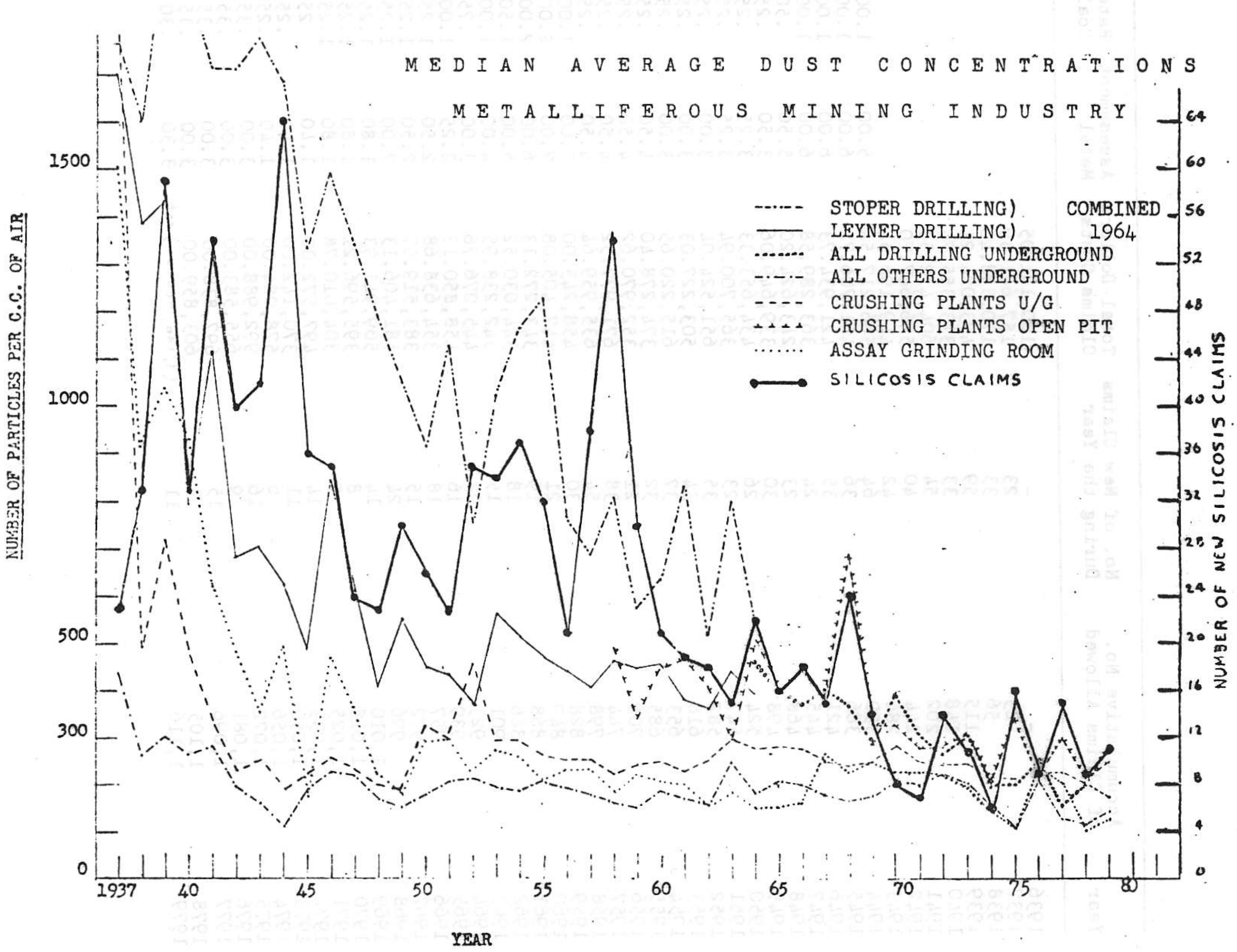
MEDIAN AVERAGE DUST CONCENTRATIONS

METALLIFEROUS MINING INDUSTRY



MEDIAN AVERAGE DUST CONCENTRATIONS

METALLIFEROUS MINING INDUSTRY



MEDIAN AVERAGE DUST CONCENTRATIONS

METALLIFEROUS MINING INDUSTRY

Year	Accumulative No. of Claims Allowed	No. of New Claims During the Year	Total Dollars Claims Costs	Assessment Metal	Rates Coal
1936	-	-	100,181.05		
1937	23	23	157,641.39		
1938	56	33	170,538.40		
1939	115	59	403,024.21		
1940	148	33	313,355.74		
1941	202	54	604,432.53		
1942	244	40	526,647.70		
1943	286	42	449,196.34		
1944	350	64	566,217.54	5.00	1.00
1945	386	36	461,706.72	6.00	1.00
1946	421	35	421,934.73	6.00	1.00
1947	445	24	363,289.58	6.00	1.00
1948	468	23	243,624.20	5.50	.50
1949	498	30	339,649.06	3.50	.25
1950	524	26	434,653.33	3.25	.25
1951	547	23	365,700.94	3.25	.25
1952	582	35	651,524.04	3.00	.25
1953	616	34	503,227.03	3.00	.25
1954	653	37	615,220.65	3.00	.25
1955	685	32	374,278.40	4.50	.25
1956	706	21	352,970.62	4.50	.25
1957	744	38	671,977.52	4.50	.25
1958	798	54	635,959.64	4.50	.25
1959	828	30	458,243.00	7.00	1.00
1960	849	21	447,405.08	7.00	2.00
1961	868	19	343,272.13	6.00	2.00
1962	886	18	344,030.52	5.00	1.50
1963	901	15	342,238.95	4.00	1.00
1964	923	22	445,076.76	3.00	.75
1965	939	16	458,850.17	2.25	1.00
1966	957	18	354,638.68	2.50	1.25
1967	972	15	383,519.57	2.50	1.25
1968	996	24	581,406.13	2.00	1.25
1969	1,010	14	509,941.93	1.80	1.25
1970	1,018	8	395,596.21	1.80	1.25
1971	1,025	7	304,010.78	1.80	1.25
1972	1,039	14	497,572.00	1.40	.25
1973	1,050	11	370,142.00	1.40	.25
1974	1,056	6	578,084.00	1.40	.25
1975	1,072	16	992,988.00	3.00	.35
1976	1,081	9	655,583.00	3.00	.35
1977	1,096	15	697,838.00	3.00	.35
1978	1,105	9	603,859.00	3.00	.35
1979	1,116	11	(1,140,900.00) est.	3.30	.30

APPENDIX 11

SILICOSIS PENSIONS STATISTICS

SILICOSIS PENSIONS STATISTICS

Year	Accumulative No. of Claims Allowed	No. of New Claims During the Year	Total Dollars Claims Costs	Assessment Metal	Rate Coal
1936	-	-	100,181.05		
1937	-	-	157,641.39		
1938	-	-	170,538.40		
1939	-	216	403,024.21		
1940	-	-	313,355.74		
1941	216	-	604,432.53		
1942	244	21	526,647.70		
1943	286	42	449,196.34		
1944	350	64	566,217.54	5.00	1.00
1945	386	36	461,706.72	6.00	1.00
1946	421	35	421,934.73	6.00	1.00
1947	445	24	363,289.58	6.00	1.00
1948	468	23	243,624.20	5.50	.50
1949	498	30	339,649.06	3.50	.25
1950	524	26	434,653.33	3.25	.25
1951	547	23	365,700.94	3.25	.25
1952	582	35	651,524.04	3.00	.25
1953	616	34	503,227.03	3.00	.25
1954	653	37	615,220.65	3.00	.25
1955	685	32	374,278.40	4.50	.25
1956	706	21	352,970.62	4.50	.25
1957	744	38	671,977.52	4.50	.25
1958	798	54	635,959.64	4.50	.25
1959	828	30	458,243.00	7.00	1.00
1960	849	21	447,405.08	7.00	2.00
1961	868	19	343,272.13	6.00	2.00
1962	886	18	344,030.52	5.00	1.50
1963	901	15	342,238.95	4.00	1.00
1964	923	22	445,076.76	3.00	.75
1965	939	16	458,850.17	2.25	1.00
1966	957	18	354,638.68	2.50	1.25
1967	972	15	383,519.57	2.50	1.25
1968	996	24	581,406.13	2.00	1.25
1969	1,010	14	509,941.93	1.80	1.25
1970	1,018	8	395,596.21	1.80	1.25
1971	1,025	7	304,010.78	1.80	1.25
1972	1,039	14	497,572.00	1.40	.25
1973	1,050	11	370,142.00	1.40	.25
1974	1,056	6	578,084.00	1.40	.25
1975	1,072	16	992,988.00	3.00	.35
1976	1,081	9	655,583.00	3.00	.35
1977	1,096	15	697,838.00	3.00	.35
1978	1,105	9	603,859.00	3.00	.35
1979 [illegible]	(1,109)	4		3.30	.30

SILICOSIS PENSIONS 1970
NEW CASES

Silicosis Claim Number	Name	Age	Coal or Metal	Exposures B. C. Years	1st B.C. Expos.	Out Prov. Expos.
1011	Lien, K.	62	Metal	12	1942 -	1-7
1012	Hallstrom, Eric	61	Metal	30	1929 -	5-5
1013	Pengelly, W.	65	Metal	9-4	1922 -	3-10
1014	Zacharuik, Harry	61	Metal	9	1932	
1015	McCrea, M. E.	66	Metal	30	1940	
1016	Oslie, Hans	62	Metal	26	1942 -	1 1/6
1017	Watson, W. N.	62	Metal	5½	1934 -	3-0
1018	Cecchetto, A.	69	Metal	9½	1928	

SILICOSIS PENSIONS 1971
NEW CASES

Silicosis Claim Number	Name	Age	Coal or Metal	Exposures B. C. Years	1st B.C. Expos.	Out Prov. Expos.
1019	Trozzo, J. L.	64	Metal	8 - 9	1935	
1020	Erickson, J. E.	65	Metal	8 - 4	1929	
1021	Nolsky, J.	57	Metal	4 - 3	1950	2
1022	Ohnstad, S.	57	Metal	24 - 1	1945	2
1023	Radulovich, M.	57	Metal	5 - 1	1936	1
1024	McLellan, L. W.	63	Metal	23 - 5	1925	
1025	Bakka, Ole	64	Metal	12 - 4	1935	

SILICOSIS PENSIONS 1972
NEW CASES

Silicosis Claim Number	Name	Age	Coal or Metal	Exposure B. C. Years	1st B.C. Expos.	Out Prov. Expos.
1026	Pavelich, T.	72	Metal	3 - 2	1926	4
1027	Rajsic, D.	75	Metal	7 - 5	1928	2
1028	Waselenko, J.	62	Metal	12 - 4	1941	
1029	Sanche, J.	62	Metal	27 - 9	1943	
1030	O'Grady, J.	72	Metal	22 - 6	1942	6½
1031	Luberg, T.	64	Metal	15 - 1	1926	2
1032	Turner, J. (F)	63	Metal	2 - 2	1938	1
1033	Monkman, J.	54	Metal	8 - 2	1946	1
1034	Drugge, C. E.	65	Metal	14 - 1	1933	½
1035	Sodja, G.	52	Metal	13 - 7	1937	
1036	Todd, J.	61	Metal	4 - 7	1936	
1037	Lakusta, N.	68	Metal	34 - 4	1931	5
1038	Garner, J. W.	70	Metal	29 - 7	1923	
1039	Wycherley, W. H.	70	Metal	6 - 2	1926	

SILICOSIS PENSIONS 1973
NEW CASES

Silicosis Claim Number	Name	Age	Coal or Metal	Exposure B. C. Years	1st B.C. Expos.	Out Prov. Expos.
1040	Walker, W.	69	Metal	28 - 6	1941	
1041	Kobetitch, E.	63	Metal	3 -10	1933	
1042	St. Marie, A.	62	Metal	10 -	1937	3
1043	Johnson, J. A.	73	Metal	24 - 2	1934	
1044	Burgess, A. B.	58	Metal	1 - 1	1936	8
1045	Brown	73	Metal	29 -10	1934	7
1046	Drew, B.	66	BOTH	2 - 8	1935	
1047	Lukey, M.	67	Metal	20 - 1	1949	6
1048	Thompson, J. M.	64	Metal	7 -	1928	
1049	Slamon, T. J.	60	Metal	17 - 11	1938	½
1050	Howlett, L.	60	Metal	1 -10	1943	3

SILICOSIS PENSIONS 1974
NEW CASES

Silicosis Claim Number	Name	Age	Coal or Metal	Exposure B. C. Years	1st B.C. Expos.	Out Prov. Expos.
1051	Gallo, J.	61	Metal	17 -	1934	
1052	Cluney, A. L.	62	Metal	6 -	1937	
1053	Danskin, R. N.	59	Metal	26 -	1942	
1054	Etherington, A.	66	Metal	2 - 1	1927	
1055	McLean, R. G.	71	Metal	5 - 4	1929	
1056	Pace, M. P.	55	Metal	16 - 2	1942	

SILICOSIS PENSIONS 1975
NEW CASES

Silicosis Claim Number	Name	Age	Coal or Metal	Exposure B. C. Years	1st B.C. Expos.	Out Prov. Expos.
1057	Kujawa, K.	50	Metal	3 - 7	1964	
1058	Billan, A.	59	Metal	7 - 9	1954	
1059	Boone, D.	62	Metal	30 -	1944	
1060	Reid, R.	63	Metal	26 -	1943	
1061	Wymer, C.	72	Metal	20	1938	
1062	Larmour, W.	62	Metal	17 - 3	1948	
1063	Smith, K.	61	Metal	8 -11	1936	
1064	Findlay	72	Metal	7 - 9	1934	
1065	Nicholson, N.	62	Metal	27 -	1929	
1066	Humennis, I.	50	Metal	19 - 9	1952	
1067	Sebediak, N.	60	Metal	37 -10	1937	
1068	Russell, W.	67	Metal	7 - 6	1933	
1069	Buck, F.	65	Metal	9 - 6	1938	
1070	Holt, E.	65	Metal	22 -11	1945	
1071	Eichen, F.	54	Metal	9 - 2	1965	
1072	White, W.	62	Metal	13 -11	1946	

SILICOSIS PENSIONS 1976
NEW CASES

Silicosis Claim Number	Name	Age	Coal or Metal	Exposure B. C. Years	1st B.C. Expos.	Prov. Expos.
1073	Renko, J.	74	Metal	27 - 2	1928	
1074	Barry, O.D.	70	Metal	13 -	1928	
1075	Recsky, P.	74	Metal	11 -	1953	
1076	Comfoltey, J.	76	Metal	23 - 7	1941	
1077	Cossarini, P.	65	(COAL)	37 -11	1928	
1078	Marty, R.	69	Metal	28 -	1936	
1079	Smith, H. T.	64	Metal	21 -	1949	
1080	Wiley, W. H.	63	Metal	6 - 1	1934	
1081	Elsmore, A.	66	Metal	31 - 6	1928	

SILICOSIS PENSIONS 1977

NEW CASES

Silicois Claim Number	Name	Age	Coal or Metal	Exposure B.C. Years	1st B.C. Expos.	Out Prov. Expos.
1082	Hanson, A.	60	Metal	11 - 10	1947	
1083	Dahlem, F.	60	Coal	17	1957	
1084	Ohlen, H. E.	73	Metal	30 - 10	1937	
1085	Gesdal, M.	74	Metal	9 - 10	1937	
1086	Elliott, N.	61	Metal	26 - 6	1948	
1087	Rudenko, I.	62	Coal	23	1953	
1088	Poznikoff, F.	65	Metal	25 - 9	1950	
1089	MacDonald, J. A.	60	Metal	22 - 7	1951	
1090	Napora, S.	63	Metal	19 - 9	1940	
1091	Zwarych, J.	63	Metal	26 - 9	1947	
1092	Estrom, I.	66	Metal	6 - 1	1937	
1093	Kleef, T.	72	Metal	3 - 8	1936	
1094	Borody, G.	53	Metal	13 - 11	1947	
1095	Pfeefer, F.	48	Metal	19 - 10	1953	
1096	Floodstrom, S.	60	Metal	22 - 10	1937	

SILICOSIS PENSIONS 1978

NEW CASES

1097	Gillis, W.	66	Metal	9 - 4	1939
1098	MacDonald	71	Metal	6 - 2	1937
1099	Gray, T.	70	Metal	6 - 2	1937
1100	Potkonjak, G.	69	Metal		1940
1101	Foote, S.	65	Metal	14 - 2	1937
1102	Berg, H.	65	Metal	19 - 11	1929
1103	Troyan, S.	66	Metal	3 - 10	1937
1104	Melissa, J.	76	Coal	26	1921
1105	Wallwin, F.	61	Metal	12 - 7	1963

SILICOSIS PENSIONS 1979

NEW CASES

1106	Szakacs, J.	77	Metal	10 - 1	1949
1107	Takala, E.	57	Metal	22 - 10	1937
1108	Ohnstad, N.	70	Metal	27 - 7	1942
1109	Futcher, R.	72	Metal	9	1933

SILICOSIS, PNEUMOCONIOSIS, ASBESTOSIS COMPARATIVE ACTIVITIES 1974 - 1978

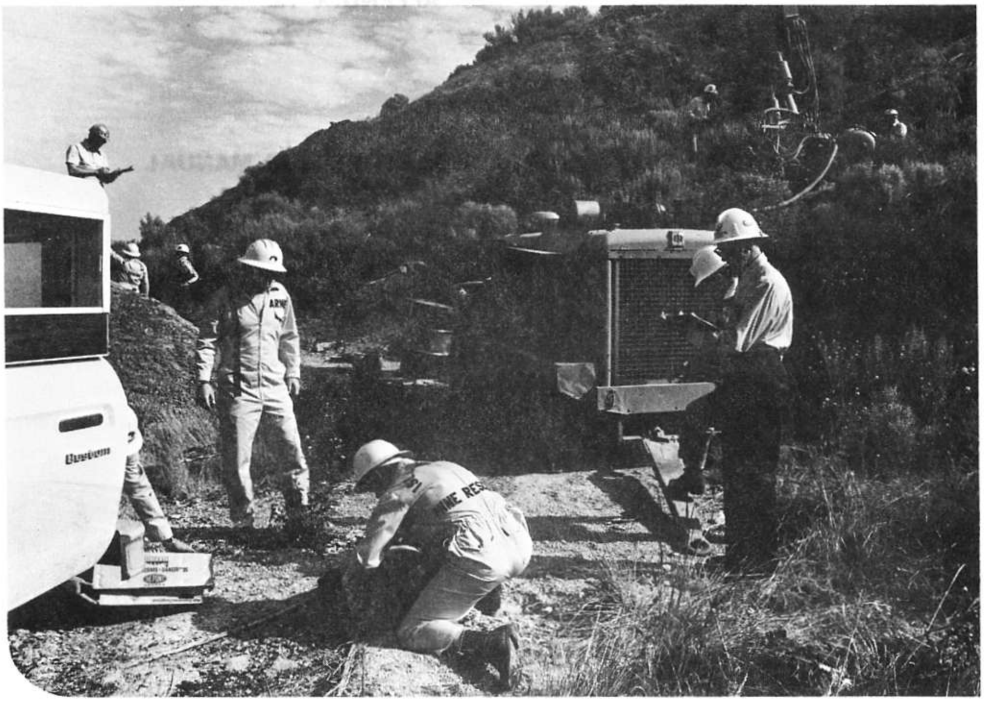
PART I	1974	1975	1976	1977	1978
No. of chest x-rays and medical examinations:	12,880	8,591	7,799	8,769	7,233
No. of first-time examinations:	7,791	4,199	3,621	3,913	2,897
No. of workers not qualified for certification:	75	36	31	25	26

PART II	1974	1975	1976	1977	1978
No. of Disability Awards granted for silicosis:	6	16	9	15	9
No. of Disability Pensioners who died:					
From Silicosis:	5	10	9	7	7
From other causes or unknown causes:	9	5	10	7	11
Total number of Disability Pensioners receiving allowances:	242	243	233	234	225
No. of Dependents in receipt of allowances:	182	182	183	185	185
Total Silicosis Expenditures:					
Wage Loss:	16,725	6,800	8,758	5,709	3,259
Reserve for Permanent Disability and Fatals:	516,488	934,357	573,441	630,619	524,561
Medical Aid:	44,871	56,831	73,384	61,510	76,039

APPENDIX 12

SURFACE MINE RESCUE MANUAL

Province of British Columbia
Ministry of Energy, Mines and Petroleum Resources



SURFACE MINE RESCUE MANUAL

British Columbia Cataloguing in Publication Data

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Inspection and Engineering Division.
Surface mine rescue manual.

ISBN 0-7719-7006-4

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2. Mine rescue work - Handbooks, manuals,
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INSPECTION AND ENGINEERING DIVISION

VICTORIA, BRITISH COLUMBIA

CANADA

December, 1977

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

INTRODUCTION

The subject matter chosen for the preparation of the surface mine rescue course was determined after a study of a survey of fatal accidents and dangerous or unusual occurrences at open-pit mining operations in British Columbia from 1950 to 1969 inclusive. The course developed was designed primarily to give training in basic rescue procedures to be applied following accidents at surface mining operations bearing in consideration the existing physical conditions such as location, additional hazards, and weather. Also the course provides a limited amount of instruction in safe operational procedures for certain circumstances where the information was not readily available from other sources. This instruction is intended only to supplement the safe job instructional training provided by management.

In order to maintain awareness in the accident or hazard statistics at surface mining operations, the survey was extended to the end of 1971 and expanded to include all surface fatal accidents and dangerous occurrences at all mining properties unless the incident was specific to underground mining operations. The expansion was made because it is believed the same hazard potential could exist at any open-pit operation. In summary during the 22-year period there were 130 fatalities and 300 dangerous occurrences falling within the limits of the survey.

Thirty-eight fatalities and 92 dangerous occurrences were attributed to vehicles getting out of control through braking, steering and driving failures, backing over dumps and driving off the roads or over the dumps. The vehicles involved were mainly tractors, trucks, frontend loaders and graders, but not including cranes where, on the operation of which two men were killed and 11 boom failures were recorded. A review of these incidents indicate the necessity for improved supervision, proper operational training, better vehicle design and maintenance, and improved road location, construction and maintenance. Surface rescue training in rope work and the use of the back support board is particularly applicable to the recovery of persons in accidents involving vehicles. In addition a brief discussion of proper dumping procedures is intended to assist in avoiding accidents occurring during this operation.

The next largest single source of fatalities was from snowslides which caused the deaths of 29 persons, 26 of whom were victims of the 1965 avalanche at Granduc mine. It was estimated these men were engulfed in a snow mass of 50,000 tons travelling at a speed of about 100 miles per hour. Additionally there were seven reported avalanches without loss of life but where mining property damage was done. The rescue course briefly discusses the causes of avalanches but provides greater detail in search and rescue procedures subsequent to the event. It is recommended, though, that where mining operations are located in potential avalanche areas, the mine management make use of the free services provided by the National Research Council at Rogers Pass, where the Snow and Ice Research Unit gives instruction in the analysis and forecasting of avalanches. The surface mine rescue course also discusses other winter problems such as ice travel and exposure during cold weather. The survey indicated there were two instances of tractors breaking through lake ice and one of these was a fatality. In addition one man died of exposure on being lost over night in a snow storm.

The second largest dangerous occurrence frequency was with fires and 73 were reported with a multimillion dollar loss to the industry. There were three fatalities reported, one by fire and two from carbon monoxide poisoning caused by faulty heating units. In addition there were three incidents reported involving the escape of propane gas where, in two instances, gas explosions destroyed the buildings involved. Also there were four explosions caused by the ignition of oil vapours in compressed air systems. The course provides training in the use of respiratory protective equipment for rescue operations where there is a fire or where irrespirable or explosive gases may be present. Instruction is given in the use of portable gas detecting devices and in the search and rescue of persons trapped in burning buildings. Only a very limited discussion is made of fire and fire fighting equipment and principles as it is presumed each company has installed such equipment and gives such fire fighting training as is necessary to its operation.

As six persons have lost their lives and five additional instances have been reported of individuals being trapped in bins and stockpiles, training is given in the use of a rescue drum.

Instruction is also given in the recovery and treatment of individuals suffering from electric shock. The statistics compiled indicate there were two fatalities and seven dangerous occurrences recorded involving this hazard.

A very brief discussion is made in the course of the stability of surface soil and spoil slopes but only with a view to avoiding accidents from the improper location and construction of cuts and dumps. However, over the survey interval there were six fatalities and eight dangerous occurrences recorded rising from incidents of this nature.

The foregoing detailed areas of rescue training presented but the following list of the balance of the fatalities and the reported unusual or dangerous occurrences indicates considerable scope for additional rescue and job instructional training.

Origin	No. of Fatal Accidents	No. of Dangerous Occurrences
Explosives and blasting	6	32
Aerial trams and skipways	3	19
Falls	7	--
Drowning	6	--
Caught in machinery	6	5
Falls of rock	6	3
Headwall failures	-	12
Helicopter	3	--
Minor to major tailings dam failures	-	5
Struck by falling objects	3	2
Pressurized vessel explosions	1	2
Miscellaneous	1	11

INFORMATION SHEET FOR SURFACE RESCUE COURSE

A. The purpose of this course is to serve as a guide for good practices when people are to be moved from any hazardous situation to a point of safety.

B. A thorough knowledge of first aid is essential to rescue techniques.

C. It is suggested that six persons be the minumum desirable number required for rescue purposes, however, accident circumstances will dictate the number of persons available at that time. Additional help may be available from bystanders who should not be expected to operate without guidance or direction from the team captain.

D. Through training, a team should know what equipment is available (Emergency tool boxes): how to use the equipment, and be aware of hazards involved (gases, fires, etc.).

E. <u>Signalling:</u> When teams cannot be directed by verbal communication, they may be controlled by the use of horns, gongs, bells, or tugging on a rope.

The code signals set by the British Columbia Department of Mines and Petroleum Resources are, as follows:

1 - to advance, if at rest
1 - to stop, if in motion
2 - to rest
3 - distress
4 - attention
5 - retreat

F. Threshold Limit Values: The degree of effect of both gaseous and particulate contaminants depends largely upon the airborne concentration and the amount of exposure.

Accordingly, a listing of Threshold Limit Values (T.L.V.'s) are published yearly by the American Conference of Governmental Industrial Hygienists as guides for exposure concentration which, it is believed, a healthy individual normally can tolerate for 8 HOURS A DAY, FIVE DAYS A WEEK WITHOUT HARMFUL EFFECTS.

Airborne particulate concentrations are generally listed as milligrams per cubic meter of air (mg/m^3) and gaseous concentrations are listed as parts per million (ppm) or per cent by volume.

This training manual has been prepared by the staff of the Inspection and Engineering Division of the ministry to assist the surface workers to become aware and be able to recognize surface hazards and to learn how to protect themselves. Rescue equipment should be readily available at all times. This will enable the mine operator to carry out proper rescue procedures.

W.C. Robinson, P.Eng.,
Chief Inspector of Mines.

FUNDAMENTAL PRINCIPLES OF MINE RESCUE TRAINING ARE, IN ORDER OF IMPORTANCE:

1. Ensuring the safety of the Rescuing Team.
2. Endeavouring to rescue or ensuring the safety of the lives of the trapped men.
3. Protecting the mine property from further damage.
4. Rehabilitating the mine.

THE MECHANICS AND FUNCTION OF BREATHING

Many gases found in a mine during normal times can have a harmful effect on the human body if breathed for a period of time in concentrations above the recognized safe limit for that time period.

At the time of a fire in an underground mine great quantities of deadly gases can be given off. The biggest problem confronting the miner at the time of a mine fire is the protection of himself from such gases.

Even during normal times certain circumstances can cause the accumulation of gases or conditions of the air that would make the air harmful to breathe.

Most dangerous gases have a harmful effect on us after they have entered the body as we breathe. If we have an understanding of what happens when we breathe we can better realize what we must do and we must do it to protect ourselves from the various dangerous gases.

MECHANICS OF BREATHING

When we wish to breathe in, the muscles of our chest surrounding the lungs and our diaphragm lying below the lungs pull away from the lungs. This has the same effect as the bellows on an accordion when they are pulled open. A vacuum is created in the lungs by this chest expansion and the outside air rushes in to fill the vacuum.

The air enters the body by way of the nose and throat (pharynx), passes through the voice box (larynx), and then down the wind pipe (trachea), and bronchial tubes to the lungs.

When we breathe out the muscles of the chest and the diaphragm push inwards against the lungs. Once again this has the same effect as when we push in on the accordion bellows. The air is forced out of the lungs and takes the same path to the outside air as it took on entering.

It can be seen then that air can only get to the lungs if the passage ways are clear of obstructions and if the muscular action takes place to cause the expansion and contraction of the chest cavity.

Some gases when breathed can cause the air passages to swell and become obstructed or they can cause an interference with the muscular action that moves the chest and diaphragm.

The muscular action which causes us to breathe is controlled by a portion of the brain at the base of the skull. This portion of the brain is stimulated and controlled by the amount of carbon dioxide gas in the blood.

In summary then, the mechanics of breathing can be likened to a set of bellows. When contracted the air is forced out and when expanded the air is pushed into the bellows by the pressure of the atmosphere. The bellows of our lungs are expanded and contracted by our chest muscles and diaphragm. These muscles must be free to work and before air can enter the lungs the passage ways must be clear.

THE FUNCTION OF BREATHING

The preceding pages have outlined in a simplified way how we breathe, that is how we get air in and out of our lungs. But why do we breathe? What is the purpose of pumping this air in and out?

Everyone knows that normal air contains a certain amount of oxygen and that oxygen is required for life. It is the oxygen content of the air that our body requires and the lungs have a way of making the oxygen content of the air available for use by the body.

Just as a fire cannot burn without oxygen so the human body cannot "burn" or use digested food stuffs to produce energy unless it has a supply of oxygen.

When oxygen enters the lungs it is distributed to the millions of tiny air sacs of which the lungs are composed. These tiny air sacs or compartments have walls so thin, that the oxygen in the air can pass through the walls of the sacs into the blood itself.

Blood is composed of red and white cells carried in an almost colourless liquid called plasma. A part of the red cell is called haemoglobin (pronounced heem-o-glow-bin) and the haemoglobin attracts oxygen to it.

As the blood circulation brings the red cells into contact with the air sacs of the lungs the oxygen is attracted to the haemoglobin. The haemoglobin then carries the oxygen throughout the body where it does its part in the energy-producing combustion of the digested food stuffs.

On the blood's return trip to the lungs it carries with it the carbon dioxide that is produced as a waste product of the combustion. As the blood passes the air sacs in the lungs it picks up more oxygen and the carbon dioxide is forced out of the blood into the air sacs. The carbon dioxide is then breathed out with our exhaled breath.

We can see then that as we breathe, fresh oxygen is carried to the blood by way of the air sacs in the lungs and carbon dioxide is picked up from the blood by the air sacs and is breathed out into the air.

As the energy-producing combustion and body-building processes cannot carry on without oxygen, just as fire cannot burn without oxygen, it is obvious that without oxygen our bodies cannot continue to live.

Anything that interferes with the steady flow of oxygen to the tissues of the body will slow down or damage the body's function.

ELECTRIC SHOCK

The widespread use of electric power through a vast network of energy bearing wires has resulted in many injuries due to electric current. Some have been unavoidable but often they have been the result of carelessness. Generally they occur where medical aid is not readily available and First Aid must be administered quickly in order to save life.

Many factors influence the severity of electrical injuries. Although high voltages and amperages are dangerous, it must never be forgotten that contact with low voltages can cause death as well as contact with high voltages. Moisture from perspiration or precipitation provides a better contact and increases the severity of the injury, whereas partial insulation of dry clothing lessens the effect. Very often falls from poles follow electric shock and produce further injury, frequently of a very severe nature.

The immediate treatment for a person who has been a victim of electric shock is to remove his contact with the source. This can be best accomplished by throwing a switch if one is present, otherwise a hot stick should be used or some dry non-conducting article with the rescuer wearing rubber gloves and rubber boots From the foregoing, it will readily be seen that no matter what means are used to remove the patient from the power source, great care must be taken to ensure that the would-be rescuer does not also become a victim.

After the patient is freed, he may be mentally confused or even unconscious. His breathing should be checked and pulse felt and, if both are fairly regular he should be kept lying down and quiet. His clothing should be loosened around the neck to ensure free breathing and he should be carefully watched. Such patients upon regaining consciousness will sometimes attempt to get up and run. This action must be carefully guarded against as the sudden exertion could easily result in death due to heart failure. After a victim of electric shock has been at rest with normal respiration for an hour or more, he should be removed to a hospital, preferably as a stretcher case and by ambulance. Persons suffering from electric shock should be advised to contact a doctor before attempting to resume normal activities.

Severe electric shock may paralyze the respiratory centre in the brain causing a cessation of breathing, or it may cause Ventricular Fibrillation, a form of irregularity of the heart action and is usually fatal. From a First Aid stand point there is not much one can do to combat this heart condition other than to keep the patient quiet and at rest, however, the lack of breathing should be recognized and some form of artificial respiration started at once after removal of contact from the cause of the injury. Even if the pulse cannot be felt the movement of artificial respiration should be continued for hours, if necessary, as many victims of electric shock who appeared dead have been revived by perseverance in the giving of artificial respiration. When such victims are revived, they should be kept at rest and examined gently for further injury, fractures, burns, etc., treated for same, and removed to hospital. The importance of keeping a careful watch on these patients cannot be over-stressed because secondary shock may result several hours after apparent recovery, especially if he has not been kept quiet and at rest. Under no circumstances should the First Aider feel free to leave the patient alone until he is under adequate medical supervision, preferably in a hospital, bearing in mind always that respiratory paralysis may recur after apparent full recovery.

Many persons place a great deal of importance on electric burn treatment but generally speaking such is not a serious first-aid problem. Burns are usually found at the entrance and exit points where the current has passed through the body. These injuries are usually small and deep. A simple dry dressing is about all that is necessary for treatment. Very severe burns are sometimes encountered as a result of electricity, but generally when this condition exists there is not too much hope for a victim's survival and in fact severe burning can occur post mortem. Despite the foregoing, it should be remembered that electric burns heal slowly and occasionally severe burning may occur without death. It also should be borne in mind that burns with their subsequent shock have in some cases been the cause of death although the victim survived the initial electric shock. The intelligent First Aider will, of course, have done his utmost to refer these patients to a doctor.

The value of oxygen administration in the treatment of shock has been brought into prominence quite recently and the benefits of oxygen are outlined in the Oxygen Therapy lecture of the Industrial First Aid Course.

SUMMARY OF TREATMENT

1. Removal of patient from source of electricity.
2. Check breathing and start artificial respiration if necessary.
3. After revival keep quiet; at rest, and under observation.
4. Examine for and treat all injuries, fractures, burns, etc., with particular emphasis on shock treatment.
5. Give no stimulants or opiates.
6. Remove to medical attention, preferably hospital.
7. Above all, do not clutter up the scene by adding your own body through failure to assure safety from contact while attempting removal of victim from source of electricity.

OXYGEN THERAPY

This is a method of administering 100 per cent oxygen by inhalation, to victims of asphyxia from gas, carbon monoxide, smoke, fumes, and suspended respiration from electric shock, drowning, collapse, and other causes.

The approved oxygen equipment consists of the following:

A. Control Assembly (regulator) with approved Pin Indexed Yoke
B. 2 Oxygen Bottles (either D or E bottles accepted)
C. 2 Plastic Type Masks (disposable)
D. 2 Airways (adult size and small size)
E. Suitable Wrenches for Medical Post
F. Carrying Case or Pack Board

When the bottles have been received from the supplier, or have been returned after being recharged, there is usually a piece of plastic tape covering the oxygen aperture. (There is usually a new gasket under this tape.) N.B. Use ONLY approved Gaskets as supplied. This part of the bottle is known as the medical post. You will have noted the aperture for the flow of oxygen, and directly below this are two small holes; this is known as pin-indexing. The purpose of this pin-indexing is to prevent the use of other gases. All different gases are contained in bottles with appropriate pin-indexing , and the equipment used can only be attached to the appropriately pin-indexed bottle. Before attaching the unit, you must first remove the tape and "crack" the bottle. (Literally this means to open the valve on top of the medical post to allow some oxygen to escape.) The reason for this is to clear out any dust or foreign material that may be lodged in the aperture.

The yoke is now placed over the medical post, and when it is in position and gasket in place it is tightened with the hand screw. BEFORE OPENING VALVE ON THE BOTTLE MAKE SURE THE REGULATOR IS TURNED OFF. TURN COUNTER CLOCKWISE. When the valve on the bottle is turned on, you will get a reading on the high pressure gauge which tells you the amount of pressure in the bottle.

Attach the tubing from the mask to the unit, and open the regulator valve clockwise to the required flow, usually six litres is adequate, and allow this to flow through the mask and tubing for a few seconds before placing the mask on the patient. It is advisable to allow this flow in order to clear out any fluid or dust that may be lodged in the tubing. It is difficult to wash and sterilize the mask without having some of the fluid fouling the mask or tube. Many patients have never seen oxygen equipment and it may cause some uneasiness or alarm; to minimize this with a conscious patient it is probably reassuring to the patient to allow him to hold the mask to his face with the oxygen flowing and when he is accustomed to it slip the elastic band of the mask over his head to hold the mask in position. It is always advisable to have the oxygen flowing when applying the mask.

When the patient's respiration and pulse are normal, or nearly so, you can discontinue the use of oxygen.

The equipment must be stored until further need for it. THE OXYGEN FROM THE BOTTLE IS SHUT OFF (VALVE ON TOP OF MEDICAL POST) "BLEED" OUT THE OXYGEN IN THE GAUGE SO THAT THE GAUGES READ "NIL". This is very important as the gauges can be damaged if left continuously under pressure.

The mask is now sterilized. PLASTIC MASKS OF THIS TYPE CANNOT BE AUTOCLAVED OR BOILED. Cold sterilization is done by carefully washing the mask with some good soap, then using a good antiseptic such as Zephiran Chloride 1/1000 solution as recommended by the manufacturer. Lacking this, a strong solution of Dettol is acceptable. NEVER USE ALCOHOL AS IT WILL DAMAGE THE MASK.

SAFE PRACTICES IN OXYGEN THERAPY

THE FOLLOWING RULES SHOULD BE STRICTLY OBSERVED:

1. Keep oil, grease, greasy clothing, and similar substances away from oxygen regulators, mask, or patient. Remember that oil coming in contact with oxygen under high pressure can explode violently.

2. No smoking should be permitted in a room where oxygen therapy is proceeding. Make sure your patient does not possess matches or smoking material. This NO SMOKING rule should be rigidly enforced and signs to that effect should be posted conspicuously in your First Aid Room.

3. Do not use Electrical heating devices or infra red lamps on a patient while oxygen therapy is in progress.

4. UNQUALIFIED PERSONS SHOULD NEVER attempt to refill a cylinder with makeshift equipment, or under any other circumstances. The refilling of small cylinders from larger ones is extremely hazardous and should be avoided. Return your empty cylinders to qualified charging plants for refilling under recognized safety and control procedure.

5. Do not store Oxygen cylinders near flammable or combustible materials such as oil, grease, gasoline, alcohol or ether, or near sources of heat such as boilers or steam pipes. Store in a cool place. Although oxygen itself does not burn or explode on contact with flame, it violently supports combustion.

6. Keep Oxygen cylinders in service or in storage secured in an upright position. Do not permit them to be dropped or to strike each other violently, as a valve might be opened whereupon the cylinders could become a dangerous projectile.

7. Before attaching gauges or regulator to cylinder, "crack" the cylinder valve in order to clear out any foreign matter which may be in aperture. Turn opening away from you while doing so.

8. After regulator is in place, attach the facepiece - making sure that the litre flow regulating valve is in the "off" position. Then turn on cylinder valve. This should give the tank pressure reading on the pressure gauge. When assured that this gauge is operated properly, turn on litre flow valve to desired flow. This will clear out any moisture or foreign matter which may be in the tubing. You may then apply the face piece or mask to the patient.

Observance of these rules may prevent serious and utterly unwarranted accidents.

ON THE THRESHOLD OF UNDERSTANDING

A great deal of attention will be paid to the toxicity of chemicals as they affect the human body. All chemicals used in industry that have a toxic effect on workers will have a maximum allowable concentration to which the employee can be exposed for an eight day hour. These concentrations will be expressed in parts per million (P. P. M.)

For many of us, "1 ppm" is about as hard to visualize as the national debt. The following from Foresty Facts helps indicate what one part per million really represents under various conditions:

1 ounce of sand in 31 tons

1 inch in 16 miles

1 minute in 1.9 years

1 ounce of dye in 7,503 gallons

1 square inch in 1/6 acre

1 pound in 500 tons

1 cent in $10,000 dollars

1/6 inch thickness in a pile 1 mile high

Keep these comparisons handy somewhere--they might sharpen your threshold limit sense of values.

CHEMISTRY OF FIRE

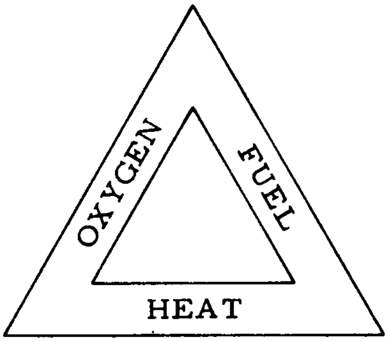
DEFINITION

Fire or burning may be described as a form of rapid oxidation of a substance and is accompanied by a large release of heat and light energy. (The release of heat energy may be so rapid as to cause a violent expansion of the gases produced which is described as an explosion.)

In examining this definition it will be seen there are three requirements necessary for a fire and these are:

(a) Oxygen to provide oxidation.
(b) A fuel or a substance which will burn.
(c) The production of heat energy.

These three items become the components of the triangle of fire, and the absence of any make a fire impossible.



OXYGEN

This is colourless odourless, tasteless gas which supports combustion. Ordinary air contains about 21 per cent oxygen.

Oxygen is the chemical combination of oxygen with another element or compound. This combination is almost invariably accompanied by a release of heat energy. Such a release is known as an exothermic reaction. The amount of heat energy released varies with the elements or compounds with which oxygen combines. Among the highest heat energy releases are those occurring when oxygen combines with carbon, hydrogen or a compound of both elements.

If the chemical combination with carbon and oxygen is complete, carbon dioxide, a colourless gas is produced. If the combination is with hydrogen and oxygen, water vapour or steam is produced. If the combination includes both carbon and hydrogen and the reaction is complete, then carbon dioxide and water vapour are produced and the resulting smoke is white. If the reaction is incomplete, the products of combustion are carbon monoxide, carbon dioxide, water vapour and particles of free carbon which form gray or black smoke.

FUEL

The fuel is any substance - solid, liquid or gas which with an adequate supply of oxygen, will burn. However, the speed of ignition is not necessarily related to these physical states but to a number of conditions such as:

(a) Physical size of burning material (e.g. dust or lump or gaseous)
(b) Concentration of flammable vapour
(c) Supply of oxygen
(d) Available heat
(e) Ignition temperature
(f) Flash point with liquids or gases

The ignition temperature is defined as the temperature at which a substance can be ignited and will continue to burn spontaneously (i.e. the heat generated by the ignition is sufficient to maintain burning). Flash point is that temperature at which a flammable liquid gives off vapours sufficient to form an ignitable mixture with air.

As mentioned earlier, ignition can be accompanied by explosive force. Certain fuels have in their vapour states a broad concentration range (explosive limits) where an explosion will occur if ignition takes place within the range. The explosive limits are expressed as a percentage by volume of a mixture of the particular fuel with air.

Some examples of the explosive limits, flash points and ignition temperatures are as follows:

Fuel	Explosive Limit %	Fl. Pt. °F	Ig. Temp. °F
Acetylene	2.5-81		571°
Carbon monoxide	12.5-74		1128°
Ether	1.9-48	-49°	356°
Gasoline	1.4-7.6	-45°	536°
Lube oil		300°-450°	500°-700°
Methane	5.0-15		1202°
No. 1 Fuel (stove oil)	0.7-5	100°	900°-1070°
Propane	2.2-9.5		871°

Flammable liquids are classified in three groups according to the temperature range of their flash points and are listed as follows:

Class 1	20°F or less
Class 11	21°F to 70°F
Class 111	71° to 200°F

HEAT

The source of heat for commencing ignition is usually from an external source, however, once commenced, the amount of heat released during ignition is frequently sufficient to maintain ignition spontaneously.

In addition to heat released in the oxidizing process of burning, the following conditions may cause ignition or may increase the available heat:

(a) Friction - An overheated bearing or the striking of a match.
(b) Electric Flow
  (i) Static spark discharge - resistance to current flow produces heat.
  (ii) Overheated current carrying wire - resistance to current flow.
(c) Chemical Generation - spontaneous combustion - e.g. oily rags, metallic sodium.
(d) Conduction - transfer of heat energy via an overheated metal rod.
(e) Convection - circulation of overheated air.
(f) Radiation - overheating by sunlight or from a nearby fire.

CONTROL

If adequate quantities of the three elements of the fire triangle are present then a fire is waiting to happen. If the fire has started, it will surely be nourished unless one or more of the elements are removed. Although it may be possible to remove or isolate the fuel as a wise fire protection act, the most common combatant procedure is to reduce the temperature by quenching or by cutting off the oxygen supply. On type "A" fires such as the free burning of wood, rubbish, textiles, paper, etc., extinguishing can be done by cooling and quenching with type "A" extinguishers which are soda-acid; pressurized pump tank, foam or water. Type "B" fires which include such volatile quick burning fuels as gasoline, oil or ether, type "B" extinguishers which are CO_2, dry chemical, vapourizing liquids should be used. These extinguishers blanket or smother the fire by displacing the oxygen. When such extinguishers have been used in closed or sunken areas great care must be taken not to have the fighter asphyxiated. Class "C" fires are electrical and require non-conductant type "C" extinguishers which are CO_2, dry chemical, vapourizing liquid or chlorobromomethane (CBM). A fourth type of fire extinguisher has been evolved in recent years and that is the use of foam. The foam is blown into the fire area and extinguishes it by cutting off the oxygen and the moisture present helps quench the flame.

ESCAPE AND RESCUE FROM BURNING BUILDINGS

RESCUE

General

The primary duty of fire-fighters is to save life. Due to fear and excitement, persons trapped often forget the normal means of escape and have a tendency to throw themselves from a window or roof into the street, despite the fact that there may be no immediate danger and that help may be at hand. Where persons are crying out for help, they should be reassured and told not to jump. Find out as quickly as possible whether any one is trapped; this information can often be obtained from neighbours. If it is suspected that anyone is still in the building, a thorough and methodical search must be carried out at once.

No hard and fast rule can be laid down as regards rescue, as it depends entirely upon the type of building and equipment available. The general rule is that the search should begin at the top of the building so that the searchers are nearest to fresh air and safety at the end of their search.

Entry

When trying to enter a building, the main door should first be tried. It may not be locked. If entry has to be forced, it should be done by the method which will cause least damage, remembering it is easier to break glass than wood. The possibility of entry by the back door should not be overlooked. The way the smoke issues from the opening will let the resucer know whether there is gas building up. If it comes out in a gentle flow, a gas build-up is not likely, but if it comes out in puffs one would suspect a gas build-up.

Searching a Building

When possible, it is advisable to work in pairs on entering a smoke-filled room or building. This gives confidence and makes it possible for one to assist the other. People trapped by fire or smoke, particularly children, often take refuge under beds or in cupboards where they hide to escape the smoke and flames. Searching, though swift, should be thorough, every room should be investigated and no possible hiding place, however unlikely, overlooked.

Searching a Room

Searching a smoke-filled room is not an easy task and is unlikely to be successful unless carried out on a definite plan. Once inside the room a complete circuit should be made, keeping close to the wall, feeling under and around objects, and opening and feeling inside cupboards, around objects and other articles of furniture. Finally, the room should be crossed diagonally to make sure no one is lying in its centre.

Always remember that floors immediately above the fire may have been weakened sufficiently to become dangerous and care should be exercised when it is necessary to search the centre of the room. Whether or not the windows should be opened to obtain fresh air during the search depends on circumstances. Only when it is known that the fire is in a distant part of the building and is being attacked, or if the atmosphere is cool, it is safe to open the windows.

When opening a door behind which fire may be found, the possibility of a back draught of flame caused by the intake of air should not be overlooked. The most obvious warning of danger is the presence of heat. The metal shank connecting the two door knobs is a good conductor of heat and if this or the door knob prove to be very hot then the door must be opened with care. A room should not be entered, except for rescue purposes, without proper equipment for the immediate application of water to the fire.

If the door opens towards you then the foot should be placed against the bottom of the door, and the handle turned gently.

There may be a considerable pressure in the room due to the expansion of the heated gases. It is desirable to crouch in such a way that any heated gases or flames which are released pass over the head.

Moving an Insensible Person

It is not an easy matter to lift an insensible person, and carrying involves the maximum danger in smoke, both from suffocation and falling. To move an insensible person, turn him on his back on the floor, tie his wrists together, kneel across him and place your head through the loop formed by his arms; then you can crawl on hands and knees dragging him with you although he may be far heavier than yourself. To move an insensible person downstaires, lay him on his back, head downwards on the stairs, place your hands under his armpits, so that his head rests on the crook of your arm and ease him gently downstairs.

MINE GASES, THEIR OCCURRENCES, PROPERTIES, EFFECTS ON HUMAN BEINGS, AND TREATMENT OF PERSONS AFFECTED BY THEM

AIR

Air is the transparent medium surrounding the earth in which plants, animals, and human beings live and breathe. It is a mixture of several gases which, though ordinarily invisible, can be weighed, compressed to a liquid, or frozen to a solid.

Pure dry air at sea level contains by volume the following gases: Oxygen (O_2), 20.94%; Nitrogen (N_2), 78.09%; Carbon Dioxide (CO_2), 0.03%; and Argon (Ar), 0.94%. Traces of other gases such as hydrogen, helium, etc., are also present.

The air in a well-ventilated mine seldom shows any depletion of the oxygen content.

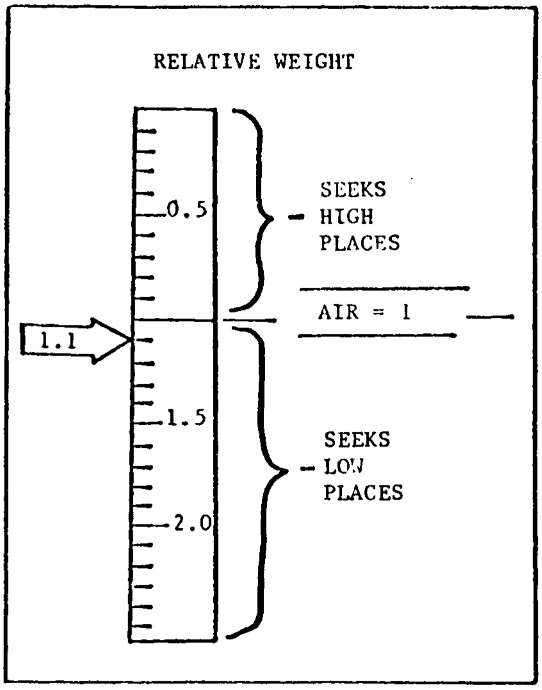
Mine air may be contaminated by the presence of other gases such as carbon monoxide, sulphur dioxide, hydrogen sulphide, methane, oxides of nitrogen, and excess carbon dioxide. The presence of these gases may be due to any of the following:

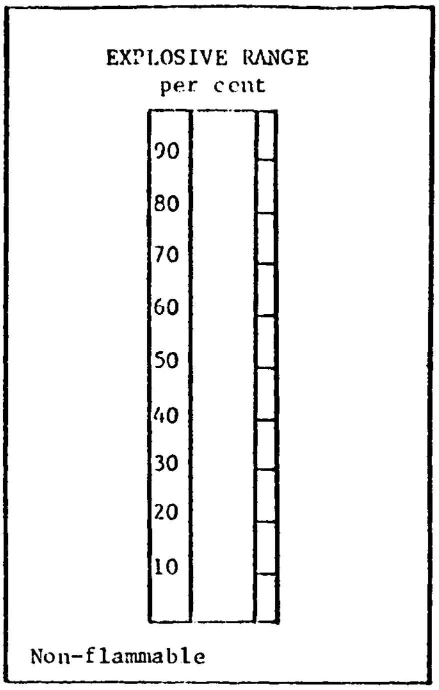
1. after effects of blasting or other explosions
2. after effects of mine fires
3. exudations from ore or country rock, as with methane
4. decay of mine timber
5. absorption of oxygen by water or oxidation of timber or ore
6. use of diesel motors underground
7. gas carried with thermal water - carbon dioxide

Except in the case of fire, positive ventilating currents of sufficient quantity will prevent any dangerous accumulation of these gases. Gases may affect people either by their combustible, explosive, or toxic qualities, or, if inert, by the displacement of oxygen. The effects may be due to varying atmospheric conditions and may be classified as follows:

ALTITUDE:	Breathing becomes more laborious due to the decrease in oxygen content as the altitude increases. This is not dangerous unless conditions are extreme or the labour arduous.

GAS OXYGEN (O_2) and oxygen deficiency





OTHER PROPERTIES

COLOUR:	NONE
ODOUR:	NONE
TASTE:	NONE
OTHER:	Detected by candle, safety lamp, these go out at approximately 16 per cent oxygen

HOW DEPLETED

Oxygen deficiency caused by humans breathing in confined space, absorption of oxygen by water, oxygen being consumed by fire, etc.

THRESHOLD LIMIT VALUE AND EFFECT ON HUMANS

Mine air should have at least 19.5 per cent oxygen. High concentration not harmful. Essential to life. Early symptoms of oxygen deficiency - buzzing in ears, rapid breathing, confusion of mind, unconsciousness

TREATMENT OF PERSONS AFFECTED (oxygen deficiency)

Remove to fresh air, give oxygen - artificial respiration if breathing stopped.

HUMIDITY: High temperatures with high humidity are very enervating and cause considerable discomfort.

TEMPERATURE: High temperatures with low humidity are not dangerous except from the blistering effect of heat.

IMPURE AIR:

1. Air deficient in oxygen is not dangerous unless the oxygen content is below 16 per cent, or unless the oxygen has been displaced by toxic gases.
2. Non-toxic gaseous impurities are not dangerous unless gases have displaced the oxygen content to below 16 per cent.
3. Some toxic gaseous impurities, even in very low concentrations, have deadly effects. Effects may be sudden or gradual according to the concentration of impurity.

OXYGEN - (O_2)

Oxygen, a colourless, odorless, tasteless gas is the most important constituent of air. It is necessary for the support of life and combustion. Men breath most easily and work best when the air contains approximately 21 per cent of oxygen, but they can live and work, though not as well, when there is less oxygen. When the oxygen content is about 17 per cent, men at work will breathe a little faster and more deeply. The effect is about the same as when going from sea level to an altitude of 5,000 feet. Men breathing air containing as little as 15 per cent of oxygen usually become dizzy, notice a buzzing in the ears, have a rapid heartbeat, and often suffer headaches. Very few men are free from these symptoms when the oxygen in the air falls to 10 per cent. Mine air should contain not less than 19.5 per cent oxygen.

The flame of a safety lamp or candle is extinguished when the oxygen falls to about 16.0 per cent. A carbide lamp flame will burn in an atmosphere containing as little as 12.5 per cent of oxygen.

Since oxygen is more soluble in water than nitrogen, air in a confined area, when exposed to water, will probably have a lowered oxygen content. As an example: the oxygen content of the air from a hydraulic compressed air plant is lowered to about 17.7 per cent of oxygen and a consequent rise in nitrogen content occurs.

Oxygen percentage higher than the normal 20 to 21 per cent apparently has no injurious effects on men. This is found to be the case in the use of self-contained oxygen breathing apparatus. There is no noticeable effect after successive periods of wear. Oxygen in high percentages, as used with the oxygen breathing apparatus, helps men to work with less fatigue. However, it is dangerous to breathe pure oxygen at pressure much higher than 15 pounds per square inch for a very long time. Lorrain Smith, the well-known physicist, states that irritating effects of oxygen are only found in human beings after they have been exposed for 48 hours or more in an atmosphere containing 80 per cent oxygen.

The effects of oxygen deficiency near or below sea level are the same as those due to the reduction of oxygen to high altitudes. At approximately 7 per cent of oxygen the face becomes leaden in colour, the mind becomes confused, and the senses dulled. When there is no oxygen in the atmosphere, loss of consciousness occurs in a few seconds without any warning symptoms. J.S. Haldane, the British physicist, says that loss of consciousness in air deprived of oxygen is quicker than in drowning; not only is the supply of oxygen cut off, but oxygen previously in the lungs is rapidly removed and used up; loss of consciousness is quickly followed by convulsions, then by cessation of respiration. Oxygen may be so lacking as to imperial life before one realizes the danger.

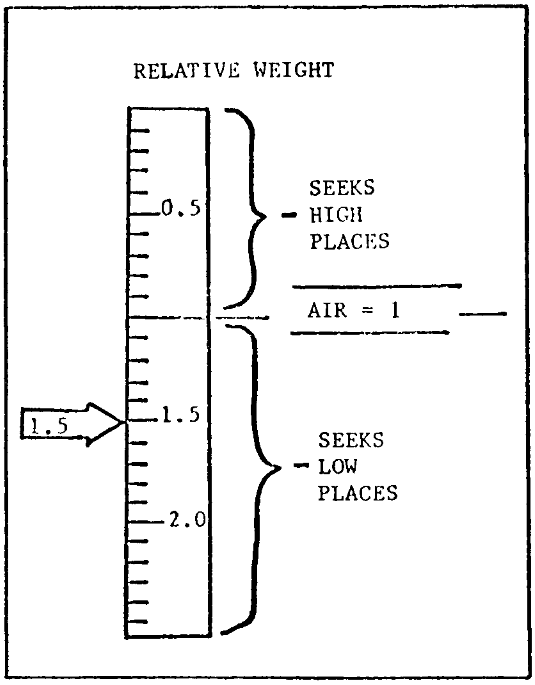
Some of the causes of oxygen deficiency underground are:

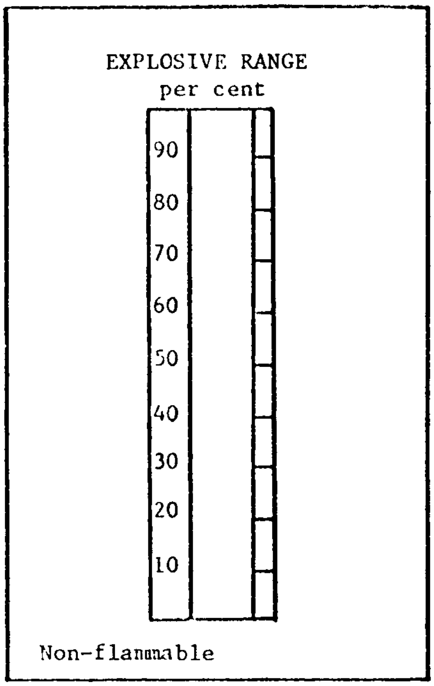
1. absorption by water or certain types of rock, ore, or fill
2. the breathing of men in confined space
3. displacement by carbon dioxide, carbon monoxide, or other gases
4. heating conditions or combustion

OXYGEN DEFICIENCY

Oxygen Present	Effect
21%	Breathing easiest
17%	Breathing faster and deeper
15%	Dizziness, buzzing noise, rapid pulse, headache, blurred vision
9%	May faint or become unconscious
6%	Movement convulsive, breathing stops, shortly after heart stops

GAS CARBON DIOXIDE (CO_2)





Non-flammable

OTHER PROPERTIES

COLOUR: NONE

ODOUR: NONE

TASTE: Acid if breathed in large quantities.

OTHER:

HOW FORMED

Oxidation of organic materials, rotting timber, burning wood, blasting, diesel engines, humans breathing and as a product of complete combustion of organic materials.

THRESHOLD LIMIT VALUE AND EFFECT ON HUMANS

T.L.V. = 5,000 ppm - stimulates breathing; 50,000 ppm - increases respiration 300 per cent; 100,000 ppm - can be endured for only short periods.

TREATMENT OF PERSONS AFFECTED

Remove to fresh air, give oxygen, artificial respiration if breathing stopped.

CARBON DIOXIDE (CO_2)

Carbon dioxide, an inert gas, is a product of the decomposition and/or combustion of organic compounds in the presence of oxygen, and also of the respiration of men and animals. It is a colourless, odorless gas which, when breathed in large quantities, may cause a distinctly acid taste. It will not burn or support combustion. Carbon dioxide, being heavier than air, is often found in low places and abandoned mine workings, and is a normal constituent of mine air. The proportions of carbon dioxide in mine air is increased by the process of breathing., by the burning of flame lamps, by fires, explosions, and blasting, or by escaping with thermal water. Clinical investigations indicate that carbon dioxide influences the respiratory rate. This rate increases rapidly with increasing amounts of carbon dioxide.

The following table shows the effect upon a human being of increasing amounts of CO_2 in the air breathed:

%CO_2 in atmosphere	Increase in respiration
0.05	slight
2.0	50%
3.0	100%
5.0	300% and laborious
10.0	Cannot be endured for more than a few minutes

Carbon dioxide in air has these effects when the oxygen content remains approximately normal and the individual is at rest. Moving around or working increases the symptoms and the danger is greater than when the individual is resting. Concentrations of over 5 per cent of carbon dioxide in the air are usually accompanied by an appreciable lowering of the oxygen content. Carbon dioxide in mine air should be not more than 0.50 per cent.

PHYSIOLOGICAL EFFECTS OF CARBON DIOXIDE

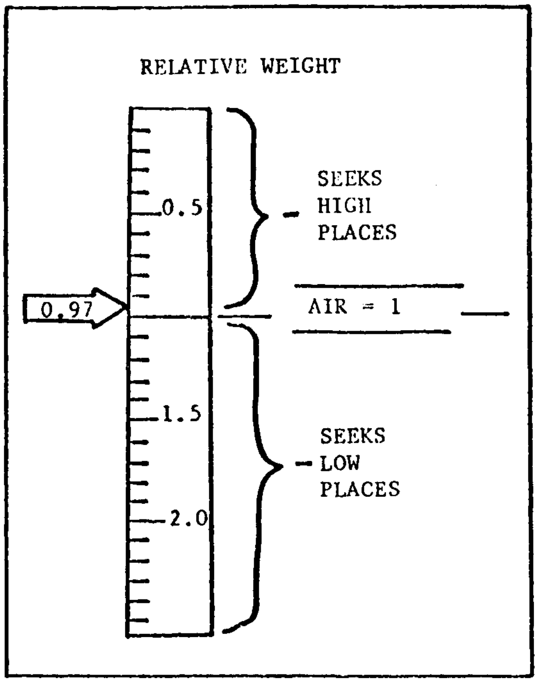
Percentage of Carbon Dioxide in the Atmosphere	Increase in respiration
.5	Maximum allowable for an 8-hr. day
0.05	Slight
2.0	50%
3.0	100%
5.0	300% and laborious
10.0	Cannot be endured for more than a few minutes

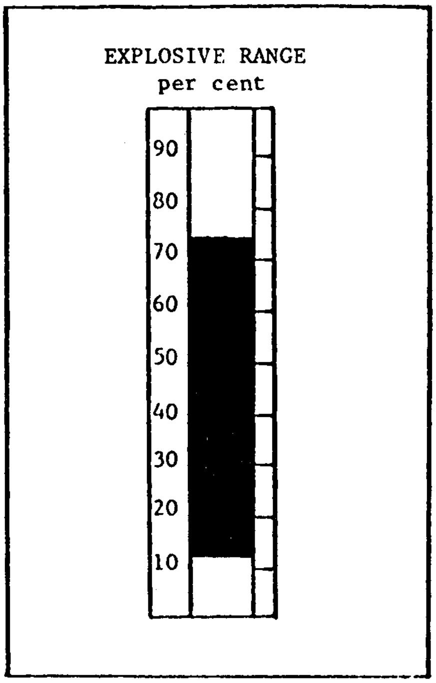
Concentrations of over 5 per cent of carbon dioxide in the air are usually accompanied by an appreciable lowering of the oxygen content.

NITROGEN (N_2)

Nitrogen is a colourless, odorless, inert gas. It is not combustible, nor will it support combustion. It has no physiological effect on men and is only dangerous if it occurs in such concentrations that it dilutes the air sufficiently to cause the oxygen content to fall below a safe limit. This dilution may result from the oxidation of various substances or from the consumption of an active fire, thus robbing the mine atmosphere of a part of its oxygen. The oxygen may be reduced to a very low point and the residual nitrogen mixed with the products of combustion such as carbon dioxide, carbon monoxide, sulphur dioxide, etc.

GAS CARBON MONOXIDE (CO)





OTHER PROPERTIES

COLOUR: NONE
ODOUR: NONE
TASTE: NONE
OTHER:

HOW FORMED

Incomplete combustion of organic materials. Diesel exhaust, blasting, fires.

THRESHOLD LIMIT VALUE AND EFFECT ON HUMANS

T.L.V. = 50 ppm - saturates blood so oxygen cannot be used. Early symptoms include tightness of skin on forehead, dizziness, nausea, confusion of mind, a pink colour of the skin, and unconsciousness. Absorption by blood is cumulative.

TREATMENT OF PERSONS AFFECTED

Remove from further exposure, give oxygen. Medical aid for acute poisoning, keep patient at rest.

CARBON MONOXIDE (CO)

Carbon monoxide gas constitutes one of the greatest hazards to life in underground mining. It is one of the products of combustion in normal blasting operations and in the use of diesel motors underground, and is dangerous unless adequate ventilation is provided. It is also produced by such abnormal occurrences as mine fires or gas explosions. It is a product of incomplete combustion and is formed wherever organic compounds are burned in an atmosphere with insufficient oxygen to carry the process of burning or oxidation to completion. It is a colourless, odorless, tasteless gas which, when breathed in even low concentrations, will produce symptoms of poisoning. Carbon monoxide will burn and air that contains 12.5 to 74 per cent of carbon monoxide will explode if ignited. It is only slightly soluble in water and is not removed from the air to any extent by water sprays. It is slightly lighter than air, having a specific gravity of 0.967.

Carbon monoxide in excess of 0.01 per cent, if breathed indefinitely may eventually produce symptoms of poisoning; 0.02 per cent will produce slight symptoms after several hours exposure. When 4 parts in 10,000 (0.04 per cent) are present and the exposure is for two to three hours, headache and discomfort usually occur. With moderate exercise, when 0.12 per cent is present, slight palpitation of the heart will occur in 30 minutes, tendency to stagger in 11/2 hours, and confusion of mind, headache, and nausea in 2 hours. In concentrations of 0.20 to 0.25 per cent unconsciousness usually occurs in about 30 minutes. The effect of high concentrations may be so sudden that one has little or no warning before collapsing. The carbon monoxide content of the air in which men are employed for a period of 8 hours should not exceed 0.005 per cent or 50 ppm.

HOW CARBON MONOXIDE ACTS

The oxygen absorbed from the air in the lungs is normally taken up by the blood in the form of a loose chemical combination, with the red colouring matter (haemoglobin) of the corpuscles, and in this form it is carried to the tissues where it is used. Haemoglobin forms a much more stable compound with carbon monoxide than with oxygen and when saturated with the former it cannot take up oxygen.

The affinity of haemoglobin for carbon monoxide is about three hundred times its affinity for oxygen; hence when even a small percentage of carbon monoxide is present in the air breathed, the haemoglobin will absorb the carbon monoxide in preference to the oxygen. When carbon monoxide is absorbed by haemoglobin it reduces the capacity of the haemoglobin for carrying oxygen to the tissues to a proportionate extent. It is this interference with the oxygen supply to the tissues that produces the symptoms of poisoning.

The symptoms of poisoning more or less parallel the extent of blood saturation. The first definite symptoms, during rest, make their appearance when 20 or 30 per cent of the haemoglobin is combined with carbon monoxide. Unconsciousness takes place at about 50 per cent saturation and death occurs at about 80 per cent.

According to experiments conducted by the United States Bureau of Mines, the symptoms produced by various percentages of carbon monoxide in the blood are as follows:

PERCENTAGE OF BLOOD SATURATION	SYMPTOMS
0 - 10	None
10 - 20	Tightness across forehead, possible headache
20 - 30	Headache, throbbing in temples
30 - 40	Severe headache, weakness, dizziness, dimness of vision, nausea, vomiting and collapse
40 - 50	Same as 30 - 40, with more possibility of fainting and collapse, increased pulse and respiration
50 - 60	Fainting, increased pulse and respiration, coma with intermittent convulsions
60 - 70	Coma with intermittent convulsions, depressed heart action and respiration, possible death
70 - 80	Weak pulse and slowed respiration, respiratory failure and death

The symptoms decrease in number with the increase in the rate of saturation. If exposed to high concentrations, the victim may experience but few symptoms. The rate at which a man is overcome and the sequence in which the symptoms appear depend on several factors; the concentration of gas, the extent to which he is exerting himself and the state of his health and individual susceptibility and the temperature, humidity and air movement to which he is exposed.

Exercise, high temperature and humidity, with little or no air movement, tend to increase respiration and heart rate and consequently result in more rapid absorption of carbon monoxide.

TREATMENT FOR CARBON MONOXIDE POISONING

The onset of carbon monoxide poisoning may be either sudden or gradual, depending on the concentration and period of exposure. Interest usually centres in the treatment of the acute or sudden form.

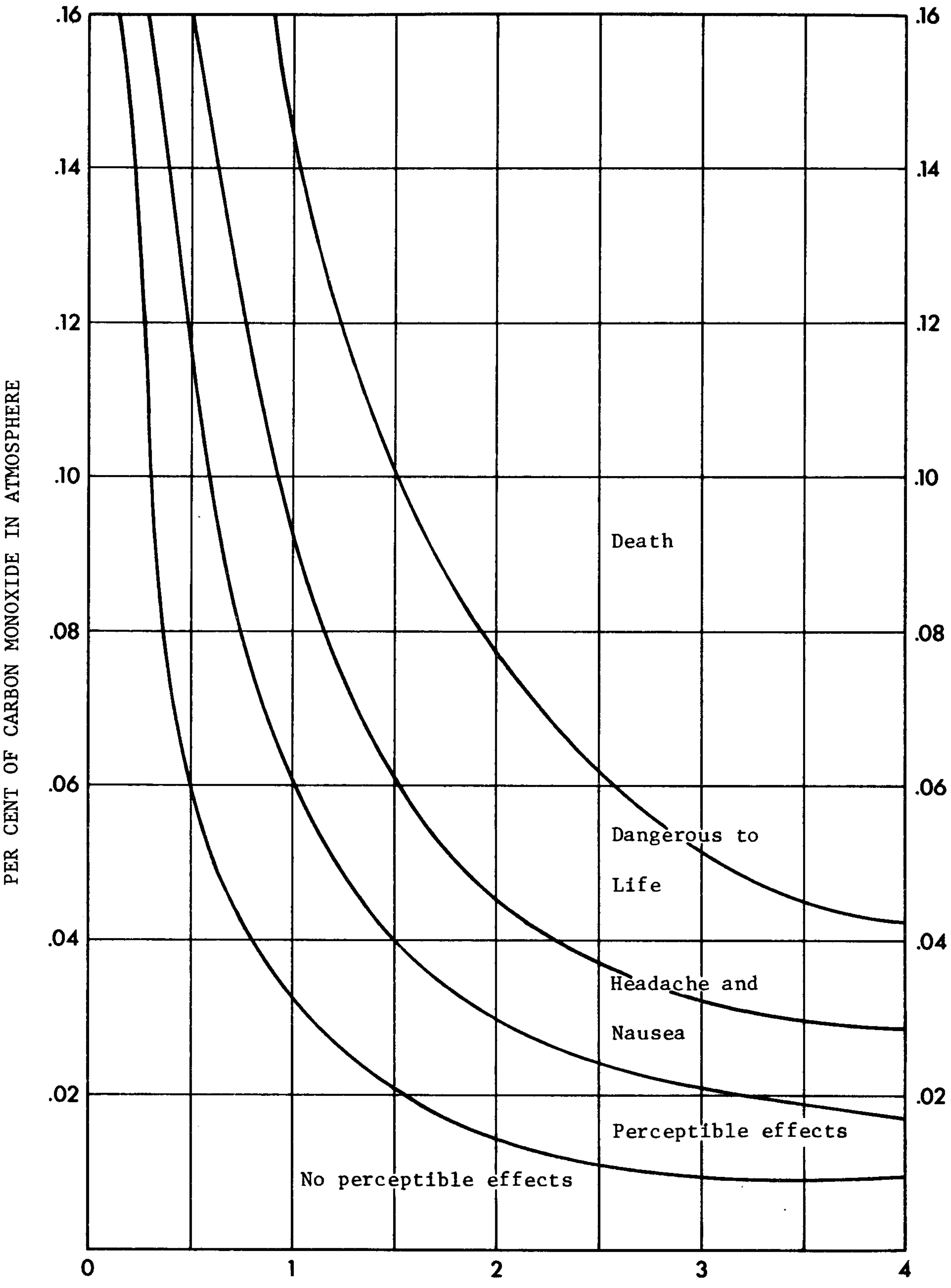
In the treatment of the chronic or gradual form of poisoning the most important factors are avoiding further exposure and taking a thorough rest. In the treatment of acute carbon monoxide poisoning the most important thing is to get the gas out of the blood as rapidly as possible, thus decreasing the possibility of serious after effects or even loss of life through failure of the heart and respiration. As soon as the patient begins to breathe air in which there is no carbon monoxide the process of eliminating the gas from the blood will begin naturally. However, this normal elimination is slow and often has serious effects. It requires possibly 8 to 15 hours to reduce the carbon monoxide haemoglobin to 10 per cent of the total haemoglobin. Inhalation of pure oxygen will remove the carbon monoxide from the blood four or five times faster. The use of oxygen alone in an oxygen therapy unit is common practice because it is usually readily available owing to its general use in industry. Inhalation treatments are preferably given with an inhalator, but the oxygen may be administered by improvised apparatus or sprayed directly over the patient's face from a cylinder when an inhalator is not at hand. Caution should be observed in controlling the flow when using the gas directly from the cylinder. The cylinder should be opened and the flow regulated before the gas is directed toward the patient. No improvised mask or device should be used in which pressure can be built up and injure the patient. Because of its great efficiency an inhalator is preferable to any improvised device.

The steps in the effective treatment of carbon monoxide poisoning are as follows:

1. The patient should be removed to fresh air as soon as possible.

2. If breathing has stopped, is weak and intermittent, or is present only in occasional gasps, artificial respiration should be given

TIME ON HUMAN BEINGS



HOURS EXPOSURE

persistently until normal breathing is resumed, or until it is definitely established that the patient is dead.

3. Pure oxygen should be administered, beginning as soon as possible and continuing as long as necessary - at least 20 minutes in mild cases and as long as one or two hours in severe cases.

4. Circulation should be aided by rubbing the limbs of the patient (towards the heart) and keeping his body warm with blankets, hot water bottles, etc.

5. The patient should be kept at rest, lying down to avoid strain on the heart; later he should be given plenty of time to rest and recuperate. It cannot be emphasized too strongly that immediate inhalation of oxygen, for 20 to 30 minutes, will lessen to a great extent the severity of results of carbon monoxide poisoning and decrease the possible serious after effects.

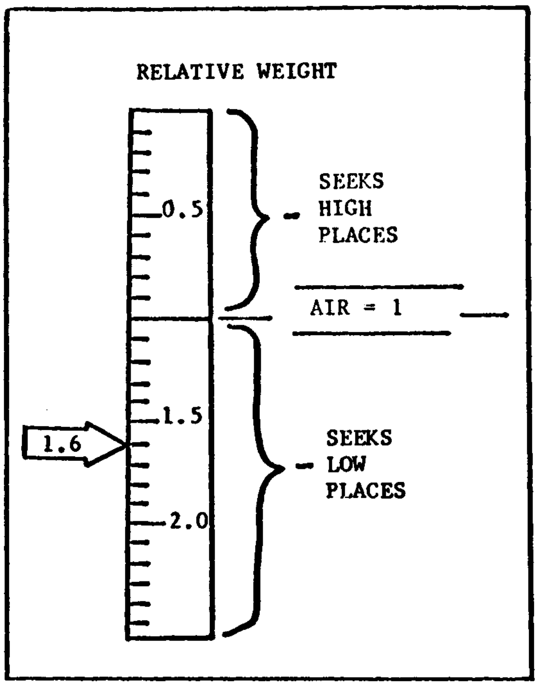
PHYSIOLOGICAL EFFECTS OF CARBON MONOXIDE

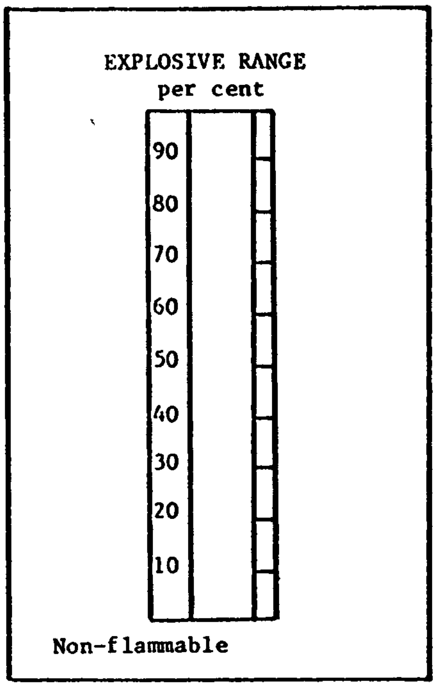
Concentration of CO Per cent	Allowable Length of Exposure
0.005	Allowable for exposure of several hours
0.04 to 0.05	Can be inhaled for 1 hour without appreciable effect
0.06 to 0.07	Just noticeable effects after 1 hour exposure
0.10 to 0.12	Unpleasant, but probably not dangerous after 1 hour exposure
0.15 to 0.20	Dangerous for exposure of 1 hour
0.4 or more	Death in less than 1 hour

OXIDES OF NITROGEN (NO, NO_2, etc.)

Oxides of nitrogen are formed in mines by the burning of explosives and, to a slight extent, by their detonation. They can usually be detected by the "burned powder" odor familiar to blasters and by the reddish colour of nitrogen peroxide (NO_2) fumes, which are formed when the nitric oxide (NO) produced by the explosion comes in contact with the air. Hall and Howell report that gases collected from

GAS OXIDES OF NITROGEN (NO and NO_2)





OTHER PROPERTIES

COLOUR: NONE in small concentrations; reddish-brown in higher concentrations.

ODOUR: NONE

TASTE: NONE

OTHER:

HOW FORMED

Diesel exhaust, blasting with dynamite and ammonium nitrate blasting agents.

THRESHOLD LIMIT VALUE AND EFFECT ON HUMANS

T.L.V. = 5 ppm - corrosive to tissues of lungs and respiratory trac. Causes oedema of lungs.

TREATMENT OF PERSONS AFFECTED

Remove to fresh air, give oxygen and complete rest. Seek medical aid.

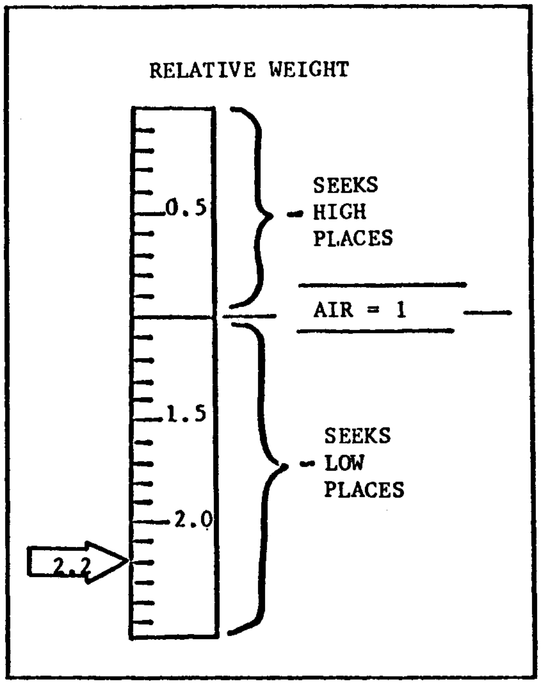
the burning of 40 per cent gelatin dynamite contain 11.9 per cent of oxides of nitrogen. When explosives having properly proportioned components are completely detonated, they usually produce exceedingly small percentages of oxides of nitrogen, which are considered harmless. Explosives from which the wrapper has been removed may produce harmful percentages of oxides of nitrogen, even when detonated. Diesel engines also produce oxides of nitrogen.

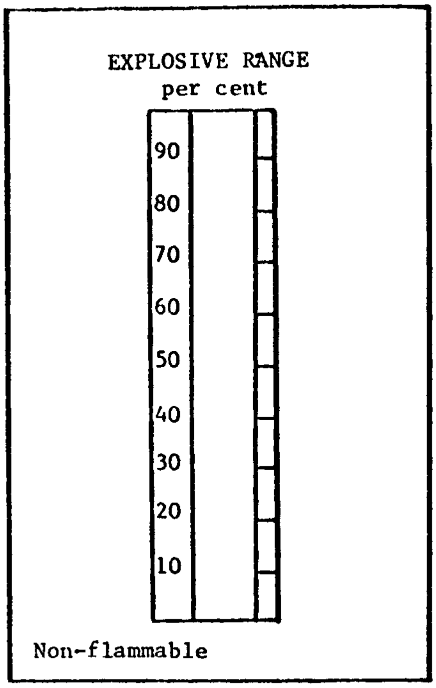
Oxides of nitrogen corrode the respiratory passages and the breathing of relative small quantities may cause death. The effect is unlike that of carbon monoxide in that a person may apparently recover and then suddenly die several days later. Nitrogen peroxide (NO_2) is probably the most irritating of the oxides of nitrogen. Its effect on the respiratory passages usually are not manifest until several hours after exposure when oedema and swelling take place. This irritation may be followed by bronchitis or pneumonia, frequently with fatal results. One-hundredth (0.01) per cent of nitrogen peroxide may cause dangerous illness if breathed for a short time and 0.07 per cent is fatal if breathed for about 30 minutes or less. The Maximum Acceptable Concentration and Threshold Limit Value for this gas are both 5 parts per million. In other words, the concentration for any short period exposure must not be greater than that for an 8-hour exposure.

PHYSIOLOGICAL EFFECTS OF OXIDES OF NITROGEN

Concentration of Oxides of Nitrogen		
Parts per million	Per cent	Effect
5	.0005	Maximum allowable for 8-hr. day
60	.006	Minimum causing immediate throat irritation
100	.01	Minimum causing coughing
100-150	.01-.015	Dangerous for even short exposure
200-700	.02-.07	Rapidly fatal for short exposure

GAS SULPHUR DIOXIDE (SO_2)





Non-flammable

OTHER PROPERTIES

COLOUR:	NONE
ODOUR:	Strong pungent sulphur smell.
TASTE:	Acid taste.
OTHER:	Very irritating to breathe - cannot be tolerated in dangerous concentrations.

HOW FORMED

Burning sulphide ores, blasting in sulphide ores, sulphide dust explosions. Some diesel fuels.

THRESHOLD LIMIT VALUE AND EFFECT ON HUMANS

T.L.V. = 5 ppm - irritation of eyes, throat, lungs, intolerable to breathe in dangerous concentrations.

TREATMENT OF PERSONS AFFECTED

Fresh air, oxygen, artificial respiration, if breathing stopped medical aid.

SULPHUR DIOXIDE (SO_2)

Sulphur dioxide is another gas produced by burning sulphide ores or by blasting in sulphide ores or explosions of sulphide ore dust. Some diesel fuels will produce sulphur dioxide when used in a diesel engine.

This gas has a strong sulphur smell which is suffocating and very irritating to breathe. This gas is so irritating to breathe that it cannot be tolerated for any length of time in dangerous concentrations. A person's natural reaction when he encounters this gas is to get out of it and this, of course, should be done.

If forced to breathe this gas for any length of time, coughing and nausea result. The gas will effect the lungs in much the same manner as oxides of nitrogen and hydrogen sulphide. Irritation of the respiratory tract and lungs will cause oedema.

The threshold limit value of sulphur dioxide is a low 5 ppm.

Solubility - Sulphur dioxide is highly soluble in water, in fact it is one of the most soluble gases found in mines.

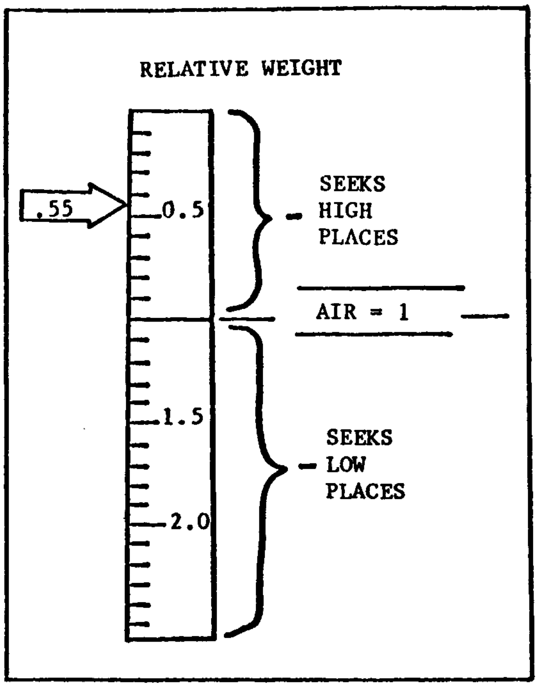
Relative weight - Sulphur dioxide is a very heavy gas and has a relative weight of 2.2. It can, therefore, be expected to accumulate in low places.

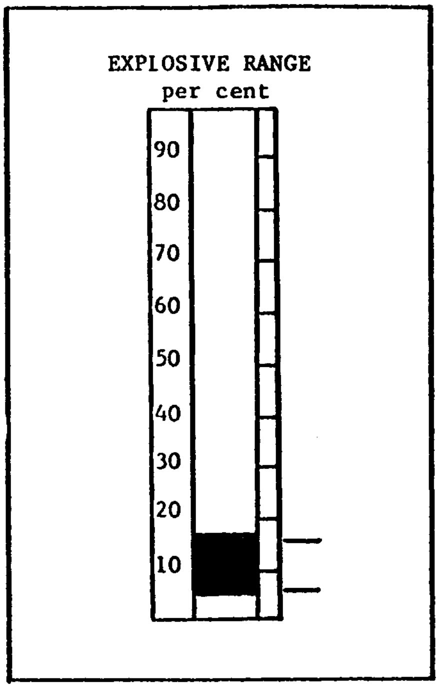
Sulphur dioxide is colourless and has a distinctly acid taste.

EFFECTS OF SULPHUR DIOXIDE

Concentration		
Parts per million	Per cent	Effect
5	.0005	Maximum allowable for an 8 hr. day
20	0.002	Coughing, irritation to eyes, nose and throat
150	.015	May be endured for several minutes
400	.04	Impossible to breathe

GAS METHANE (CH_4)





OTHER PROPERTIES

COLOUR: NONE

ODOUR: NONE - often associated with other sulphurous gases.

TASTE: NONE

OTHER:

HOW FORMED

Decomposition of vegetable matter. Released from coal seams or some rocks when mining carried out or when diamond drilling.

THRESHOLD LIMIT VALUE AND EFFECT ON HUMANS

Non-poisonous. But due to flammability men must withdraw at 2.5 per cent. Blasting stopped at 1 per cent.

TREATMENT OF PERSONS AFFECTED

Non-toxic. If concentration causes oxygen deficiency treat as such.

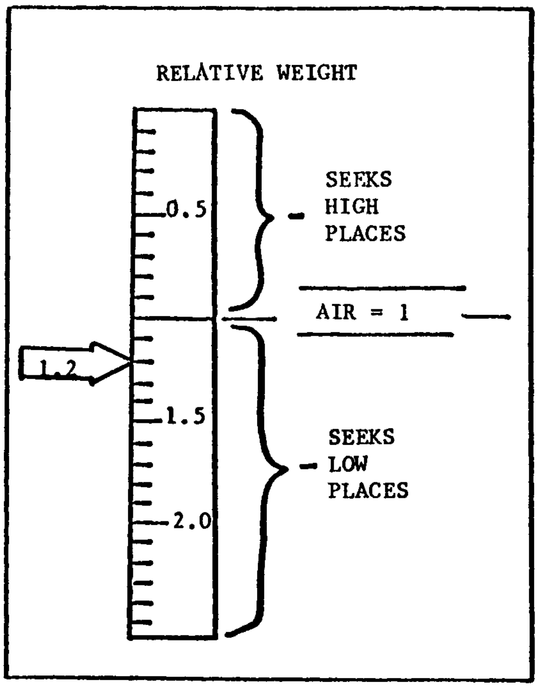
METHANE (CH_4)

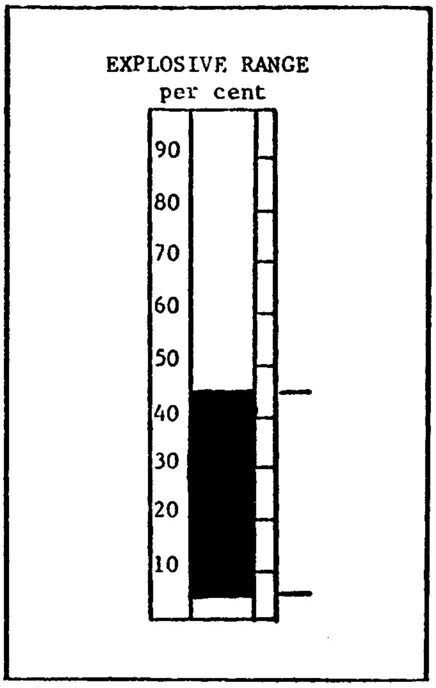
Methane or marsh gas is encountered in some metal mines in the Bridge River and in practically all coal mines in British Columbia. Flow of the gas is variable and is occluded in the pores of the coal. It is formed by the decomposition of organic matter in the presence of water and the absence of air or oxygen. It can be seen in the form of bubbles in stagnant pools, hence the name "Marsh Gas".

Methane is a colourless, odorless, tasteless gas. An odor caused by the presence of other gases such as hydrogen sulphide, often accompanies it. Methane will burn with a pale blue non-luminous flame and still air that contains 5 to 15 per cent of methane and 12 per cent or more of oxygen will explode and this is its chief danger. However, the inflammable and explosive range of methane is variable and all occurrences of the gas should be considered as dangerous. Where the occurrence of methane is suspected or known adequate ventilation to dilute the gas to a harmless percentage is important.

Methane is considerably lighter than air and when found in mines is usually near the roof or in high places. Accumulations of the gas may be encountered in unused and poorly ventilated mine workings, or when old workings are being dewatered. It may be caused by the decaying of old timbers.

Methane has no direct effect upon men, but it may displace the oxygen content of the air to such an extent as to cause oxygen deficiency. An open-flame lamp or a spark may cause an explosion. The British Columbia Coal Mines Regulation Act requires that all men be withdrawn from any work heading when the methane content of the general body of air in that heading reaches 2.5 per cent. This Act also requires electrical circuits to be isolated in any work area when the methane content in the general body of air in that area reaches 1.25 per cent and that no blasting or shotfiring is done when the methane content exceeds 1 per cent.





OTHER PROPERTIES

COLOUR:	NONE
ODOUR:	Rotten egg smell in low concentrations.
TASTE:	NONE. Irritates nose, throat, eyes, etc.

HOW FORMED

Burning sulphide ores, explosions of dusts from sulphide ores, hydrochloric acid on sulphide concentrate.

THRESHOLD LIMIT VALUE AND EFFECT ON HUMANS

T.L.V. = 10 ppm - paralyzes respiratory centre.
Low concentrations cause oedema of lungs, bronchitis, pneumonia.

TREATMENT OF PERSONS AFFECTED

Remove to fresh air, give oxygen, artificial respiration if breathing stopped, get medical aid and advise of exposure to hydrogen sulphide.

HYDROGEN SULPHIDE (H_2S)

Hydrogen sulphide is one of the most poisonous gases known. Fortunately only traces of it are ordinarily found in mine operations. In some respects it is more dangerous than hydrogen cyanide. In low concentrations its distinctive "rotten egg" odor is noticeable, but in high concentrations the sense of smell is quickly paralyzed by the action of the gas on the respiratory centre and cannot be relied on for warning. The gas has a specific gravity of 1.19 and, being heavier than air, may collect at low points.

Hydrogen sulphide inhaled in a sufficiently high concentration produces immediate asphyxiation; in low concentrations it produces inflammation of the eyes and respiratory tract and sometimes leads to bronchitis, pneumonia, and oedema of the lungs.

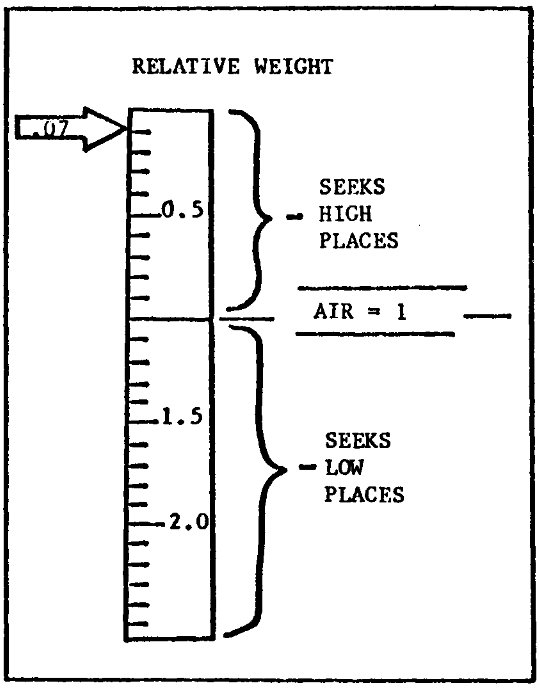
Subacute poisoning may be produced by long exposure to concentrations as low as 0.005 per cent. Immediate collapse usually results from exposure to concentrations of 0.06 to 0.1 per cent, and death quickly ensues. The 8 hour daily exposure should not exceed 0.001 per cent or 10 ppm.

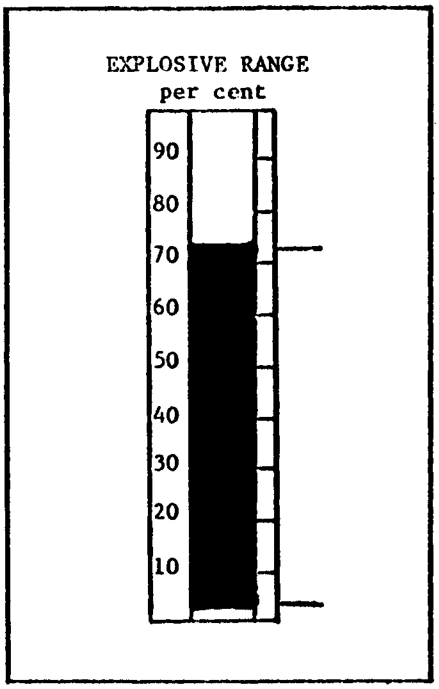
When explosions of dust occur in blasting operations in sulphide orebodies, the resulting gases may contain varying amounts of hydrogen sulphide, along with sulphur dioxide and possibly other sulphur gases.

EFFECTS OF HYDROGEN SULPHIDE

Per Cent		
.001	Maximum allowable for 8 hr. day	
0.005 - 0.010	Subacute poisoning	
	1. Mild eye irritation	1 hour
	2. Mild respiratory irritation	
.02 - .03	Subacute poisoning	
	1. Marked eye irritation	
	2. Marked respiratory irritation	1 hour
.05 - .07	Subacute to acute poisoning	
	1. Unconsciousness	1/2 - 1 hour
.10 - .20	Acute poisoning	
or more	1. Unconsciousness	Minutes
	2. Death	

GAS HYDROGEN (H_2)





OTHER PROPERTIES

COLOUR:	NONE
ODOUR:	NONE
TASTE:	NONE
OTHER:	Highly explosive over wide range

HOW FORMED

Electrolysis in battery changing stations. Incomplete combustion and molecular breakdown of water when rock heated to incandescence. Present in coal gas and caused by blasting in coal.

THRESHOLD LIMIT VALUE AND EFFECT ON HUMANS

Non-toxic. Only physiological effect is when oxygen depleted.

TREATMENT OF PERSONS AFFECTED

As for oxygen deficiency.

HYDROGEN (H_2)

Hydrogen is a colourless, odorless, and tasteless gas. It is very much lighter than air with a relative weight of .07 and is highly flammable. Hydrogen is explosive over a broad range of concentrations, i.e. from 4 per cent to 74 per cent. It will explode with as little as 5 per cent oxygen in the air and is most violently explosive at concentrations of 7 per cent to 8 per cent.

Hydrogen is not a toxic gas and as with methane the only danger of breathing it is when the concentration is such that the oxygen content of the air is reduced.

The only real hazard of hydrogen gas then is from its flammable and explosive properties.

Hydrogen gas is normally found in mine air in only very small quantities. It can, however, be produced at the time of mine fires when rock is heated to incandescence and as a result of incomplete combustion.

The most common source of hydrogen gas under normal circumstances in metal mines is in battery locomotive charging stations. The electrolytic action which takes place during battery charging releases hydrogen gas. Charging stations must, therefore, be well ventilated and smoking, electric arcs, etc., must be avoided in them.

In coal mines hydrogen gas occurrences in small quantities are more general.

From a trace to as much as 9 per cent can be found in crevices of a coal face after blasting. It is formed here as a result of incomplete combustion of explosives and by distillation of the coal caused by the explosion.

Hydrogen gas is usually present in amounts up to 2 per cent in gas from gob and ordinary mine fires and is always present after coal dust explosions.

Coal gas can contain as much as 50 per cent hydrogen.

Hydrogen gas can be detected with the multi-gas detector previously described and with vacuum bottles.

A vacuum bottle is simply a sealed bottle from which all air and other gases have been removed. The bottle is taken into the suspected atmosphere and the vacuum is released, allowing the atmosphere to enter the bottle. The bottle is then sealed and sent to a laboratory for analysis of the contents.

Almost the same result as a vacuum bottle can be obtained by filling a clean bottle with water and emptying the bottle in the suspected atmosphere. As the water is dumped from the bottle the surrounding atmosphere enters the bottle. The bottle can then be sealed and sent out for analysis.

The flame safety lamp will indicate the presence of hydrogen or any flammable gas. Concentrations of the gas, however, cannot be determined with the safety lamp.

Hydrogen is not a common gas in mines but when it occurs its explosive nature makes it extremely dangerous. We should be aware that it can be released at the time of mine fires.

MERCURY (QUICKSILVER) (Hg)

A heavy (S.G. 13.6)* silver-white liquid (above -38° F) metal capable of conducting heat and electricity. It sometimes occurs free or in the metallic state in some ore deposits but more commonly occurs as cinnabar (HgS), a carmine-coloured sulphide which is readily converted to the metallic state by heating in an abundant air supply. There are several occurrences of cinnabar in British Columbia and at least on one deposit a mine has been developed. Mercury has a large number of industrial uses including the manufacture of electrical equipment, explosive detonators, insecticides and the recovery of metallic gold and silver in the form of amalgams.

When in the liquid state and while in contact with air, mercury vapor is being released continually, the amount released increasing with increasing temperature. The recommended safe working limit for a daily eight-hour exposure to mercury vapor is not more than 0.1 milligrams of mercury per cubic metre of air. Exposure of an individual to amounts greater than this may, depending on the concentration encountered and time of exposure, develop chronic or acute mercury poisoning. This condition should be prevented from developing by close control of all vapor escape sources which can be determined with regular use of a mercury detector (sniffer) and by regular employment rotation of workmen away from vapor source areas. Regular urinalyses or blood analyses of such workmen makes it possible to ensure their mercury level remains within safe limits. As mercury is readily eliminated in

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*The specific gravity of solids is the ratio of the weight of the solid with respect to the weight of an equal volume of water.

body perspiration and body waste, the regular rotation of workmen as determined by the aforementioned analyses will prevent the development of mercury poisoning.

The symptoms of mercury poisoning are stomatitis, tremors, and physic disturbances. Usually the first complaints are of excessive salivation and pain on chewing, with loosening of teeth in severe cases. The use of a dust respirator is not effective in removing the mercury vapour and type "N" respirator is only partly effective, hence, the only satisfactory protection is an airline respirator or self-contained breathing apparatus.

The possibility of mercury poisoning can be greatly reduced by endeavouring, wherever possible, to:

1. keep metallic mercury covered with a layer of water
2. avoid spillage and clean up any spills immediately
3. spray contaminated areas with lime-sulphur spray
4. observe habits of good personal hygiene, e.e. frequent baths and washing of hands, frequent laundering of clothes, no smoking or eating in contaminated areas.

HAZARDS DUE TO GASES DURING OR AFTER MINE FIRES OR EXPLOSIONS

During and following metal mine fires the two greates hazards to life are poisoning from the breathing of carbon monoxide and suffocation in an atmosphere deficient in oxygen. The conditions which cause contamination in mine atmospheres are listed below in the order of hazard:

CARBON MONOXIDE:	This gas is always present at the time of an underground fire and gives little or no warning.
OXYGEN DEFICIENCY:	This condition occurs because of the consumption of oxygen by combustion or chemical reaction and its replacement by toxic or inert gases. Precautions must always be taken against it.
SMOKE:	The hazard is due to its irritating qualities and obstruction of vision. It may be explosive.
DANGER OR EXPLOSION:	Gases caused or generated by fire (as in smoke) may explode.

METHANE·	This gas is not produced by mine fires or explosions but may cause them. Its presence in a mine during rescue or recovery operations create a considerable hazard.
SULPHUR DIOXIDE:	This gas is present at the time a fire occurs in a sulphide orebody. Because of its irritating qualities, it gives advance warning when in less than toxic concentrations
OTHER GASES:	Hydrogen sulphide, nitrous oxides, etc. are not likely to be encountered, but the possibility of their occurrence should be kept in mind. Hydrogen sulphide sometimes indicates the presence of methane.

ARSINE GAS

Toxicity

Arsine gas (ars nous hydride or AsH_3 is a powerful hemolytic poison. Only 0.05 parts per million (ppm) can be permitted and 1 - 10 ppm is dangerous after one hour. Over 100 ppm is immediately dangerous to life.

Symptoms of Poisoning

Arsine has an affinity for the haemoglobin of the red corpuscles of the blood. Symptoms of poisoning usually occur three to four hours after exposure and are evinced by tightness of the chest, nausea, vomiting, bronzing of the skin, enlargement and tenderness of the liver and spleen. Symptoms of severe poisoning are red, to black-red urine. Continued exposure to low concentrations may result in chronic poisoning which can lead to anemia and jaundice.

Occurrence

Arsine is a poisonous gas formed by the reaction of hydrogen with arsenic. It is not produced commercially but only accidentally and thus cases of poisoning may escape detection. Arsine is a colourless gas, with an odor somewhat like garlic. It is almost three times as heavy as air, soluble in water, and inflammable.

The presence of acids, alkalis, and metallics are conducive to the formation of arsine but not absolutely necessary. The most probable formation is where a metal, such as zinc, is added to a mill circuit. Hydrogen would be produced here if the solution was acidic and hydrogen would then react with any arsenic present to form AsH_3. Arsenopyrite is the most likely source of arsenic but arsenic can be added to the mill circuit by reagents containing arsenic (e.g., impure copper sulphate.)

Other common sources of arsine are where impure acids are used for scale removal, where impure lead is used in soldering, where zinc coated galvanized pails are used in dipping into impure solutions. Arsine may also be formed by the action of water on metallic arsenides, especially if the solution is heated.

Detection

1. Test papers can be made up by immersing filter paper for two minutes in a cold aqueous solution of 50 grams of mercuric chloride per litre and then hanging up to dry. Such papers will turn brown, dark brown or black in the presence of arsine. For such testing, papers should be hung up at predetermined stations in the plant and changed every shift whether coloured or not. Only a week's supply of test papers should be made up at one time. Storage should be in tight containers.

2. Arsine detectors should be used intermittently to check against test paper method.

Prevention of Poisoning

If the formation of arsine gas is possible the following procedure is required:

1. Pre-employment haemoglobin medical test for all new employees.

2. A haemoglobin test every three months for all workers in the suspected area.

3. Immediate haemoglobin and urine tests for any persons showing symptoms of poisoning.

4. Adequate ventilation in the suspected areas. This ventilation should be from above as well as below the areas.

5. Evacuation of personnel from any area where tests indicate presence of arsine.

QUESTIONS ON GASES

1. What are the main components of air; in what percentages do they occur?

2. Give the properties of oxygen.

3. Will oxygen burn or explode if it is pure?

4. (a) What gases are we most likely to encounter in a fire in a mine?
   (b) Name the most deadly of these gases. Describe it.
   (c) At about what percentage in air does this gas become dangerous to breathe?
   (d) What first aid treatment is recommended for persons affected by this gas?

5. What other gases may be found in a mine fire in sulphide orebodies?

6. What gas or gases are usually associated with blasting?

7. What gases are usually present with smoke?

8. What explosive gases, if any, are we likely to find in mine air?

9. Name some of the causes of deficiency of oxygen in air.

10. What colour is the face when the oxygen content of the air is low?

11. What difference is there in the symptoms of oxygen deficiency between air at sea level that has a low oxygen content and the atmosphere at 5,000 feet?

12. When a person succumbs to oxygen deficiency does respiration or heartbeat stop first?

13. Without the use of special instruments is there any way we can detect the presence of certain gases?

14. (a) With what gas do we associate the smell of rotten eggs?
    (b) In a very small concentration of this gas, what are the first noticeable symptoms?

15. Does breathing pure oxygen at atmospheric pressures have any adverse effect on men?

16. What are considered the two greatest hazards to men during mine fires with regard to mine air?

17. Name the "Damps" and give a brief description of each.

18. What gases displace oxygen in mine air?

CHART OF MINE GASES

NAME	SYMBOL	RELATIVE WEIGHT (air = 1)	SOLUBILITY GRAMS PER 100 cc. WATER AT 41°F	PROPERTIES	HOW FORMED	WHEN DANGEROUS	THRESHOLD LIMIT VALUE	HOW DETECTED	FLAM-MABLE	EXPLO-SIVE	EFFECT	TREATMENT
1. Air	Air	S.G.=1	0.00295	Colourless Odorless Tasteless	Constituents O_2 20.93% N_2 79.04% CO_2 0.03%	If O_2 falls below 16% or when poisonous gases enter.	Minimum 19.5% O_2 for 8 hr.	For O_2 with safety lamp & gas detection	No	No	If O_2 below and man working 17% panting- 15% dizziness 9% collapse 7% fatal	Ventilation Fresh Air. If unconscious, give artificial respiration.
2. Oxygen	O_2	A trifle heavier than air S.G.=1.1	0.005498	Colourless Odorless Tasteless Non-poisonous at ordinary temperatures and pressures	Regenerated by plant life	As above	As above	Safety lamp & candle go out at 16.25% O_2. Carbide light goes out at 12.5% O_2.	No	No	As above	As above
3. Carbon dioxide	CO_2	Much heavier than air S.G.=1.53	1.237	Colourless Odorless Tasteless in low concentrations. Acid taste in high concentrations induces breathing.	Normal constituent of mine air. From breathing of humans and animals from decay of animal and vegetable matter. Released from thermal water & exuded from some rock strata. Mine fires.	Above 2% causes greatly increased lung ventilation up to collapse.	Maximum 0.5% for 8 hr. exposure	Analysis of vacuum bottle sample Detectors Displaces O_2 and will therefore extinguish lamp at high concentration.	No	No	At 2% increases lung ventilation by 50%. At 3% increases ventilation by 100%. At 5% increases ventilation by 300%. May displace oxygen.	Provide fresh air and oxygen. If unconscious, give artificial respiration.
4. Nitrogen	N_2	A trifle ligher than air S.G.=0.97	0.002365	Colourless Odorless Tasteless Acts as a diluent of O_2 in air.	Normal constituent of mine air. Highly concentrated N_2 has been reported to issue from rock strata in some mines.	High N_2 concentration, displaces O_2 in air.	Maximum 81% for 8 hr. exposure	Analysis of vacuum bottle sample. Displaces O_2 and will therefore extinguish lamp at high concentrations.	No	No	No effect but O_2 shortage experienced in high concentrations.	Provide fresh air. If unconscious, give artificial respiration.

	NAME	SYMBOL	RELATIVE WEIGHT (air = 1)	SOLUBILITY GRAMS PER 100 cc. WATER AT 41°F	PROPERTIES	HOW FORMED	WHEN DANGEROUS	THRESHOLD LIMIT VALUE	HOW DETECTED	FLAM-MABLE	EXPLO-SIVE	EFFECT	TREATMENT
5.	Methane	CH_4	Much lighter than air S.G.=0.55	0.00717	Colourless Odorless Tasteless	Decay of certain bacteria or organic matter in coal measures and in some metal mines in contact with carbonaceous rock. Decaying timber.	When displaces O_2 or explosive when 5%-15% present with at least 12% O_2	Withdrawal point for men 2.5% Electric motors stopped at 1.25%. Blasting stopped at 1%.	Flame safety lamp when in excess of 1.25% methane detector.	Yes	Yes, see column 8. Maximum explosive force at 9.0%	No effect physiologically except can displace O_2.	As for O_2 deficiency.
6.	Carbon monoxide	CO	lighter than air S.G.=0.97	.003559	Colourless Odorless Tasteless Poisonous	From incomplete combustion. Blasting, diesel exhaust, underground fires.	Depends on concentration and length of time of exposure. 0.4% death in less than 1 hr. 0.15 to 0.20 for 1 hr. 0.04 for 1½ hr. Headache and nausea.	0.005% or 50 ppm-8 hr. exposure maximum.	CO detector** canary vacuum bottle sample assay.	Yes in certain concentrations.	12.5% to 75.0%	Headache, nausea, death. Dangerous after effects. Pink to red skin colour.	Fresh air O_2 if nausea or unconsciousness. Artificial respiration if not breathing. Rest.
7.	Hydrogen sulphide	H_2S	A little heavier than air S.G.=1.19	0.5276	Colourless. Smell of rotten eggs Irritates eyes and respiratory tract Poisonous	Decomposition of some sulphur compounds. Blasting in sulphide ores. Hydrochloric acid spilled on sulphide concentrate or ore. Thermal waters. Underwater decomposition of vegetable matter.	+0.01% acute poisoning +0.07% rapid unconsciousness +0.05% dangerous + ½ hr. .002 - .003*	0.001% or 10 ppm for 8 hrs.	Rotten egg odor. Detectors. Eye irritation, Subacute to acute poisoning.	Yes 4.3-45% if enough O_2.	Yes 4.3-45% will explode	Sense of smell deadened. After 1 or 2 inhalations will paralyze the respiratory system.	Fresh air. Artificial respiration if unconscious. Get to doctor.

*subacute poisoning
0.005 - 0.16% irritation of eyes & throat

**Note: A scrubber must be used ahead of detector tube if testing for CO in diesel exhaust.

	NAME	SYMBOL	RELATIVE WEIGHT (air = 1)	SOLUBILITY GRAMS PER 100 cc. WATER AT 41°F	PROPERTIES	HOW FORMED	WHEN DANGEROUS	THRESHOLD LIMIT VALUE	HOW DETECTED	FLAM-MABLE	EXPLO-SIVE	EFFECT	TREATMENT
8.	Oxides of Nitrogen	NO NO_2 N_2O_4 N_2O_2 N_2O N_2O_3 N_2O_5	Heavier than air S.G.=1.59	NO_2 0.007747	Colourless in low concentration. Reddish brown in high concentrations. Odorless Tasteless Poisonous	From blasting or burning of dynamite. Diesel exhaust. Burning or decomposition of nitrates or nitrated material.	0.01% may be fatal in ½ hr.	0.0005% or 5 ppm maximum exposure at any time.	Detector	No	No	Toxic will cause oedema of lungs. Delayed effect.	Complete rest. Give O_2. See doctor and advise man's exposure to oxides of nitrogen.
9.	Sulphur dioxide	SO_2	Much heavier than air S.G.=2.20	Highly soluble in water 16.80	Colourless Suffocating Irritating with strong sulphur smell, acid taste, poisonous.	Blasting in or burning of sulphide ores. Some diesel fuels may have appreciable sulphur present and will form SO_2 on burning.	400 ppm dangerous even for short exposure. 50 ppm subacute poisoning, irritation to eyes, throat & lungs. 20 ppm irritating to eyes. Coughing caused.	0.0005% or 5 ppm for 8 hr. exposure	Odor of burning sulphur Irritating to eyes and respiratory tract. Detector.	No	No	Irritating to eyes, throat & lungs. Produces oedema of lungs.	Fresh air Artificial Respiration if not breathing. Get to doctor.
10.	Hydrogen	H_2	Lighter than air S.G.=0.0695	0.0001756	Colourless Odorless Tasteless	Thermal water Battery charging Electrolysis of water. Product of incomplete combustion in explosions and mine fires. Corrosive action of strong acids on metal (iron).	No harmful effects.		Laboratory analysis of gas sample. Would give indication on detectors using Wheatstone bridge resistance measurement.	Yes	Yes 4.1% -74% with as little as 5% O_2. Violently explosive 7-8%.	None except may displace O_2	Treat for low O_2

	NAME	SYMBOL	RELATIVE WEIGHT (air = 1)	SOLUBILITY GRAMS PER 100 cc. WATER AT 41°F	PROPERTIES	HOW FORMED	WHEN DANGEROUS	THRESHOLD LIMIT VALUE	HOW DETECTED	FLAMMABLE	EXPLOSIVE	EFFECT	TREATMENT
11.	Powder smoke	Consists of small particles of carbon, tarry substances, solid and liquid matter in air.	About the same as air	N.A.	Smokey odor of nitrous fumes. Irritates eyes, has CO and NO_2 mixed in it. Poisonous.	Product of incomplete combustion during blasting.	When CO and NO_2 content above acceptable limit.	Regulated by Mines Act on use of explosives.	Odor, colour of nitrous fumes. CO and NO_2 detectors.	Yes, if flammable gases are present in sufficient quantity	Yes under certain conditions	Headache, dizziness nausea, throat irritation.	Remove to fresh air or give fresh air or O_2. If unconscious artificial respiration Watch for 48 hours
12.	Aldehydes	-	Normal same as air	-	Irritates eyes and respiratory tract.	Diesel engine operation. Soluble in water. Removed by a water scrubber on the diesel engine.	1 ppm will irritate the eyes	10 ppm for 8 hr. exposure.	Smell, eye irritation. Analysis of vacuum bottle, sample collected in special solution.	No	No	Small concentrations cause stinging of eyes.	Fresh air
13.	Fire damp	CH_4 and air	See methane	See methane	See methane	See methane	5%-15% with +12% O_2. See methane.	See methane. 2½%	See methane	Yes	Yes	See methane	See methane
14.	After damp	Mixture of CO, O_2, CO_2, N_2, H_2, H_2O and CH_4	Varies from less than to greater than that of air	-	See CO	Resulting from all underground fires and explosions.	See CO may also have nitrous fumes.	Depends on the amount of CO.	See detection methods for various gases.	Certain mixtures are.	Yes when mixtures are right.	See CO, CH_4, N_2, CO_2 and H_2	Same as for O_2 and CO.
15.	White damp	CO		-	See Carbon Monoxide -----------			--See Carbon Monoxide					

	NAME	SYMBOL	RELATIVE WEIGHT (air = 1)	SOLUBILITY GRAMS PER 100 cc. WATER AT 41°F	PROPERTIES	HOW FORMED	WHEN DANGEROUS	THRESHOLD LIMIT VALUE	HOW DETECTED	FLAM-MABLE	EXPLO-SIVE	EFFECT	TREATMENT
16.	Black damp	Mixture of CO_2 and N_2	If CH_4 present it will be lighter.	-	See CO_2	Absorption of O_2 by water, timbers, oxidation of ore, decay of timbers, men breathing.	Displaces O_2 causing a dangerous condition.	Not over 0.5% CO_2 or less than 19.5% O_2.	If safety lamp goes out, then black damp is assumed. Assay of vacuum bottle sample. CO_2 detector.	No	No	No effect when sufficient O_2 is present.	Same as for O_2 deficiency
17.	Stink damp	H_2S		-	See Hydrogen Sulphide			-- See Hydrogen Sulphide					
18.	Arsine (Arsenous hydride)	AsH_3	About three times as heavy as air.		Highly poisonous.	Formed by reaction of hydrogen with arsenic. Hydrogen may have been formed with strong acid on a metal and in the presence of arsenic or arsenic compounds, e.g. mill circuit.	1-10 ppm.	0.05 ppm 1-10 ppm dangerous after one hr. 100 ppm dangerous to life.	Mercury chloride filter paper test. Detectors or by physiological effect.	Yes	Yes	Destroys red blood corpuscles nausea bronzing of skin, black-red urine. Tightness of chest. Slight delayed action. Cumulative effect.	Fresh air, immediately, turn over to doctor. Advise doctor of exposure if known.
19.	Hydrogen cyanide acid. Prussic acid.	HCN			Smell of bitter almonds. Deadly poison.	Hydrochloric acid on sodium or potassium cyanide. May occur in mill areas where cyanide is used. Produced during heat treating of drill steel. May be released from tailings where cyanide has been used for mineral recovery.	10 ppm.	10 ppm	Smell of bitter almonds. Detector.	Gas-yes	Gas-yes	Paralyzes respiratory system developing chemical asphyxia. Absorbed through skin as well as in lungs.	Fresh air. Give cyanide antidote as directed. Get doctor. Type "N" canister not satisfactory. Special cyanide type canister required. Use mask with extreme caution.

NAME	SYMBOL	RELATIVE WEIGHT (air = 1)	SOLUBILITY GRAMS PER 100 cc. WATER AT 41°F	PROPERTIES	HOW FORMED	WHEN DANGEROUS	THRESHOLD LIMIT VALUE	HOW DETECTED	FLAM-MABLE	EXPLO-SIVE	EFFECT	TREATMENT
20. Mercury	Hg			Vapourizes when in liquid state	May occur as free metal in some mercury ores, is produced by heating of mercury ore. Used industrially as in production of mercury-gold amalgam.	As mercury adheres to one's clothing and skin unless careful control is maintained contamination might be continuous.*	0.1 mg/m^3 self-contained equipment only. Safe respiratory protection in areas of high concentration.	Physiological reaction. Detector. Analysis of vacuum bottle sample.	No	No	Excess flow of saliva, loosening of teeth. Diarrhea. Nervous and psychic changes in persons.	Careful personal hygiene-body and clothing. No smoking or eating in areas where mercury is present. Clean plant and spray with lime-sulphur spray.
21. Propane	C_3H_8	1.56	0.1 approx.	Gas inflammable tasteless colourless odorless scented commercially.	Petroleum distillate.	Explosive range 2.4%-9.5%	1000 ppm	Safety lamp methanometer	Yes	Yes	Displaces oxygen.	As for oxygen deficiency.
22. Acetylene	C_2H_2	0.91	0.05	Gas inflammable colourless distinct odor	Water on calcium carbide	Explosive range 2.8%-81%. Tank may explode on shock, i.e. by dropping pressure sensitive above 15 p.s.i.		odor	Yes	Yes	Displaces oxygen	As for O_2 deficiency
23. Chlorine	Cl_2	2.49	1.08	Greenish yellow gas	Various ways chemically but principally from electrolysis of of common salt.	Above 1 ppm	1 ppm	odor	No	No	Corrosive irritant eyes, skin, lungs, etc. Use. Type "N" mask up to 2% concentration.	As for oxides of nitrogen
24. Ammonia	NH_3	0.6	Highly soluble in water	Colourless Strong odor Caustic action	Combination of hydrogen nitrogen with catalytic action	When exposed to oxidizing substances & heat becomes explosive.	50 ppm	odor detector	Yes	Yes	Corrosive irritant to eyes, nose, throat & lungs	Fresh air rest

*Keep plant clean.

GAS CONTROL

Ventilation is not a serious problem around surface or open pit operations, but nevertheless every year workers are killed or injured because of dangerous amounts of gases or vapors, or because of not enough oxygen in places where they work. Such places, which are called Confined Spaces, include buildings, manholes, tunnels, vaults, chemical tanks, oil tanks, storage bins, silos, and pumps, etc.

There are several types of hazards that may be found in confined spaces:

1. Toxic gases or vapors - gases that poison

2. Flammable gases or vapors - gases or vapors that ignite easily

3. Asphyxiant gases - gases that cause suffocation

4. Lack of oxygen

Most people who expose themselves to a dangerous atmosphere are not aware the danger could exist or of the need to protect themselves. In an area where a dangerous atmosphere exists the hazards can best be taken care of by proper and adequate ventilation. (The exception to this rule is when a fire is involved.)

If a surface rescue team cannot ventilate an area, and lives or property are involved, proper respiratory equipment must be worn. This is why we feel a rescue team should be trained in the use of the following types of apparatus - filter type, chemical oxygen and pressure type self-contained equipment.

To control gases on a property, supervisors and rescue teams should be made aware of any special gas-producing chemicals used on their property and should be able to test an area to see if it contains a dangerous atmosphere.

There are various methods and devices in use for detecting the presence and quantity of toxic, noxious and explosive gases. The presence of carbon monoxide and deficiency of oxygen are the greatest hazards in rescue or recovery work, but the chance of encountering other gases make it necessary to train in the use of at least two detectors.

1. The Colorimetric Carbon Monoxide Tester.

2. The multi Gas Detector (Draeger or M.S.A.)
3. Flame Safety Lamp
4. Oxygen Detector
5. Methane Detectors

INSTRUMENTS USED IN MINE RESCUE TRAINING COURSE

The following instruments are used to determine the condition of mine air and the state of the ventilation:

FLAME SAFETY LAMP

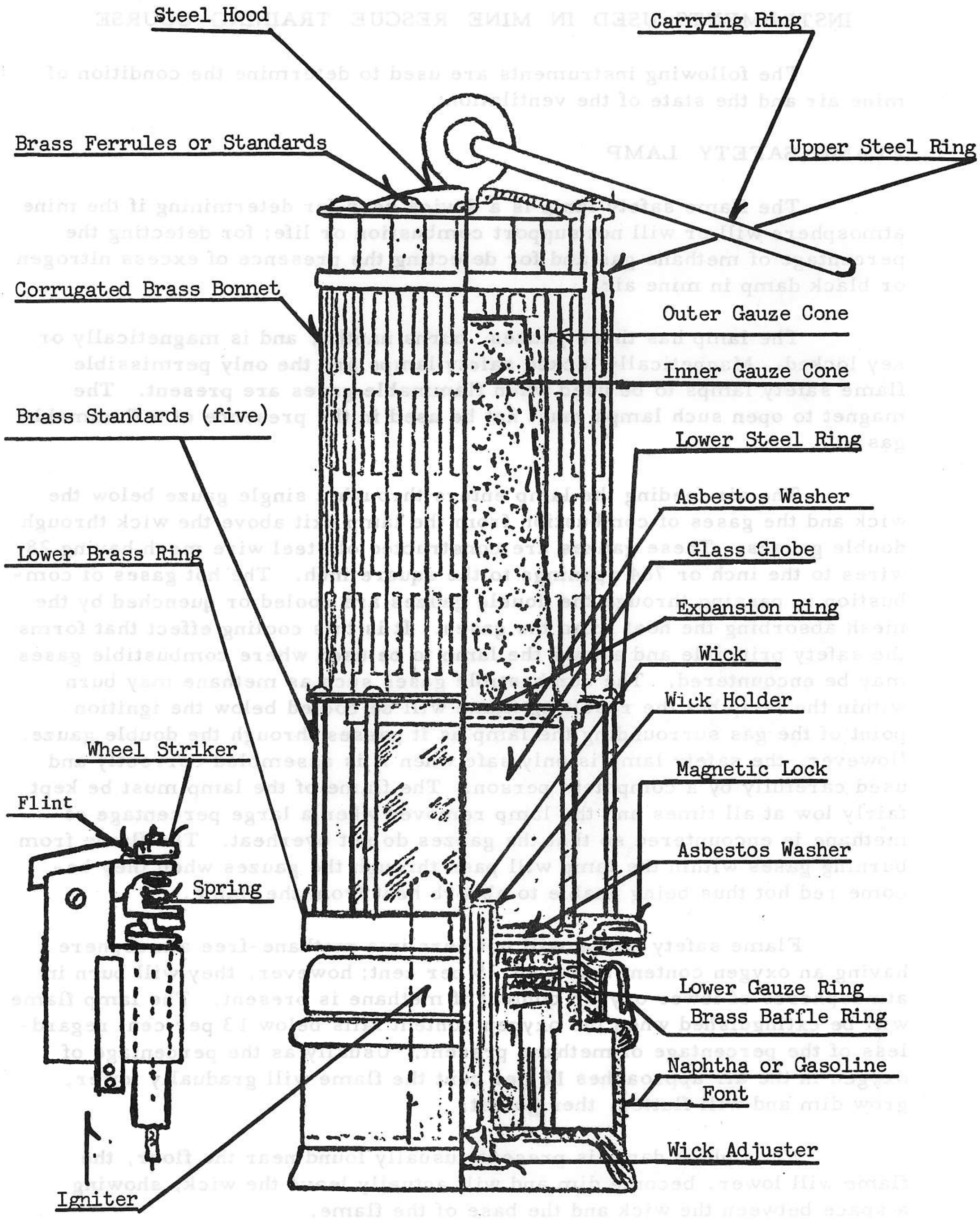
The flame safety lamp is a device used for determining if the mine atmosphere will or will not support combustion or life; for detecting the percentage of methane gas and for detecting the presence of excess nitrogen or black damp in mine air.

The lamp has three gauzes, burns naptha, and is magnetically or key locked. Magnetically locked safety lamps are the only permissible flame safety lamps to be used when flammable gases are present. The magnet to open such lamps must not be used in the presence of a flammable gas.

The air feeding the lamp enters through a single gauze below the wick and the gases of combustion from the lamp exit above the wick through double gauzes. These gauzes are constructed of steel wire mesh having 28 wires to the inch or 784 openings to the square inch. The hot gases of combustion in passing through the double gauzes are cooled or quenched by the mesh absorbing the heat from the gases. It is this cooling effect that forms the safety principle and allows the lamp to be used where combustible gases may be encountered. The combustible gases such as methane may burn within the lamp but the resulting flame will be cooled below the ignition point of the gas surrounding the lamp as it passes through the double gauze. However, the safety lamp is only safe when it is assembled correctly and used carefully by a competent person. The flame of the lamp must be kept fairly low at all times and the lamp removed when a large percentage of methane is encountered so that the gauzes do not overheat. The flame from burning gases within the lamp will pass through the gauzes when they become red hot thus being unable to absorb heat from the flame.

Flame safety lamps will not burn in a methane-free atmosphere having an oxygen content below 16.25 per cent; however, they will burn in atmospheres of lower oxygen content if methane is present. The lamp flame will be extinguished when the oxygen content falls below 13 per cent regardless of the percentage of methane present. Usually as the percentage of oxygen in the air approaches 16 per cent the flame will gradually lower, grow dim and will flutter, then go out.

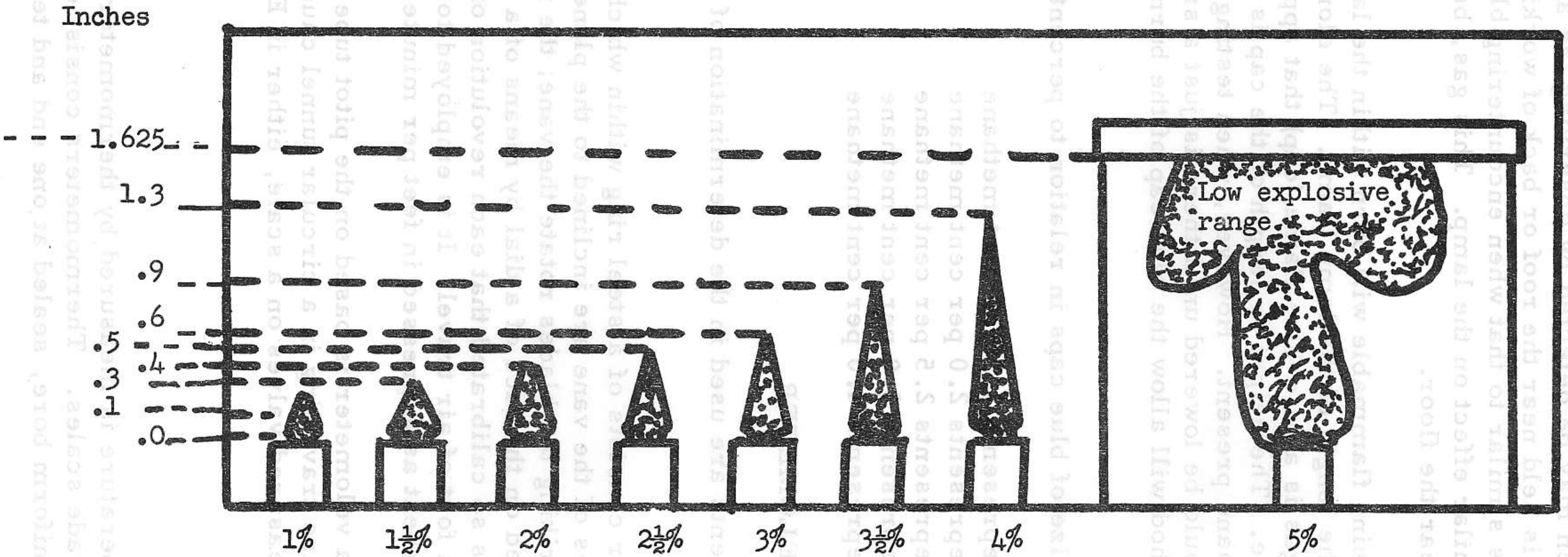
When black damp is present, usually found near the floor, the flame will lower, become dim and will actually leave the wick, showing a space between the wick and the base of the flame.



Wolf Safety Lamp

Scale - Two Thirds
Full Size

Colour of Methane Gas Cap on lamp——LIGHT BLUE



Percentage of Methane Gas with Wolf round wick lamp
Testing flame 1/10 th.inch high
x—— Upper limit of visible gas cap
1% visible to naked eye —— 2½% withdrawal point.
5% lowest—10% most violent—15% highest Explosive range.

Excess nitrogen may be detected by observing the action of the flame when the lamp is held near the roof or back of working places. The action of the flame is similar to that when encountering black damp. Carbon dioxide has a similar effect on the lamp. This gas, being heavier than air, will be found near the floor.

Methane gas being flammable will burn within the lamp and has the effect of increasing the length of the lamp flame. The elongation of the flame caused by the gas is a pale-blue flame (cap) that appears to ride on or over the lamp flame. The height or length of the cap is indicative of the percentage of methane present. However, when testing for methane the flame in the lamp should be lowered until there is just a small yellow flame visible. This method will allow the blue cap of the burning methane to be more visible.

Approximate size of blue caps in relation to percentage of methane:

1/3 inch cap represents 1.0 per cent methane
3/8 inch cap represents 2.0 per cent methane
1/2 inch cap represents 2.5 per cent methane
7/8 inch cap represents 3.0 per cent methane
1 1/3 inch cap represents 4.0 per cent methane

ANEMOMETER AND VELOMETER

These instruments are used in the determination of air flow for ventilation purposes.

An anemometer consists of a steel ring within which is posed a rotating vane; the blades of the vane are inclined to the plane of rotation. The air current striking the blades rotate the vane; the number of revolutions being recorded on the face of a dial by means of a series of gears. The instrument is so calibrated that each revolution of the vane corresponds to one lineal foot of air travel. It is employed to measure the velocity of the air current as expressed in feet per minute.

The design of a velometer is based on the pitot tube principle. Pressure exerted on a vane travelling in a circular tunnel causes a pointer to indicate the measured valves on a scale, either in English units or metric units.

THERMOMETER

Moderate temperature is measured by thermometers, on either the Fahrenheit or centigrade scales. Thermometers consist of a thick glass tube with a small uniform bore, sealed at one end and terminating in a small bulb at the other end. This bulb contains mercury or alchol; when the temperature rises the liquid expands and rises, when the temperature drops the liquid level drops.

Fixed points on the Fahrenheit thermometer are 32° and 212° F, 32° F is freezing temperature and 212° F is boiling point.

Fixed points on the centigrade are 0° C, freezing temperature and 100° C boiling point.

To convert centigrade to Fahrenheit $9/5 \times C + 32 = F$
To convert Fahrenheit to centigrade $(F-32) \times 5/9 = C$

Example

Convert 60° centigrade to Fahrenheit
$60 \times 9/5 = 108 + 32 = 140° F$

Convert 140° Fahrenheit to centigrade
$(140 - 32) \times 5/9 = 108 \times 5/9 = 60° C$

The safety cap on a McCaa oxygen apparatus bottle contains Rose Metal, which melts at 94° C

$94° C = 9/5 \times C + 32 = 201° F.$

In the gram-metric measurement system being adopted in Canada by 1978, centigrade and Celcius temperature readings are the same.

Two thermometers are used in the construction of an hygrometer, a device for determining the humidity of air. The thermometers are mounted side by side on a frame and the bulb of one is covered with muslin kept moistened with water. Evaporation from the moistened bulb produces a depression of temperature so that this thermometer reads lower than the dry bulb. The thermometers should be mounted so as to permit the free circulation of air around the bulbs. Usually the device is constructed so that it can be freely swung in the air being monitored in order that the thermometers will reach constant readings. The two readings are recorded and by reference to a chart or special slide rule the relative humidity of the air can be determined.

MINE WATER GAUGE

A mine water gauge is a U-shaped glass tube having a 1/4 inch bore and mounted on a suitable base to which an adjustable scale is affixed.

Water is placed in the bend of the tube to indicate by difference of water level in the two arms of the gauge, what is the difference of pressure exerted on them. Both ends of the tube are open, and one arm is extended and bent at right angles to enable it to be inserted in a hole in the wall separating the intake and the return airway. The pressure on the intake is always greater than that on the return side of the mine. This causes the water level to sink in the arm of the tube exposed to the intake and rise a corresponding amount in that open to the return. The difference in the two levels is read on the scale in inches, each inch of water gauge reading corresponds to 5.2 pounds per square foot.

Example

A water gauge reading of 2.5 inches would show a ventilating pressure of 13 pounds per square foot (2.5 x 5.2 = 13).

A cube, 12 inches on each side filled with water, weighs 62.5 pounds. It is evident that an inch in depth of this water will have a weight of 62.5 ÷ 12 = 5.2 pounds. This weight of water, being distributed over a square foot of area, corresponds to a pressure of 5.2 pounds per square foot due to 1 inch of water level.

BAROMETER

A barometer is an instrument used to measure the pressure of the atmosphere. The most reliable instrument for the purpose is a mercurial barometer. This consists of a glass tube closed at one end and open at the other. This tube, being first filled with mercury, is inverted and its open end immersed in a basin or vessel of mercury. The surface of the liquid in the basin being exposed to the pressure of the atmosphere, the column of the mercury in the tube now sinks to a level such that the weight of the mercury column is supported by the atmospheric pressure acting on the surface of the mercury in the basin, there being a vacuum or no pressure at the top of the tube. Since each cubic inch of mercury weighs 0.49 pound, and the height of the mercury column supported by the atmospheric pressure at sea level is 30 x 0.49 = 14.7 pounds per square inch.

A rapid fall in the barometer indicates a decrease in the atmospheric pressure which in turn decreases the mine ventilating pressure. This would allow the gases in gobs and abandoned workings to expand and flow into the active workings, thus creating a dangerous condition.

The barometer gives an indication of different elevation, it varies approximately 1 inch for each 900 feet of ascent.

The barometer reading with an elevation of 3,315 feet would be 3,315 divided by 900, which would be 3.68 of a drop in barometer. Therefore, 30 minus 3.68 is 26.32, which is the barometer reading at this elevation.

ELECTRIC CAP LAMP

The electric cap lamp is the safety lamp which is most commonly used by miners. It is a lamp in which the energy necessary to provide electricity for the light is stored in a chemical form in the cells during charge, and is released by chemical action during discharge.

The principal safety feature of the electric cap lamp in a methane concentration is the spring supporting the light bulb. In the event the light bulb is broken, the spring automatically breaks the electrical circuit.

OXYGEN DETECTOR

In 1966 a new type of polarographic electrode was developed by the Safety in Mines Research Establishment in Great Britain. This instrument is capable of determining the amount of oxygen present in a sample of gas being tested. The apparatus is an electrolytic cell having a lead anode and a cathode made of a membrane of either teflon or silicone rubber metallized on one face with a layer of gold overlain with a layer of silver. The oxygen in the sample diffuses through the membrane to the cathode and an electric current is produced the magnitude of which depends on the amount of oxygen present. Instruments based on this electrode are insensitive to shock, orientation, air velocity, and to other gases generally found underground. The instrument should not be used in atmospheres containing oxides of nitrogen or where it is possible to coat the membrane with oil or similar material. This equipment has several models available but most notably with the following ranges of oxygen:

1. 0 per cent - 25 per cent
2. 0 per cent - 40 per cent
3. 0 per cent - 100 per cent
4. 0 per cent - 50 per cent and 0 per cent - 100 per cent monitor

The time required to make a test is between 20 and 30 seconds with an accuracy of ± per cent if the instrument is at ambient temperature.

METHANE DETECTORS

Several electrically operated methane testers are available some of which pump either mechanically or manually the gas sample being tested while others rely on infusion of the gas sample through a porous fitting. All operate with a Wheatstone bridge circuit which has one of the four balanced resistance paths of the bridged circuit passing through the burning chamber. The burning gas causes an increase in the amount of heat in the wire and this causes a change in resistance which varies with the heat generated or the amount of combustible gas present. The circuit imbalance is represented by a meter reading calibrated to indicate the percentage of methane in the atmosphere. Departmental experience indicates that the porous head detectors can give low readings where there is an appreciable ventilating current. This is caused by the cooling effect of the circulating air.

COLORIMETRIC CARBON MONOXIDE TESTER

This instrument consists of an aspirator bulb with an adjustable control valve, a replaceable indicating tube, and a standard colour scale. The operator must have good eyesight to make a comparison between the colour scale and the indicating tube.

Inspecting the Detector Before Use

To test the instrument for air tightness, deflate the bulb fully place a finger firmly over the inlet opening and observe the bulb. If the bulb tends to inflate, the rubber band over the outlet opening, or the bulb itself may be leaking.

Thirty seconds (+ or - 3) are required to inflate the aspirator bulb when all air is exhausted from it with no tube in place. Adjust flow control valve screw, if necessary, using a small screwdriver to obtain this rate. If proper flow cannot be made by adjustment remove valve screw and clean orifice with a fine wire. Replace screw and adjust to obtain correct flow.

Use of Tester

In use, the sealed ends of the indicating tube are broken and the tube is inserted in the tube holder of the tester with the empty end of the tube towards the aspirator bulb. A measured sample of air, controlled by a specially designed metering orifice, is then aspirated through the tube. When the air sample contains carbon monoxide, the yellow silica gel in the detector tube turns green, the shade and intensity being directly proportional to the concentration of carbon monoxide in the air sample. The varying shades of green shown on the colour scale are easily distinguished and the comparable carbon monoxide concentrations which they indicate are clearly marked in percentages. The bulb should be completely deflated before sampling begins.

The tester is capable of indicating the presence of carbon monoxide in air from 0.001 to 0.10 per cent by volume. A special chemical is placed on either side of the silica gel to act as a guard. The guard chemical removes water vapor, gasoline vapor, and other interfering substances ordinarily encountered with carbon monoxide. One squeeze of the suction bulb is recommended to obtain an accurate indication of carbon monoxide concentration in the range of 0.005 to 0.10 per cent. In the range from .001 to .005 more accurate colour determinations may be obtained by giving the bulb from two to five squeezes. The tube will retain any colour change indicating carbon monoxide for a period of at least eight hours providing the broken ends are sealed immediately after testing. New tubes may be kept indefinitely, providing the ends are not broken. The tube may be used only once if any colour appears, but several tests may be made if no colour change takes place.

Testing Diesel Exhaust with the Colorimetric

Where diesel motors are used in mining operations, it is necessary that frequent tests be made to check the amount of carbon monoxide in the exhaust gases. A scrubber, filled with gasorbent is available, and should be attached to the inlet of the instrument. The gasorbent prevents the passage of all gases except carbon monoxide, which would have an effect on the silica gel. Readings may then be taken in the regular manner. Samples should not be taken directly from the exhaust manifold, as hot gases will cause errors in the result.

DRAEGER GAS DETECTOR

This instrument, consists of a spring- loaded rubber bellows with a capacity of 100 cubic centimetres of air, and a replaceable indecating tube. Air to be tested is drawn directly into the indicating tube before passing into the bellows, and thus the instrument requires no purging before inserting the tube. The outlet valve of the bellows provides so little resistance that the air will not return through the testing tube.

The Draeger gas detector is designed for the testing of a number of gases, using various indicating tubes. We are concerned here primarily with the testing of carbon monoxide.

Two different types of indicating tubes are available for testing of low and high quantities of carbon monoxide. The low-range tubes are used in testing CO from 10 to 3, 000 parts per million, (0.001 per cent to 0. 3 per cent.) The high-range tube, identified by the yellow band, is used for testing CO from 0. 3 per cent to 4 per cent. All tubes contain filtering chemicals to remove hydrocarbons and other gases that could affect the reading on the instrument.

Inspecting the Detector Before Use

The bellows should be squeezed once or twice to be sure the outlet valve is operating. Then place a finger over the inlet and collapse the bellows. The bellows should remain collapsed unless the outlet valve is leaking. It is not necessary to check the time taken for the bellows to inflate, as that action is controlled by the resistance huilt into each indicating tube. If the outlet valve is leaking, the valve cover plate may be removed and the valve seat inspected or cleaned.

Use of the Detector

To use the detector, select the proper CO indicating tube,

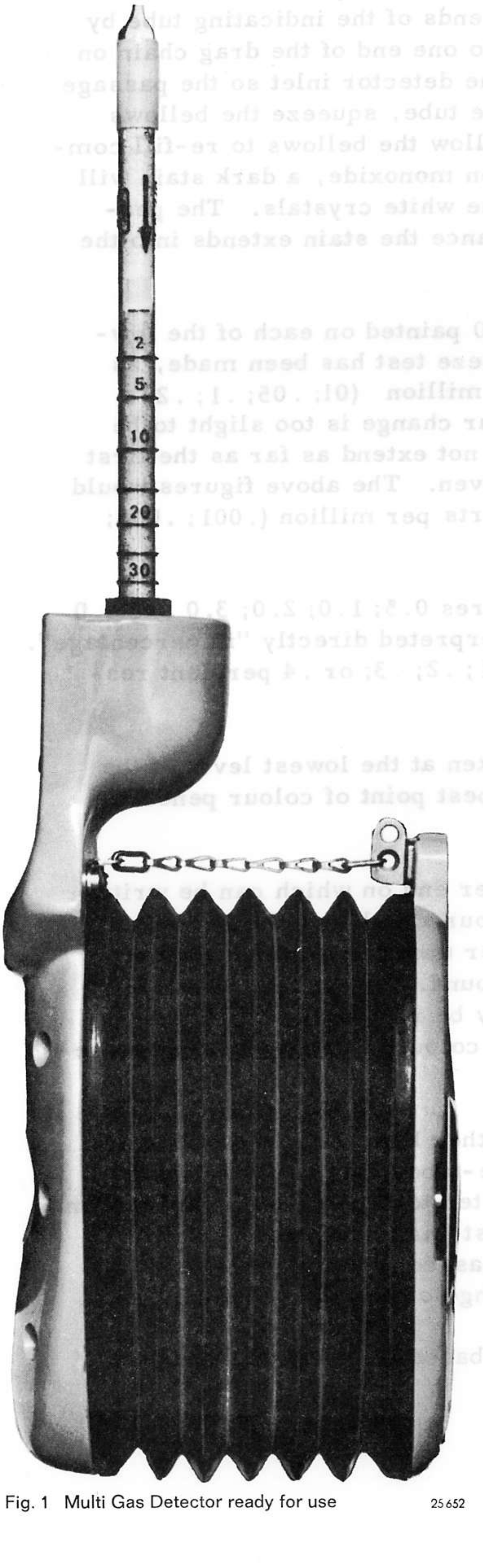


Fig. 1 Multi Gas Detector ready for use 25652

The DRÄGER Multi Gas Detector, ready for use, consists of two parts:

THE GAS DETECTOR PUMP

and the

DRÄGER TUBE

chosen as a function of the measuring problem involved.

Pump and tube together form one unit in the measurement. The DRÄGER tube is the indicating instrument of the Multi Gas Detector.

The unit is supplied in a metal carrying case. A protective bag for the pump and spare parts are also supplied with the unit.

Accessories for the DRÄGER Multi Gas Detector:

1. **Pump stroke counter**
2. **Extension tube (3 m long), with bag, for sampling at inaccessible points**
3. **Hot air probe for the investigation of furnace waste gases**
4. **Supplementary part for the respiratory CO test**
5. **Motor vehicle exhaust probe for the investigation of exhaust gases**
6. **Mixing device**
7. **Dust sampler.**

The advantages of the DRÄGER Multi Gas Detector are:

- **Operation with one hand**
- **Low weight and simple operation**
- **Always ready for use**
- **DRÄGER tubes for about 100 different gases and vapours**
- **Printed measuring scale on the DRÄGER tubes**
- **Immediate reading of the result on the DRÄGER tube.**
- **Optimum accuracy of measurement**
- **Maintenance-free bellows pump**

depending on the concentration of CO that may be expected due to conditions that are known. Break the sealed ends of the indicating tube by inserting them in the "breaker" attached to one end of the drag chain on the bellows. Insert the tube firmly into the detector inlet so the passage of air will be according to the arrow on the tube, squeeze the bellows fully to expell the residual air, and then allow the bellows to re-fill completely. If the air sampled contains carbon monoxide, a dark stain will be noticed extending downwards through the white crystals. The percentage is measured according to the distance the stain extends into the crystals.

The figures 1, 5, 10, 20, and 30 painted on each of the low-range tubes are interpreted when a 1-squeeze test has been made, as 100, 500, 1000, 2000, and 3000 parts per million, (01; .05; .1; .2 and .3 per cent) respectively. If the colour change is too slight to be readily observed after 1 squeeze, or does not extend as far as the first marking, nine more squeezes should be given. The above figures would then indicate 10, 50, 100, 200, and 300 parts per million (.001; .005; .01; .02; and .03 per cent).

The high range tube has the figures 0.5; 1.0; 2.0; 3.0 and 4.0 painted on it, and a 1-squeeze test, is interpreted directly "in percentage". A 10-squeeze test is interpreted as .05; .1; .2; .3; or .4 per cent respectively.

In either tube, the reading is taken at the lowest level of the general discoloration, and NOT at the deepest point of colour penetration.

All tubes have a band on the upper end on which can be written data concerning the test. Tubes, once coloured will not change colour for several hours, and so may be read later under better lighting conditions than found in testing areas underground. Tubes that have been used and no colour reaction obtained, may be re-used up to 10 times or until colour is found, in one day. Once coloured, they must not be re-used.

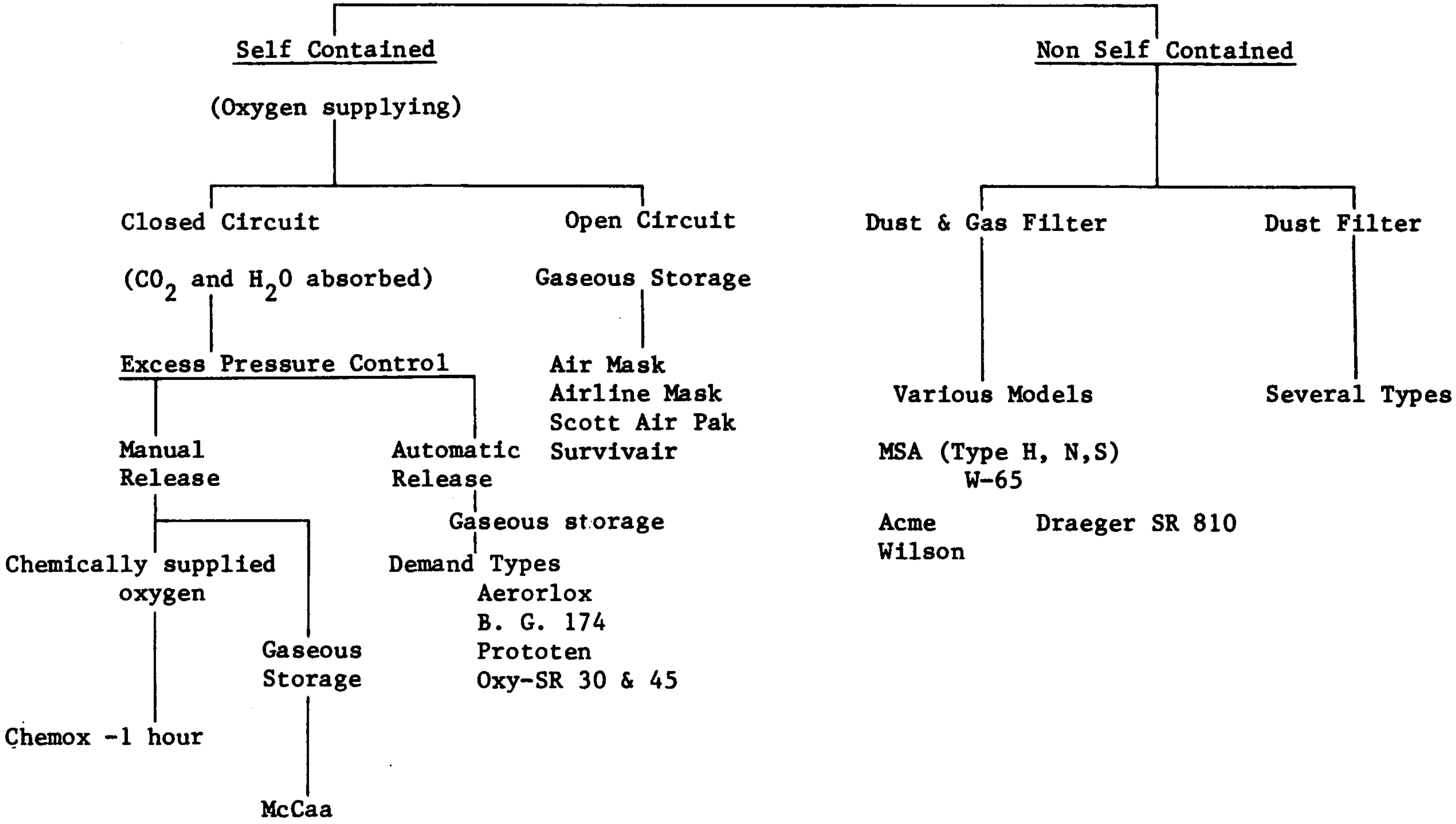
When testing diesel exhaust or other high mixtures of hydrocarbons for carbon monoxide, a carbon pre-tube, filled with activated charcoal should be used as an additional filter to prevent the hydrocarbons from reaching the testing crystals. Exhaust gas should not be sampled directly from the manifold, but should be passed through some form of cooler to bring the temperature into the range of 50° to 112° Fahrenheit.

The example described above is based on testing for carbon monoxide. Since this apparatus is a Multi-Gas Detector a wide range of detector tubes are available for different contaminants. Each gas and its indicating tube has its own characteristic and method for use, making it impossible to have a working knowledge of how to use them all. This is not a problem, for in each new box of tubes is a Data Sheet which contains all the information needed to make a test with the type of tube to be used; therefore, it is important that anyone using a multi-gas detector should know how to read the Data Sheet.

Common Applications of the Draeger Multi-Gas Detector

1. For controlling the threshold limit values of contaminated air in work areas.
2. Testing tanks, sewers, and manholes before entry.
3. For tracing leaks in gas pipes and reservoirs.
4. In detecting gas losses in certain types of processes such as recovery plants, etc.
5. Identifying unknown gaseous contaminants by using different detector tubes.
6. Measuring the hydrogen sulphide in refinery gases and sewage disposal plants.
7. Controlling CO_2 concentrations in greenhouses, fermenting rooms, grain silos, fruit storage rooms, and testing for leaks in CO_2 extinguisher systems.
8. Measuring the CO_2 content in flue gas or fork-lift and vehicle exhaust gases.
9. Adjustment of the fuel injection pump for diesel engines.
10. To rapidly diagnose the per cent CO in alveolar air or in samples of blood.

RESPIRATORY PROTECTIVE EQUIPMENT



FILTER-TYPE SELF-RESCUERS

The filter-type "self-rescuer" is a small gas respirator designed to provide protection to the wearer against carbon monoxide gas which is usually present in the air following a mine fire or explosion.

Owing to its small size, the filter-type self-rescuer may be easily carried on the underground worker's belt as is the case with coal miners, or they can be carried on the machine the worker is operating. It can therefore be readily available in the case of emergency.

Filter-type self-rescuers are also commonly stored in "caches" in strategic locations in mines so as to be readily available in case of emergencies.

There are two models, the Draeger Model 810 and the MSA Model W65. Both the model 810 and the model W65 self-rescuers are sealed at the factory and these seals should not be broken unless the self-rescuer is to be used. Once the seal is broken the chemicals in the apparatus can deteriorate and render the apparatus useless to the wearer.

The model 810 is sealed in a vacuum while the model W65 is sealed under pressure in the inert gas nitrogen.

Miners should always examine their self-rescuers for dents or other external damage before being used. If the seal is broken or the container damaged, do not use it.

Although there are slight variations in design, both the W65 and the model 810 operate on the same principle.

When the wearer inhales through the mouthpiece, air is drawn in through the bottom of the self-rescuer and passes through the coarse dust filter bag which enclosed the lower part of the apparatus. Coarse dust is removed by this bag. The air then passes through a fine dust filter in the bottom of the canister and through a drying agent. This drying agent removes excess moisture from the air which could reduce the effectiveness of the apparatus.

After passing through the drying agent, the air flows through a chemical called "Hopcalite" which changes the deadly carbon monoxide gas to relatively harmless carbon dioxide. The air containing the harmless amounts of carbon dioxide is then breathed by the wearer after having its temperature reduced by a heat exchanger.

When exhaled, the air again passes through the heat exchanger and out through a check valve to the outside air. The check valve allows air to pass outwards through it but will not allow air to come in from the outside. All inhaled air must pass through the canister and is treated before it reaches the wearer's lungs.

The filter-type self-rescuer is a very simple apparatus.

Protection Provided by the Filter-Type Self-Rescuer

The filter-type self-rescuer will protect the wearer against a 1 per cent carbon monoxide concentration (10,000 ppm) for up to one hour providing there is enough oxygen present to support life.

Protection is provided against higher concentrations of carbon monoxide for shorter periods of time. However, the heat build-up in the apparatus is quite rapid for higher concentrations. There is always a certain amount of heat build-up of the air and this is an indication that carbon monoxide is actually present, and the more carbon monoxide that is present the hotter will be the air breathed.

In spite of heat build-up the self-rescuer must be kept in the mouth until fresh air is reached. Death from carbon monoxide poisoning can be swift and is more permanent than the discomfort caused by breathing hot air.

It is important to remember that a heat build-up in the air can be expected when using a self-rescuer in an atmosphere containing carbon monoxide. The hotter the air the more carbon monoxide is present and the more important it is to continue using the apparatus.

When mounted on moving equipment or carried by workmen, the self-rescuer has a service life of five years provided the seal is not broken.

When placed in properly constructed caches, the shelf life is indefinite. A properly constructed cache should be moisture proof, as moisture will seriously affect the life of a self-rescuer.

When the Self-Rescuer is Used

The self-rescuer should be used immediately at the first indication of a fire or explosion even though no smoke is visible.

Waiting until smoke is visible could well prove fatal because the area could be filled in advance of the smoke by lethal concentration of carbon monoxide. Smoke may not appear at all.

Use the self-rescuer at the first indication of a fire or explosion and keep it on until fresh air is reached.

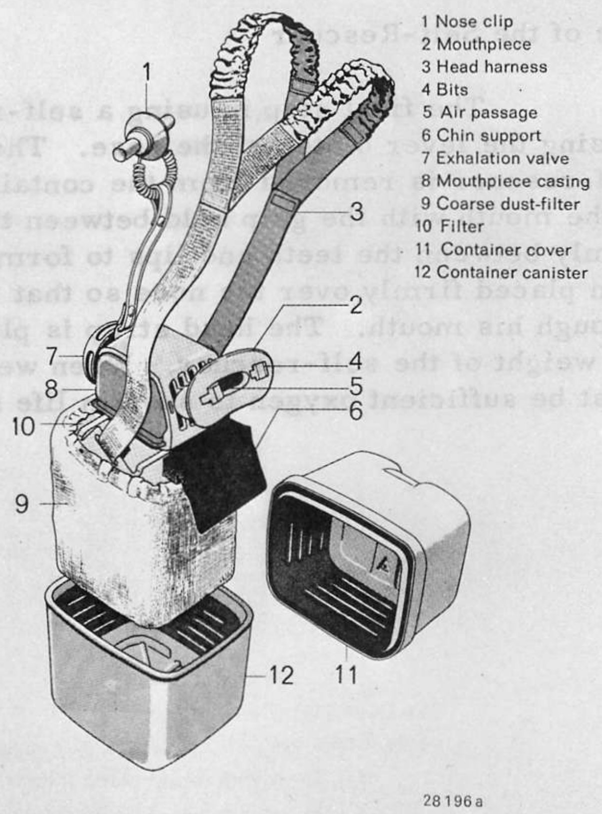
Use of the Self-Rescuer

The first step in using a self-rescuer is to break the seal by raising the lever on top of the case. The cover is then removed and the self-rescuer is removed from the container. The mouthpiece is inserted in the mouth with the grip held between the teeth and the flange placed firmly between the teeth and lips to form a good seal. The nosepiece is then placed firmly over the nose so that the wearer is forced to breathe through his mouth. The head strap is placed over the head to support the weight of the self-rescuer. When wearing the self-rescuer, there must be sufficient oxygen to sustain life (16 per cent by volume).

(illustr. 3) is now available for the first time in plastics with a new type of vacuum closure. The can part and the lid part are pressed together firmly and tightly by the action of a strong internal vacuum. The closure force holding the two parts together is approximately 70 kp (154 lbs.). The protection afforded to the filter and its mouthpiece by the container is exceptionally good. To open the plastics container in an emergency, the tear-open tab is pulled up (illustr. 4): air can then flow into the container, so that it can be immediately opened. The filter can then be taken out.

Component (c):

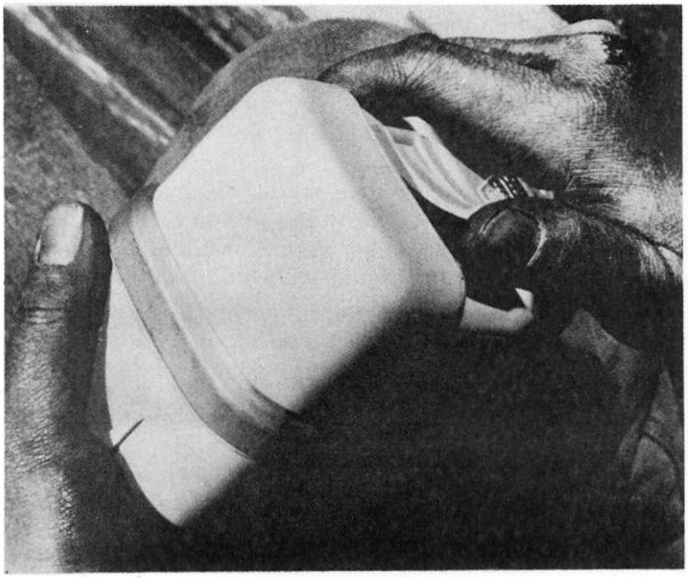
In case of emergency it must be possible to take hold of the filter self-rescuer without delay and to put it on quickly. It should therefore always be carried and not laid down, not even at the working place. This purpose is served by the carrying pouch (illustr. 5) which can be fastened to the lamp strap or to the belt. The carrying pouch is of soft, rubber-like plastics. It enables the filter self-rescuer to be carried in comfort and ensures that it is always readily available in every situation.



3 Principal components of the FSR 810 filter self-rescuer

4 Tear-open tab of the plastics container

27 398



Carrying pouch **5**

31 145

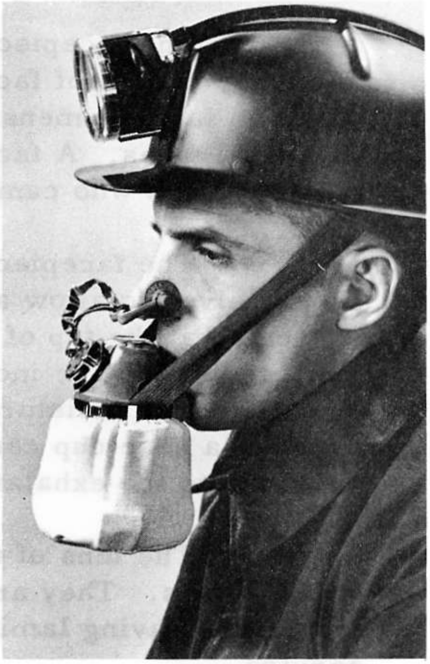
Using the Self Rescuer Respirator Is As Simple As This:

1. OPEN

(Pull Red Lever up hard to break seal. Remove cover and discard.)

2. REMOVE

(Pull mask from case. Discard case bottom.)



3. USE

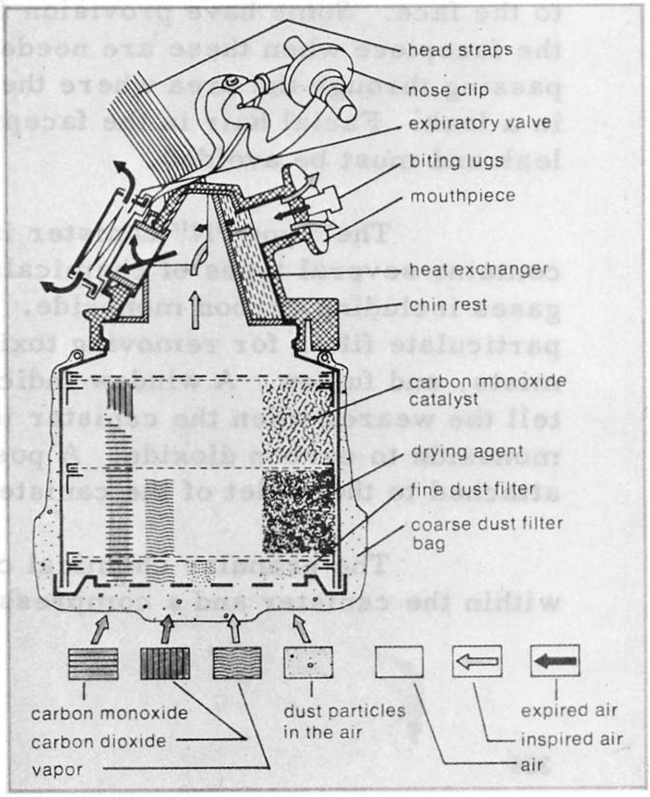
(Insert mouthpiece between lips and teeth, bite on lugs, place nose clip over nostrils. Pull support strap over head. Breathe thru Self-Rescuer.)

The M-S-A Self Rescuer W65... unique construction... simple operation

The filter unit consists of an outer coarse dust filter and an inner fine dust filter to remove dust particles, a drying agent to protect the hopcalite from moisture and the hopcalite catalyst to oxidize carbon monoxide. Separator screens and baffles are spot welded securely in position.

Breathable air is cooled by the heat exchanger before inhalation. Expired air passes back through the heat exchanger and out through the spring-loaded mica disc expiratory valve. The rubber mouthpiece utilizes a saliva drainer to protect the filter bed from moisture.

The Self Rescuer is secured to the wearer's head with a self-adjusting, cradled headstrap. The cushioned spring steel nose clip, attached by cord and "reminder" metal strip, prevents nasal breathing. Prior to use, a hermetically sealed stainless steel case protects the respirator.



TYPE "N" CANISTERS AND MASKS

The Type "N" mask is a gas mask consisting of a full facepiece covering the eyes, nose, and mouth, a flexible elastomeric, non-kinking breathing hose attached to an air purifying canister. The canister is carried in a chest harness having a neck strap and waist strap to hold the canister tightly to the body.

The facepiece is designed to give a comfortable gas tight fit to a wide variety of facial sizes and shapes. Because of the many variables in facial dimensions and sizes of faces a single facepiece size will not fit all faces. A face-fitting program should be used to determine those persons who cannot be fitted.

The facepiece, hose, and canister assembly must include check valves to allow air flow in one direction only. An inhalation valve is located at the top of the canister and an exhalation valve is a part of the facepiece. The incoming air into the facepiece is directed over the lens to reduce moisture condensation and where this is a significant problem a nose cup can be installed in the facepiece to direct the exhaled air to the exhalation valve without contacting the lens.

The lens of the facepiece is shaped and positioned to give wide visual limits. They are usually made of plastic with some twin lens facepieces having laminated safety glass for a better scratch resistant service.

An adjustable molded rubber head harness holds the facepiece to the face. Some have provision for supporting prescription lens within the facepiece when these are needed. Any support for prescription lens passing through the area where the facepiece contacts the face will result in a leak. Facial hair in the facepiece contact area will also result in a leak and must be avoided.

The Type "N" canister is an air purifying type of device that contains several types of chemicals for removing different groups of gases including carbon monoxide. It also contains a highly efficient particulate filter for removing toxic particulates including smokes, dusts, mists, and fumes. A window indicator is a part of the canister to visually tell the wearer when the canister is no longer able to convert carbon monoxide to carbon dioxide. A positive closing external check valve is attached to the outlet of the canister and connects to the breathing hose.

The granular chemical contents are placed in several layers within the canister and a compression spring at the top of the canister keeps them from shifting their position thereby assuring that all the incoming air contacts the chemical to remove toxic contaminants. The top of the canister also contains layers of filter material which are placed so that any dust from the chemicals cannot come into the facepiece when the mask is worn. Canisters have corrugated bodies or internal baffles to more effectively use their contents. When a granular chemical is placed against a smooth surface such as the side wall of the canister body, it does not pack as tightly to the smooth surface. This then becomes the path of least resistance for the air flowing through the canister. Corrugations or baffles cause this easy flowing air to take a longer path of travel and thereby bring it in contact with as much of the canister chemicals as possible. This prolongs the life of the canisters and prevents channelling and short canister life.

Because the chemicals are affected by moisture, a top seal and bottom seal close the canister inlet and outlet, and should always be kept in place while the canister is stored. Type "N" canisters should be stored in a clean, dry location away from widely varying temperatures and high humidity. When stored in the recommended location their shelf life is three years from the date of manufacture or no longer than one year after the seals have been broken to attach the canister to a mask assembly. Canisters are code dated or otherwise identified regarding their date of manufacture. (Check with the manufacturer to learn their particular date coding.)

The function of the canister is to remove all toxic contaminants from the air drawn into the canister. This is accomplished as follows as the air flows through the several layers of materials:

1 A high efficiency filter removes particulate contaminants by mechanical filtration. The openings in the filter media are small enough to remove particles of smoke that are sub-micron in size.

2. Acid gases such as chlorine, sulphur dioxide, hydrogen sulphide, phosgene are absorbed chemically on materials that are caustic.

3. Ammonia and other basic types of gases are absorbed on chemicals that have an acid reaction.

4. Organic vapors or materials that generally contain carbon and hydrogen plus many other elements are absorbed on the surface of activated carbon. Organic vapors include gasoline, paint solvents, chloroform, and many others.

5. The catalyst Hopcalite oxidizes carbon monoxide to harmless carbon

dioxide. It is placed above all the other canister chemicals which act as dryers to help keep moisture from the Hopcalite. Excess moisture will destroy the Hopcalite. When fighting fires with water, fog, foam, etc., and the canister is openly exposed, the Hopcalite could be destroyed in a few minutes.

6. A layer of calcium chloride is placed at the top of the chemical bed to remove any moisture which may enter from the top of the canister. This is a protection for the Hopcalite when the canister is stored attached to the complete mask assembly.

The indicating window in the Type "N" canister contains panels of two shades of a light blue colour. The darker shade section changes colour with a change in the moisture content of the chemical directly behind it (Hopcalite). The light section is a reference colour. When the canister is used or stored and it picks up moisture, the darker section will gradually become lighter in colour until it matches or becomes lighter than the reference section. When this change takes place the canister is no longer capable of catalytically oxidizing the carbon monoxide to carbon dioxide. The indicating window is designed to tell the condition of the Hopcalite layer only and does not in any way relate to the other chemicals or the canisters ability to remove other classes of gases.

Because the canister contains a variety of chemicals it is able to give protection against a variety of gases and vapors, as well as toxic particulates. The label affixed to the canister describes its protection capabilities. The maximum concentrations in which the canister can be used are 2 per cent acid gases, 2 per cent organic vapors, 2 per cent carbon monoxide, and 3 per cent ammonia. These limits were established by the United States Bureau of Mines a good many years ago and are at the present time undergoing consideration for revision. The Type "N" canister is painted red for identification. Other types of canisters giving protection against single gases, single classes of gases, or combination of gases and vapors are identified by other colours. Only the Type "N" canister with the exception of the mine rescue escape respirator can give protection against carbon monoxide.

The most important precaution when using a Type "N" is that it should never be used where the oxygen content of the contaminated air is not sufficient to sustain life (16 per cent by volume).

Because Type "N" masks have been used for fire fighting in atmosphere containing a high concentration of toxic gases and vapors, and in areas having a low oxygen content, they are no longer recommended for use in fire fighting. A label stating "not to be used for fire fighting" is attached to each canister. Where there is adequate oxygen and some knowledge of the contaminant in the atmosphere this type mask can, however, give very good protection.

When the Type "N" mask is used to enter a toxic atmosphere after it has been donned according to the instructions furnished with each mask, the wearer should cautiously enter the atmosphere and if any odor or irritation is noted, he should leave the area. The mask should be rechecked, tested for tightness, and again entered cautiously. Continued odor or irritation is an indication of a serious problem and the mask and canister should be completely checked. The wearer may also have facial characteristics that precludes his wearing a mask.

Type "N" canisters are designed and laboratory tested to meet performance requirements using test gases that are representative of the classes of gases the canister will protect against. The high concentration tests are made using 2 per cent of the gas by volume in an air flow of 64 litres per minute, low concentration in an air flow of 32 litres per minute. Canisters and complete mask assemblies also must meet pressure drop or resistance to breathing requirements test that are made at an air flow of 85 liters per minute. The flow rates used are based on the minute-volume requirements of people doing moderate to heavy work. The high flow resistant test assures a reasonable resistance to breathing during high inspiratory flows when doing heavy work. A complete mask will have a resistance on inhalation at 85 litres per minute flow 3.75 - 4.00 inches water gauge and .6 - .75 inch water gauge on exhalation.

When the canister is used in an atmosphere containing several toxic gases and vapors, they are removed by the chemical layers as the air moves up through the canister. At the same time the gases are removed water vapor is also taken from the air. Clean, dry air that may contain only carbon monoxide then passes through the Hopcalite layer. This layer requires clean dry air containing only carbon monoxide to preserve its activity as long as possible. As the canister is used and approaches the end of its life it will begin to pass low concentrations of the toxic gases. These can be detected by smell or irritation. The change in odor takes place gradually and will give the wearer adequate time to return to fresh air to replace his canister with a new one. Because carbon monoxide has no odor, the window indicator should be carefully watched when the canister is used in the gas. As long as the indicator section of the window shows a darker colour than the reference section, the canister will give protection against carbon monoxide.

It is extremely difficult to estimate the life of a canister when variable exposure conditions, including concentration of contaminants in the air, breathing rate of the wearer, temperature, and humidity adversely affect service life Since the exposure conditions are subject to wide variation, it is most difficult to estimate the service life of a gas mask canister. However, for guidance purposes, actual man tests performed under Bureau of Mines Schedule 14F stipulate the following minimum service requirements at an average breathing rate of 25 litres per minute in concentrations of 2 per cent for most gases and vapors or 3 per cent ammonia can predictably and reliably give acid gases 15 minutes, organic vapors 25 minutes, ammonia 15 minutes, and carbon monoxide 30 minutes. This time will be correspondingly higher at lower concentrations. Against carbon monoxide the canister life may range between 1 1/2 - 2 hours, depending upon the amount of moisture in the atmosphere. This time, however, should not be considered definite. The window indicator should be relied upon to tell when the canister will no longer protect against carbon monoxide. The canister also can only give protection where the total concentration of toxic gases does not exceed 2 per cent by volume. Where the combined total concentration of toxic gases may possibly exceed this concentration other types of breathing equipment should be used.

During use it is possible the canister may become warm or even hot. This is an indication that it is being exposed to relatively high concentrations of gases and vapors. Each of the reactions involved in the removal of gases and vapors produce heat. This is most particularly true for the carbon monoxide reaction. When the incoming air into the facepiece becomes intolerable the wearer should retreat to a less contaminated area. It is also possible under conditions of very high humidity that an increase in breathing resistance will be noted. If this occurs the canister should be replaced even though an odor or irritation has not been observed.

The Type "N" gas mask features the Window-Cator Canister which contains a moisture indicator. A small, round window in the front of the canister has two half circles--one shows a light blue reference colour, the other a darker blue indicating colour. In use, as the absorbent is penetrated and absorbs moisture, the indicator colour grows gradually lighter....closer to the reference colour. When the colours match, the canister is beginning to lose its effectiveness against carbon monoxide and should be replaced.

Gas mask canisters used for emergency purposes should be replaced after each use. Specific indications for canister replacement and/or return to fresh air are:

1. If the window indicators of the Type "N" canisters show the specified colour changes.

2. If any leakage is detected by smell, taste, or eyes, nose or throat irritation.

3. If high breathing resistance develops.

4. If the canister shelf life is exceeded.

The Type "N" mask can give good protection when it is used wisely and in recognition of its limitations. Steps to consider when using the mask are:

1. Don the mask carefully following the manufacturer's instructions.

2. Test for tightness and comfortable fitting of the facepiece. If leakage is noted repeat donning procedure.

3. Enter the contaminated area cautiously. If an odor or irritation is noted, return to fresh air and determine cause.

4. When odor or irritation is noted after mask has been used, return to fresh air and replace canister.

Type N Cannister and Mask

5. If canister and incoming air becomes hot, retreat from contaminated area. Canister is being exposed to very high concentrations of toxic gases or vapors.

6. Frequently observe the indicator window when exposed to carbon monoxide.

7. Never use a Type "N" mask where the oxygen content of the atmosphere is less than 16 per cent.

8. Do not use the Type "N" mask for fire fighting or where the total toxic gas, vapor or particular concentration exceeds 2 per cent by volume.

9. Use suitable instruments to determine concentration of oxygen and air contaminants.

10. When fighting fires with water, fog, foam, etc., endeavour to protect canister from being unduly exposed to these agents.

DRÄGER Oxygen Self Rescuer
OXY-SR® 30

The oxygen self rescuer Oxy-SR® 30 is a newly designed escape apparatus for use in work places where toxic atmospheres and oxygen deficiency may be expected.

The **Oxy-SR® 30** is a compact, easily carried apparatus which makes the wearer completely independent of the surrounding air for approximately 30 minutes. The unit is of the closed circuit type, i. e. the expired air is regenerated and enriched with oxygen for re-breathing.

The Oxy-SR® 30 is fitted with an oxygen cylinder with lever valve enabling its use to be interrupted. The apparatus is therefore suitable for inspections and similar short operations.

Special features are

- **Instant readiness for use**
- **Adaptable to all breathing air requirements through a lung demand valve**
- **Compact and very light (2.3 kg)**
- **Minimal breathing resistance**
- **Low temperature of the breathing air**
- **Charging control by pressure indicator**
- **Low business costs**

Procedure for use:

1. **Open cover and put on the unit**
2. **Place the mouthpiece in the mouth and put on the nose clip**
3. **Open the cylinder valve**
4. **lay on gas-protection glasses**

The impact-resistant plastic casing with cover contains:

The oxygen cylinder — working pressure 300 atmospheres, re-chargeable soda lime container, folded

29 054

Fig. 1 How the Oxy-SR® 30 is carried

29 052

Fig. 2a Oxy-SR® 30

29 053

Fig. 2b Oxy-SR® 30 M

Fig. 3 Oxy-SR® 30 29055

Fig. 4 Oxy-SR® 30 M 27600

breathing bag with pressure relief valve, high pressure control valve with a constant dosage of 1.5 litres/minute and lung demand regulator, corrugated breathing tube with mouthpiece set i.e. breathing-protection mask.

With the cover open, breathing connection fitted, and cylinder valve open, the lung demand valve supplies oxygen over and above the constant dosage to flow into the breathing bag to meet the wearer's requirements, which is particularly important in the first few seconds.

The expired air passes through the breathing tube into the soda lime container, where the carbon dioxide is absorbed. The respirable air then flows into the breathing bag where oxygen from the constant dosage unit is added. On inhalation, the air flows via two non-return valves and the breathing tube to the mouthpiece. The self rescuer Oxy SR® 30 is thus a self-contained breathing apparatus.

With low body work, excess breathing air is discharged into the atmosphere through the pressure relief valve.

When the apparatus is put into operation it functions entirely automatically.

After use, the oxygen cylinder must be re-charged and the soda lime canister refilled.

The Oxy SR® 30 will be delivered in two different types.

- Oxy SR® 30 with mouthpiece-set and gas-protection glasses fitted into cover of casing.
- Oxy SR® 30 with breathing-protection mask. The cover of this apparatus was made higher, so that it can take a small elastic full-mask.

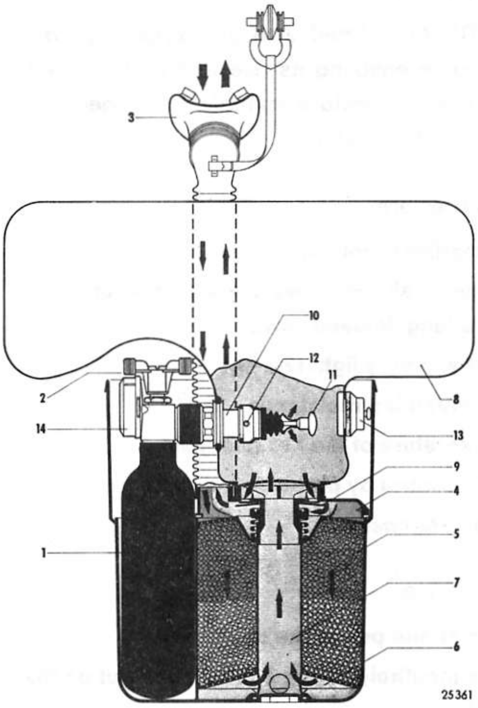


Fig. 5 Circuit diagram of the Oxy SR® 30

1	Oxygen cylinder
2	Lever valve
3	Breathing tube with mouthpiece and nose clip
4	Valve chamber
5	Soda lime
6	Collecting chamber
7	Central pipe
8	Breathing bag
9	Non-return valve
10	Control valve
11	Control lever for lung demand regulator
12	Constant dosage unit
13	Pressure relief valve
14	Valve with pressure gauge

SELF - CONTAINED SELF - RESCUERS

At least two self-contained self-rescue units have been manufactured for rescue purposes in mines. Among these are the units produced by the Auer and by the Draeger companies in West Germany.

The Auer self-rescuer is a miniature chemical oxygen producing unit with a quick start canister It provides a 45 minute supply of oxygen The oxygen is quite hot inasmuch as the compactness of the unit does not allow for cooling as is done in the Chemox.

The Draeger rescuer OXY-SR is supplied in two units which are the same except for the oxygen release valve. The OXY-SR 45 has a push button valve which can be operated once only. It supplies oxygen from the small storage tank pressurized to 4,000 pounds per square inch for a 45-minute period at a flow rate of 1.2 litres per minute. This unit must be returned to the factory for replacement of the push button valve.

The OXY-SR 30 has a hand operated valve control and can supply oxygen for 30 minutes at a rate of 1.5 litres per minute. This unit can be recharged by means of an oxygen cascade system and high pressure pump.

Both models may be supplied with mouthpieces or face masks. When mouth pieces are used a pair of goggles should be packed within the carrying case lid. A complete unit with case weighs approximately 5 pounds.

DESCRIPTION AND FUNCTION

The impact resistant plastic casing and cover contains:

The oxygen cylinder - working pressure 300 atmospheres, refillable soda-lime canister, folded up breathing bag with pressure relief valve, high pressure control valve with 1.5 litres per minute constant flow and lung demand regulator, corrugated breathing tube with mouthpiece and nose clip, or optional full facepiece.

With cover open, mouthpiece and nose clip fitted, and cylinder valve open, the required oxygen supply is maintained by the constant flow unit and the lung demand regulator. The operation of the latter is most essential as it fills the breathing bag in the first seconds of use.

The expired air passes through the breathing tube into the soda-lime canister where the carbon dioxide is absorbed. The respirable air flows on into the breathing bag where oxygen from the constant dosage unit is added. On inhalation, the air flows via the double non-return valve and the breathing tube to the mouthpiece. The OXY-SR self-rescuers are thus self-contained breathing apparatus.

At low respiratory rates, excess gas is eliminated by the pressure relief valve

When the apparatus is put into operation it functions entirely automatically.

After use, the oxygen cylinder must be recharged and the soda-lime canister refilled.

Duration of OXY-SR 45

Charging Pressure:

300 atm (4410) psi .... 45 minutes
200 atm (2940) psi .... 30 minutes
135 atm (1985) psi .... 20 minutes

Procedure for use

1. Open cover and don unit.

2. Insert the mouth piece and adjust the nose clip or, if the unit has a full facepiece, this is put on in the regular manner and face straps adjusted.

3. Open cylinder valve and breathe.

ONE-HOUR CHEMOX OXYGEN BREATHING APPARATUS

portable self-contained equipment generates its own oxygen, providing complete respiratory protection in any area of oxygen deficiency or concentration of toxic gases

Portable self-contained equipment generates its own oxygen, providing complete respiratory protection in any area of oxygen deficiency or concentration of toxic gases.

Bureau of Mines Approved M-S-A One-Hour CHEMOX Oxygen Breathing Apparatus utilizes a replaceable chemical canister which removes the carbon dioxide from the wearer's exhaled breath and evolves an ample supply of oxygen which automatically continues in accordance with the wearer's breathing requirements. Entire unit is well balanced and comfortable to wear.

APPLICATIONS

Fire departments, steel plants, chemical plants and laboratories, petroleum industry, food processing, marine transportation.

Oxygen deficient atmospheres or in hazardous concentrations of toxic gases.

FEATURES

Complete respiratory protection for one hour.
Automatic timer rings a bell at end of pre-set time to warn wearer to return to fresh air.
No cylinders, valves, and other mechanical components.
Easily replaceable canisters.
Canisters last indefinitely in storage.
Speaking diaphragm allows easy conversation.
Quick Start Canister enables starting at temperatures as low as — 20°F.

SPECIFICATIONS

Carrying case: 23⅛ in. x 17¼ in. x 9⅜ in.

Weight, complete, with canister: approximately 13½ pounds.

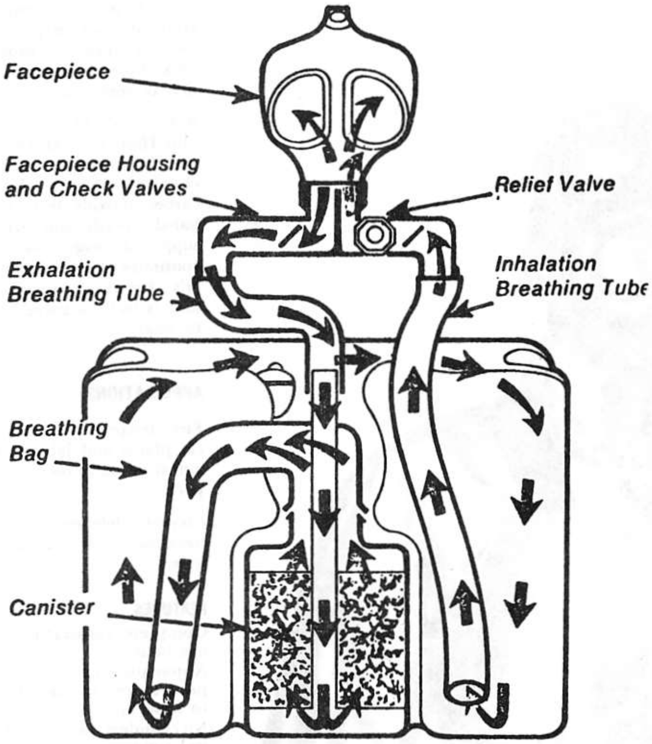
Should more detailed information be desired, ask for Bulletin No. 0103-5.

Complete parts list 994219 available at no charge on request.

CATALOG NUMBERS

01-87500	One-Hour CHEMOX Oxygen Breathing Apparatus with Cleartone Speaking Diaphragm and one canister, complete in case.
01-45151	CHEMOX Canister, only.
01-92900	Quick Start CHEMOX Canister.

Note: ¾ hour Chemox Oxygen Breathing Apparatus can be upgraded to 1 hour type at a nominal cost.



This flow diagram traces the passage of exhaled breath from the facepiece through the exhalation valve and tube to the canister. There the carbon dioxide in the breath is removed, and the moisture content reacts with the chemicals to evolve pure oxygen. This oxygen flows up through the canister into the breathing bag reservoir through the tube to the wearer's facepiece.

CHEMOX OXYGEN BREATHING APPARATUS

The Chemox oxygen breathing apparatus is a self-contained, closed-circuit machine employing a replaceable canister containing a chemical which, when in contact with the moisture in the exhaled breath, evolves a supply of oxygen for breathing requirements and absorbs the exhaled carbon dioxide and moisture. This apparatus has been approved for one hour by the United States Bureau of Mines. It affords the wearer complete respiratory protection in atmospheres which are gaseous or deficient in oxygen.

PARTS OF THE APPARATUS

The apparatus has six main parts: the facepiece and breathing tubes, the frame and harness, the manifold, the breathing bag, the canister, and the time-limit warning bell.

Facepiece

The facepiece is full-vision with a speaking-diaphragm. It has corrugated-rubber inhalation and exhalation tubes, fastened respectively to the left and right hand sides of a metal housing which holds the inhalation, exhalation, and pressure relief valves and is connected to the lower part of the facepiece. The breathing tubes are connected to the manifold by their respective couplings.

Frame and Harness

The frame consists of an aluminum breast plate and canister-holder. These are covered on the outside with a padded, rubberized fabric to protect the wearer from the heat of the canister when in use. The frame is carried by webbing shoulder and waist straps. The canister is supported by a swinging bail, or stirrup, attached to the metal holder and is tightened into place against the manifold by means of a jack screw and hand-wheel on the bail. A rubber gasket forms the seal between the canister and the manifold.

Manifold

The manifold is a metal distribution chamber or box attached to the top of the framework over the canister holder. A metal tube passes down through the centre of the manifold chamber and a cone-shaped socket-casting at the bottom of the manifold into which the neck of the canister fits. The lower end of the tube has a puncturing nose for breaking the copper-foil seal of the canister and fits into a tube in the centre of the canister. The upper end of the tube has a coupling for attaching it to the exhalation tube. Outside the tube in the base of the manifold there is an annular opening leading to the chamber of the manifold. This opening connects with the outer circuit of the canister. On the side of the manifold there is a connection leading from this chamber to the right hand section of the breathing bag A bracket on the side of the manifold carries an elbow which connects the left-hand section of the breathing bag and the inhalation tube.

Breathing bag

The breathing bag is made of rubberized fabric. It is divided into two sections, one on each side of the canister holder, connected together at the top. The bag is held in position to the frame by the connections with the manifold at the top and by a bolt to the frame at the lower end of each section.

Quick Start Canister

The quick start canister is a metal container filled with an oxygen-producing chemical (potassium superoxide.) It is held in the holder between two sections of the breathing bag, and weighs four pounds before use.

An oxygen candle, fired by pulling on a cord lanyard, is attached to the bottom of the canister.

Warning Bell

The apparatus is fitted with a warning bell which is pre-set and warns the wearer when it is time to leave the working place. It is attached to the upper part of the manifold.

OXYGEN FLOW THROUGH APPARATUS

During exhalation the flow is from the facepiece through the right-hand breathing tube, the metal tube through the manifold chamber and the seal-puncturing nose, and down the centre tube of the canister to the bottom. The oxygen then flows up through the chemical, which absorbs the carbon dioxide and the moisture and liberates oxygen, to the top of the canister. From here the flow continues to the bottom of the right hand side of the breathing bag, then to the bottom of the left hand side of the breathing bag, from which it flows into the facepiece through the left hand breathing tube.

INSTALLING QUICK STARTING TYPE CANISTER

A. Lift up on lip of plastic cap until seal is broken. Completely remove the remainder of the cap, exposing the air tight copper foil canister seal. This Copper Foil Seal Must Be Fully Exposed Before Inserting Canister.

B. With the handwheel screwed down far enough for the bail to be swung outward, swing the bail outward and insert canister fully into canister holder with the smooth side to the front. The canister should be inserted sufficiently so that the copper foil seal is punctured and the rubber gasket fits snugly against the V-shaped recess in the plunger casting. Screw the handwheel clockwise until it is tight against the canister.

C. Remove candle cover by rotating swivel plate 180°. Pull swivel plate down, push cover toward centre of canister, and let cover dangle. WARNING. DO NOT PULL LANYARD UNTIL READY FOR USE.

NOTE: The Canister Must be Inserted with the Smooth Side to the Front.

DONNING OF APPARATUS

The following are the consecutive steps in putting on the apparatus before entering a toxic atmosphere. The Apparatus Must Always Be Put On In Fresh Air.

1. Unfasten and straighten all harness straps.

2. With one hand, grasp the apparatus by the plunger casting, dropping the facepiece over the hand holding the apparatus. With the other hand grasp the D-ring assembly where the two large web straps join, placing the breast plate of the canister holder on the chest and slipping the head through the V-shaped opening formed by the two web straps.

3. Continue to hold the apparatus on the chest with one hand and with the other reach around the body at one side and grasp the free end of the web strap on that side. Bring the end of the strap under the arm and snap into the D-ring located on the top side of the breast plate. Repeat this procedure for the other strap.

4. Adjust the position of the apparatus on the body by means of metal slides located on the web harness straps. The position of the apparatus on the body should be such that when the facepiece is put on, the breathing tubes will permit free head movement.

5. Attach the waist strap to the small D-ring located on the lower corner of the breast plate and pull up to a snug fit, tucking in the loose ends.

6. Pull out the facepiece headband straps so that the ends are at the buckles and grip facepiece between thumbs and fingers. Insert chin well into the lower part of the facepiece and pull the headbands back over the head. To obtain a firm and comfortable fit against the facepiece at all points, adjust headbands as follows:

   (a) See that straps lie flat against head.
   (b) Tighten lower or "neck" straps.
   (c) Tighten the "side" straps. (Do not touch forehead or "Front" strap.)
   (d) Place both hands on headband pad and push in toward the neck.
   (e) Repeat operations (b) and (c).
   (f) Tighten forehead or "Front" straps a few notches if necessary.

   Test the facepiece for tightness by squeezing the corrugated breathing tubes tightly. Inhale gently so that the facepiece collapses slightly and hold breath for 10 seconds. The facepiece will remain collapsed while the breath is held, providing the assembly is gas tight. If any leakage is detected around the facial seal, readjust head harness straps. If other than facial seal leakage is detected, investigate the condition and correct. The facepiece must be subjected to a tightness test before each use.

7. With the facepiece adjusted and checked for tightness, start the canister by the following method:

   STARTING QUICK STARTING TYPE CANISTER
   This must be done in Fresh Air

   (a) Pull lanyard straight out away from body. Removal of cotter pin fires candle, inflating breathing bag with oxygen within 15 seconds. NOTE: If Candle Fails to Fire, Insert New Canister.

   (b) Starting of the candle may be accompanied by a slight amount of harmless smoke. The breathing bag will be inflated with oxygen.

   After initial start and use of canister, do not attempt to restart and reuse either type of canister.

The CHEMOX Apparatus Should Be Stored And Started At Temperatures Above 32°F. When a Quick Start Canister is used, the apparatus can be started at temperatures as low as -20°F.

8. To check the complete apparatus for tightness:

   (a) Grasp the lower end of the inhalation (left hand) breathing tube and squeeze it tightly. Inhale gently and if the facepiece collapses the facepiece seal is sufficiently tight and the exhalation valve is functioning properly. This will also test the upper part of the inhalation breathing tube for leaks.

   (b) Continue to squeeze the lower end of the inhalation (left hand) breathing tube. Depress the pressure relief valve button. It should then be possible to exhale through the valve. While still holding the button down, inhale and if the facepiece collapses as above, the relief valve is functioning properly.

   (c) Release the inhalation (left hand) tube and squeeze the lower end of the exhalation (right hand) breathing tube. Inhale and then exhale forcibly. The exhaled air should be forced out between the face and the facepiece only, this will indicate that the inhalation valve is functioning properly and the upper end of the exhalation tube is free of leaks.

   (d) With the bag well inflated, grasp the upper ends of both breathing tubes and squeeze tightly, and depress both sides of the breathing bag with the elbows. If The Breathing Bag Does Not Deflate, The Complete Apparatus is Tight.

   If a Leak or Defect Is Indicated In Any Part Of The Apparatus, It Should Be Checked And The Condition Corrected Before Use.

9. Breathe normally as the apparatus furnishes enough oxygen to meet any breathing requirement.

Use of the Timer

Since the apparatus has a nominal one hour service life as indicated below, it is necessary to determine the length of time required to return to fresh air from the working place and set the timer accordingly. The timer dial is calibrated in minutes, and by turning the pointer clockwise to the number of minutes left after deducting the time for exit, the timer will be properly set. For example, if it takes 10 minutes to return to fresh air, deduct 10 minutes from 60 and set the timer at 50. The bell on the timer will ring for approximately 7 seconds when the pointer returns to 0, at which time the wearer must return immediately to fresh air.

GENERAL INFORMATION FOR USE

The canister will produce more oxygen than will be used so the breathing bags will become over inflated, causing exhalation resistance. The excess volume can be eliminated (vented) by depressing the valve button on the facepiece. Do not over vent.

There are two indications in addition to the timer that the canister is becoming expended--fogging of the lens(es) on inhalation and increased resistance of exhalation. These two indications will not normally appear until after one hour of use but may become noticeable under conditions of extreme hard work. The lens(es) will clear on inhalation until the canister is almost expended, then they will begin to fog. Do not confuse excess breathing bag pressure with canister resistance. If excess breathing pressure is relieved by use of the pressure relief valve and the exhalation resistance is still present, the canister is about expended.

If Either Of These Two Indications Appear, Return To Fresh Air.

CAUTION

NEVER ALLOW ANY SUBSTANCE TO ENTER THE NECK OF THE CANISTER, ESPECIALLY OIL, WATER AND OIL, GASOLINE, GREASE, ETC., AS THE CHEMICAL CONTAINS OXYGEN, WHICH WILL CAUSE COMBUSTION OF ANY INFLAMMABLE MATERIALS WITH WHICH IT IS BROUGHT INTO DIRECT CONTACT, ESPECIALLY IF SUCH MATERIALS ARE MOIST.

AFTER USE

1. To remove the canister turn the handwheel down, swing bail outward and remove the canister with the hand suitably protected by a glove or other covering since the canister may be hot. Do Not Reuse The Canister.

2. Always use the following procedure before discarding the canister:

To dispose of canister, remove to surface, punch a small hole in front, back and bottom, and place in bucket of clean water sufficiently deep to cover the canister at least 3 inches. When bubbling stops, any residual oxygen will be dissipated and the canister will be expended. Pour the residual water which is caustic, down a drain or dispose of in any other suitable manner and then discard the canister. Do Not Puncture Canister Underground.

DEMAND APPARATUS

Scott Air Pak	MSA Oxygen Mask*	MSA Air Mask*
Model No. 6000A2M	Model No. 401	Model No. 401

The Air or Oxygen Pak may be used safely in any atmosphere containing any gas except one which irritates or poisons through the skin, such as hydrogen cyanide or highly concentrated ammonia. It may be used under any conditions of temperature, pressure,or moisture in which a man can work.

Model No. 6000A2M is approved by the United States Bureau of Mines for a half hour of continuous use with a fully charged air cylinder having a capacity of 40.3 cubic feet at 1,980 psi. Its total weight is 29 1/2 pounds.

The purity of the air used to recharge Air Pak bottles is of prime importance as the compressed air must contain not less than 20.5 oxygen and more than 0.005 carbon monoxide. Oxygen Pak bottles are of approximately 100 per cent oxygen. Many companies use the same equipment for compressing air as they use for filling oxygen cylinders thus assuring themselves of the purity of the air. This type of compressor uses water, or soap and water lubrication and the cylinders of the compressor are usually water cooled to eliminate the formation of carbon monoxide which could be caused through the heat generated.

Air compressors using oil lubrication may be used as a source of compressed breathing air only when carbon monoxide indicating devices are used in the circuit continuously to check the purity of the air and the air is properly filtered. Oil or grease, etc., must NOT be used in or around an oxygen pump or Cascade system.

PARTS OF THE APPARATUS

The Air or Oxygen Pak has five main parts: an alloy metal cylinder or bottle, containing pure breathing air or oxygen; a reducing valve and demand regulator with a shut off valve and by pass valve; a facepiece and corrugated breathing tube with "quick connect" coupling; a metal back-plate to which is fastened the web-type carrying harness; an auxiliary charging hose and the female half of a high pressure self sealing coupling.

Air-cylinder or Bottle

For purposes of clarity the term "bottle" will be used throughout

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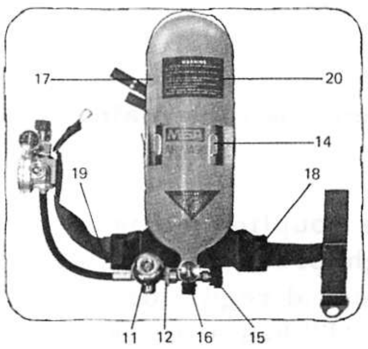
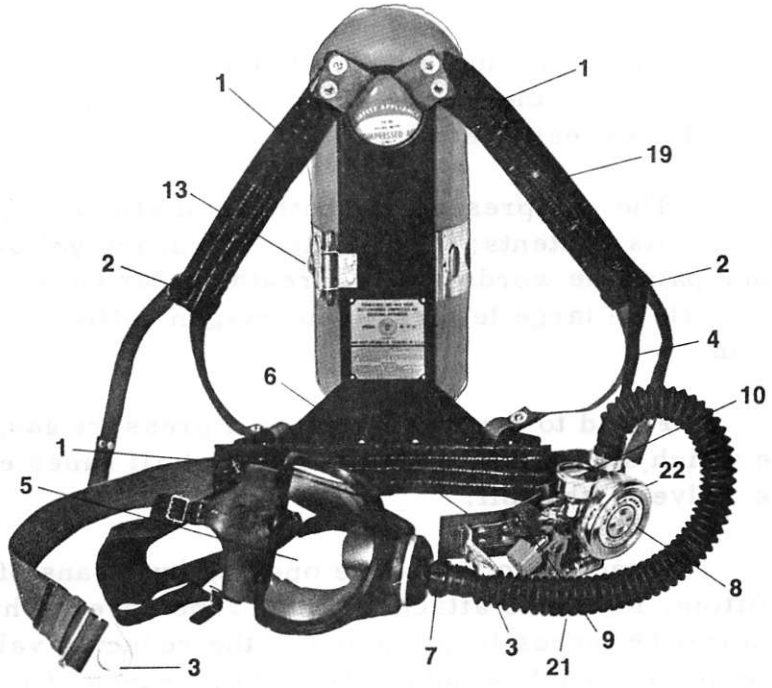
*See final paragraph on page 115

At twenty checkpoints, the new Model 401 MSA Air Mask has the features you need:





1. 3-zone comfort . . Cushionaire harness with wide, foam-padded straps at the shoulders and lower back. Harness is strong, latex-treated, mildewproof nylon.

2. Shoulder straps have quick-adjust buckle.

3. Waist strap has snap fastener and quick-adjust buckle.

4. Retaining strap for chest is also quick-adjust.

5. The Ultravue Facepiece is easily interchangeable with other principal MSA respiratory equipment. A speaking diaphragm assists communication when the facepiece is worn. This facepiece has picture-window visibility and means for mounting prescription glasses. The Ultravue Facepiece has a baffle to inhibit direct breathing against the lens. An optional antifogging "nosecup" is available.

6. A snap-on neck strap holds mask when mask is removed from the face.

7. Facepiece coupling provides easy disassembly for cleaning.

8. With the new Model 401, breathing is easy even under hard work conditions because the demand regulator requires minimal inhalation effort. This low resistance to breathing builds the wearer's confidence because the MSA regulator delivers all the air he needs.

9. Should the automatic functioning of the regulator be impaired, the bypass valve can be opened for direct, controlled flow from the cylinder to the mask. Identified by its bright red color and indented finger grip, this valve is separate from the yellow, round, main-line valve.

10. Pressure gauge can be read easily.

11. The MSA Audi-Larm provides a loud, clear, continuous ringing to indicate when the breathing supply is low. There is no lever to move or adjustment to make, because the Audi-Larm cocks automatically when cylinder valve is opened. The Audi-Larm is separate from the demand regulator to facilitate replacement, should it ever be necessary.

12. The high-pressure hose connection to the cylinder is made with a hand-tightened fitting which eliminates using a wrench. The connection fits any standard air cylinder.

13. For fast cylinder change, simply turn this positive cam-type latch, slip out the empty cylinder, slide in the recharged cylinder, and twist the latch to lock.

14. With the same MSA Air Mask, several different sizes of cylinders can be used because the stainless steel holder fits all 45-, 43-, 40-, 26-, or 22-cubic-foot-size cylinders.

15. Right-angle position makes MSA's cylinder valve handwheel easy to open and eliminates the need for a guard assembly which could interfere with its turning.

16. Pressure gauge on valve is flush mounted for increased safety, and a unique rubber guard protects it from damage if cylinder is accidentally dropped.

17. MSA cylinders have a bright, hard, lasting finish.

18. Sturdy MSA back plate, made of tough, anodized and painted aluminum, can withstand severe usage.

19. Harness straps are replaceable. Fastened to the frame with snaps, they can be easily replaced in the field.

20. Cylinder has 45-cubic-foot air capacity (10 percent more than in older models).

21. A pressure relief valve to release pressure in excess of the normal operating pressure of the reducing valve. Mounted external to the regulator to vent to the air.

22. A pressure relief valve to release any excessive pressure which may develop on the low pressure side of the regulator because of blockage on the regulator outlet.

Catalog numbers

457153	MSA Air Mask complete in case
457152	Same, less case
94007	Cylinder, Air Mask, complete with valve.

this description. The bottle is made of metal alloy and is much lighter than steel bottle of comparative size would be. It is approved by the United States Interstate Commerce Commission and tested to a pressure of 3,000 psi. When charged to its present permitted pressure of 1,980 psi, it contains 40.3 cubic feet of air or oxygen.

There is a main bottle valve which should be opened at least one full turn when the Pak is being worn. There is a safety cap designed to fail under excess pressure.

The compressed air bottle is distinctively coloured and marked to identify its contents; it is painted a "canary yellow" and has stencilled in black paint the words "Pure Breathing Air Only" marked on the body of the bottle in large letters. The oxygen bottles are green and marked "Oxygen."

Fitted to the valve body is a pressure gauge known as the bottle-gauge which shows the bottle pressure at all times even when the main bottle valve is shut off.

Attached to the bottle opening by means of a coupling nut is a "T" fitting, to this is attached a neoprene covered high pressure flexible hose about 18 inches long leading to the reducing valve and regulator. This is on the Air Pak only. The other branch of the "T" has a pressure operated check valve to which is connected a neoprene covered high pressure flexible hose about 24 inches long ending in the female half of a high pressure self sealing coupling. This latter hose is used when re-charging the apparatus while wearing it, from one or more large cylinders. This type of hose is available for the Oxygen Pak if requested. The threads on the cylinders and hoses are made so that the air thread will not fit on the oxygen thread coupling, thus preventing dangers of interchanging same.

Low Pressure Alarm

An alarm bell is available for Demand Apparatus, to sound when the bottle pressure is reduced to approximately 400 psi. This bell cannot be shut off and will continue to ring for four to five minutes, by which time the wearer will have emptied the bottle.

Reducing Valve and Regulator

The regulator delivers air to the user in accordance with his requirements. When the user inhales, the regulator delivers air or oxygen from the bottle, reduced to a pressure approximately three and a half psi. above atmospheric pressure during the inhalation period and in a volume dependent upon the depth of inhalation. The maximum volume which may be supplied is 165 litres per minute. When the user exhales, the regulator shuts off the air or oxygen from the bottle, thus conserving the air or oxygen supply.

The regulator assembly consists of (1) the regulator body and mechanism (2) the high pressure gauge, (3) the by pass valve, (4) the regulator shut off valve, (5) the shut off regulator lock.

The high pressure gauge is mounted on the regulator-housing in view of the wearer at all times. This gauge indicates the bottle pressure when the main bottle-valve is opened and provides a positive indication of the amount of air left in the bottle. The figures on the dial are luminous for maximum visibility.

The assembly is connected to the flexible hose from the bottle and fastened to the chest strap of the harness. The regulator is connected to the breathing tube from the facepiece by a "quick-connect" coupling at the top of the regulator. The regulator shut off valve (yellow knob) is provided to shut off the air to the regulator if and when the by-pass valve (red knob) is in use.

A by pass valve is provided for use in the event of damage to the demand regulator.

OPERATION OF THE REGULATOR

Air or oxygen at bottle pressure enters the regulator and passes through the shut off valve orifice, and continues through the passage, screen, and orifice. After being reduced by the first stage valve to a lower pressure, the air or oxygen continues past it to the inside of the bellows assembly which is spring loaded to maintain a constant pressure of 35 psi in this chamber. If this pressure increases, the bellows expands, actuating the lever, which in turn closes the first stage valve, reducing the pressure. If the pressure in the bellows drops, the reverse takes place, building the pressure up to 35 psi, and maintaining the pressure in the bellows chamber at 35 psi, passes through the passage to the demand valve.

When the user inhales he creates a decrease of pressure or a suction in the mask and breathing tube assembly which is connected through "quick-connect" coupling tc the chamber. When the pressure in the chamber is reduced, the outside atmospheric pressure depresses the diaphragm inward, moving the demand valve stem toward its open position. The demand valve then opens, permitting the air or oxygen to flow from the passage and under the diaphragm. Since the area of the diaphragm is large and the spring rate of the demand valve is low, the negative pressure, or suction required for full opening of the demand valve is small. The variation in effort in breathing is not noticeable, regardless of whether the user is at rest or performing violent physical exertion.

The orifice is protected by the inlet screen which has a total area of openings of over 15 times that of the normal orifice opening. This provides adequate protection against any clogging of the orifice which would restrict the flow to less than maximum requirements.

If the first-stage valve sticks in the open position permitting the pressure in the passage to build up beyond 50 psi, the safety valve opens, discharging air or oxygen in a continuous flow, at reduced pressure, directly into the chamber. Under such circumstances the user would be warned that the initial reduction stage had failed. He would receive a continuous flow of air or oxygen to the mask at an increased pressure. He should return to fresh air at once. It is almost impossible for the valve to stick in the closed position because the high pressure is applied to the underside of the valve. This would force the valve open under any conceivable condition.

Should the demand valve stick in the open position the flow of air or oxygen through the restricting orifice would so limit the volume that there would only be a tendency to inflate the mask, and the pressure in the mask would be held at less than three inches of water by the operation of the exhalation valve.

FACEPIECE AND BREATHING TUBE

Two models of facepieces are available for the Scott Air-Pak. Both are full-face, full-vision type. On air or oxygen masks a rubber diaphragm exhalation valve in front of the wearer's mouth permits talking or telephoning. Air or oxygen is inhaled through a corrugated rubber tube connected to a Y-shaped fitting at the bottom of the facepiece. Each branch of the Y leads to the bottom of the eyepiece lenses. The inhaled air or oxygen strikes the lens and clears off any fogging that may occur. The facepiece is held tight to the face by a six-strap headpiece.

The bottom end of the breathing-tube has a quick-connect female coupling which enables the user to connect or disconnect the breathing tube easily and quickly, using his fingers only. When connecting, a sleeve approximately one inch long slides into the regulator orifice and the coupling nut is tightened. It is not necessary to use any tools to tighten the nut as the sleeve prevents the threads being cross-threaded.

HARNESS

The harness is made of a specially treated webbing. The metallic snaps and buckles are treated to reduce sparking.

The harness consists of a back plate under the bottle, two shoulder straps, a chest strap, and a waist strap. At the top of the back plate is a "D" ring for attaching a life-line.

CHARGING ASSEMBLY

The superiority of these types of apparatus over other types of breathing devices is the ability to recharge the bottle when wearing the machine in an irrespirable atmosphere.

At the bottle opening a pressure operated check valve is connected to the "T" fitting; this valve prevents air or oxygen escaping from the bottle when the charging hose assembly is not in use. Connected to this check valve is a neoprene covered high pressure hose about 24 inches long, the free end having the female half of a high pressure self-sealing coupling (the male portion of this coupling has the self-sealing valve in it). This apparatus charging hose assembly is fastened when not in use, to the chest strap on the right side by means of a snap buckle or small strap.

DIRECTIONS FOR OPERATING THE SCOTT AIR-PAK

During normal operation of the apparatus the shut off valve (yellow knob) should be fully opened and locked in position. It is provided to shut off the operation of the demand regulator in the event of damage or failure and should be closed only after the by pass valve has been opened. The emergency by pass valve (red knob) should be fully closed. It is provided for use in case the automatic demand regulator becomes inoperative. When opened it provides a continuous flow of air or oxygen to the facepiece, by-passing the regulator mechanism. If required, the by pass valve should be opened first, by turning counter-clockwise, then the regulator shut off valve should be closed and the flow of air through the by pass valve adjusted to suit the user's requirements. WHEN OPERATING THE VALVES, TURN GENTLY WITH THE FINGERS. DO NOT USE FORCE.

TESTS FOR THE SCOTT AIR-PAK

Similar to all other breathing devices the oxygen or Air-Pak should be frequently tested between periods of actual use (at least once a month) to determine its condition and should always be carefully tested for airtightness and proper working order before it is worn. Any leaks and/or defective parts found during these tests should be adjusted, repaired,or replaced. There is absolutely no excuse for wearing a breathing device that is known to be not working properly or is leaking.

When soapsuds have been used for detection of leaks at connections the parts should be thoroughly cleansed after the test has been completed.

With the exception of the demand regulator, repairs, adjustments or replacement of parts should only be done by a competent person. Any repairs or adjustments necessary to the regulator must only be done by the manufacturer, his agent or by a person authorized to make such repairs.

STATION TESTS

Check the equipment to see if it is complete, paying particular attention to the harness, that no undue weakening has taken place through wear or chafing especially where the webbing passes through the backplate and where the regulator loop fastens over the chest strap.

TESTING BOTTLE

Test for moisture in bottle--After the bottle has been charged, hold it in a vertical position with the valves down. Open the main bottle valve and close it quickly. If water is blown from the valve, it shows that moisture has gathered in the bottle. Accumulations of moisture, sediment, rust, or scale should be removed by taking the valve out of the bottle and cleaning the bottle. This is to be done by experienced persons only.

Test for tightness of bottle valve--To test the main bottle-valve firmly attach a metal cap with the gasket provided for this purpose to the outlet end of the valve under test, making sure that the bottle is fully charged, and open the valve to its fullest extent. Immerse the valve and neck of the bottle in water. Escaping bubbles around the valve stem indicate a leak in the packing gland. Close the main bottle valve, remove the metal cap and again immerse the outlet of the valve in water. Bubbles indicate that the valve is not closed tightly or that it has a defective seat. Any leaks or defective parts found during either test should be repaired or replaced before the bottle is used.

All air bottles, like oxygen bottles, must be re-tested every five years to comply with Board of Transport Commissioners' regulations.

Test for Regulator and Regulator Hose Assembly

With the equipment connected (except facepiece and breathing tube) open the bottle valve and observe the bottle gauge pressure. Observe the pressure of the gauge mounted on the regulator housing. The two gauges should check. Close the main bottle valve. The regulator and regulator hose assembly should hold the trapped pressure. Should a drop in the pressure be shown by the needle of the regulator gauge moving back toward zero, a leak is indicated.

Regulator Shut ·off Valve--Yellow Knob

With the regulator shut-off valve and by-pass valve closed and the main bottle valve open, draw air or oxygen in from the "quick-connect" orifice by inhaling until the regulator gauge is at zero. Then watch the gauge to see if the pressure builds up. If the pressure rises, the regulator shut off valve is leaking.

With the regulator shut off valve and by-pass valve closed and the main bottle valve open, place a soap-bubble across the "quick-connect" fitting on the regulator. If the by pass valve is leaking, the bubble will expand and break.

Charging Hose Assembly

With the main bottle valve in the full opened position remove the safety cap from the end of the charging coupling, immerse the end of the coupling in water. Any bubbles will indicate a leak in the pressure operated self sealing valve. Check the connection by means of a soap and water solution. A leak in the hose may be found by immersing the hose in water when bubbles will indicate a leak.

Facepiece Test

Put on the facepiece and tighten the straps on the head-harness; seal the bottom of the breathing tube with the hand, inhale, and hold the breath as long as possible. Do this several times. If the facepiece or the breathing tube appears to leak, check the fitting on the face and, if the leak is still indicated, locate it or replace the facepiece and the breathing tube with one you know to be in good order.

General Test

Connect the facepiece and plug in the "quick-connect" coupling and tighten the nut with the fingers and thumb; check the regulator performance. Inhale deeply and quickly. The regulator should supply a full flow to give the user, on demand, all the air or oxygen he requires.

If, during slow light inhalation a "honking" or "chattering" sound is heard in the regulator, it can usually be stopped by breathing faster. If the bellows vibrate under any breathing condition, the regulator should be changed and sent to the manufacturer for overhauling.

If the demand valve sticks in the open position, air will continue to flow when the user is not inhaling. This condition can usually be corrected by blowing back into the regulator "quick-connect" opening. Check and re-check the regulator several times before discarding it.

FIELD TESTS

The Field Tests are to be carried out by the user each time the apparatus is worn, before leaving the fresh air base. Check the general condition of the apparatus paying particular attention to the harness.

High Pressure Test

1. Open the main bottle valve and check the bottle gauge and the regulator gauge. The pressure registered on these gauges should correspond.

2. Close the main bottle valve. Watch the needle of the regulator pressure gauge; should the needle move steadily towards zero, a leak is indicated, and should be corrected. (Note--a drop in pressure here of less than 100 pounds in one minute may be ignored.) When satisfied there are no leaks, open the main bottle valve one full turn only.

3. Put the apparatus on your back and adjust it comfortably.

Facepiece Test

Before connecting the breathing tube to the demand regulator, put on the facepiece, adjust it, and inhale and exhale several times. Place the hand on the bottom of the breathing tube and try to inhale. If the user can inhale, the facepiece may not be adjusted properly. Re-check the adjustment and try again. If a leak is still indicated, locate and correct it, or replace the facepiece and breathing tube.

Regulator Test

With the facepiece still on the face, connect the breathing tube to the regulator. Inhale and exhale several times to check the operation of the regulator; open and close the by pass valve to ensure it is working properly.

Remove the facepiece until you are ready to enter the irrespirable atmosphere.

USE OF APPARATUS WITH AIR LINE OR EXTENSION HOSE

The equipment consists of a standard apparatus equipped with an auxiliary connection in the air supply line between the apparatus bottle and the regulator, and cylinders of compressed air equipped with special supply hoses, connections and gauges.

A person may travel in an irrespirable atmosphere, using air or oxygen from the apparatus bottle he is carrying to a place where there is an auxiliary supply of compressed air or oxygen at the fresh air base. Here he may recharge his apparatus bottle from a large cylinder by equalization, or obtain air directly from the large cylinder. A 244-cubic-foot cylinder, at 2 200 psi, will supply the user under normal conditions for a minimum of six hours. A "jumbo" size cylinder, with a capacity of 300 cubic feet at 2,400 psi, will supply the user for a minimum of eight hours.

The complete apparatus with extension-hose assembly consists of one or more large cylinders of air or oxygen at the desired location, with suitable manifolds if necessary; a main large cylinder valve with a "T" connection; an 18-inch high pressure hose connected to one branch of the "T", equipped with a check valve and a quick release coupling; a pressure-reducing regulator equipped with gauges, one showing the cylinder pressure and one showing the reduced or regulated pressure; a high pressure hose of the desired length connected to the low pressure outlet of the regulator, equipped with a check valve and a quick release coupling; a "T" connection and an 18-inch high pressure hose equipped with a check valve and a quick release coupling for insertion into the apparatus air supply tube. Care must be maintained in preventing large cylinders from upsetting.

USES

In non-flammable atmosphere, the wearer may leave the fresh air base with this type of apparatus and, on arriving at the working-place still using the air or oxygen from the apparatus bottle, may re-charge it by connecting the quick release coupling of his apparatus to the coupling on the 18-inch hose from the large cylinder, opening the large-cylinder valve and re-charging the apparatus bottle by equalization until the apparatus gauge shows a pressure of not more than 1,980 psi, then closing the valve of the large cylinder and disconnecting the quick release coupling. If he wishes to use the air from the large cylinder instead of from the apparatus bottle, he should connect the "quick release coupling" on the apparatus to the coupling on the long extension hose, and then open the valve on the large cylinder. The next step is to adjust the regulating valve pressure to 500 psi, and then close the bottle valve. His movements are restricted only by the length of the extension hose.

When the operator is ready to return to the fresh air base he should open the main bottle valve on the apparatus bottle, close the main valve on the large cylinder, disconnect the quick release coupling of the extension hose, and proceed to fresh air.

The MSA Air Mask and MSA Oxygen Mask Model No. 401 which are used on some properties are basically the same, except that the cylinder capacities are 45 cubic feet at approximately 2,000 psi and they weigh about 33 pounds.

COLD WEATHER PROBLEMS

Inasmuch as the majority of open pit mines are in areas having cold winter weather, they have the usual safety problems such as driving on icy roads walking on slippery paths and ice falling from roofs. Most of these dangerous conditions can, with a little effort, be made safe either by using the right equipment to stop slipping or remove the hazard. There are other hazards that may prevail such as avalanches, travel on lake ice and chill effect developed by a combination of wind and low temperatures. These three situations may not exist at every property but at least one will.

Of course, avalanches are more frequent and larger in areas of heavy snowfall, but may occur anywhere provided:

(a) there is snow on an adequate slope (30° -45°) reasonably free of obstructions, such as trees, etc.

(b) the snow has not compacted and its shear strength is minimal.

(c) the snow crystals have, through pressure and/or temperatures approaching freezing, altered to globules of ice, thus developing in effect, a bed of ice marbles on a slope.

(d) there is some agent such as wind, an animal or man to trigger the slide action.

Where avalanches may occur, the safest course of action would be to avoid that area, but this is not always possible to do. If it must be passed, then endeavour to pass by around the bottom of the path or over the top at the head of the slide. If the avalanche path must be crossed, then endeavour to do so in the early morning before the sun melts the night frost and before wind action starts.

If a slide does occur when its path is being crossed, do not expect to outrun it as it has been estimated slides can travel in excess of 100 miles per hour. The Granduc slide in which 26 men lost their lives was estimated to contain 50,000 tons of snow, travelling at 100 miles per hour.

AVALANCHE RESCUE

In Avalanche rescue work there is always the possibility that the rescue party may be exposed to avalanches themselves. For this reason no man should ever travel alone; however, the party should travel so that only one man at a time is exposed to avalanche danger.

The rescue party should stay off the avalanche paths themselves and especially stay out of the fractured zones. The safest route around an avalanche path is over the top by way of the ridges. The next safest route is along the valley floor under the avalanche.

The highest danger exists during or immediately after heavy snowfall or prolonged periods of high wind. If the temperature is low the danger may persist for many days.

It should never be assumed that a slope is safe just because it did not slide when the first man crossed it. Especially in the case of hard slabs and low temperatures, avalanche release may be triggered unexpectedly, even after considerable traffic on the slope. There is one case on record where an avalanche trapped the thirty-third man of a military patrol crossing a dangerous slope.

Lee areas, slopes beneath cornices, and deep drifts, especially those with a convex profile, are especially dangerous.

It should not be assumed that avalanches are confined to open slopes. Dense timbers usually provide good protection, but open or scattered timber stands may not necessarily hold the snow. This is particularly true in the Rocky Mountain regions where depth hoar formation is common in early winter.

Crossing an avalanche slope always involves a certain calculated risk. While it may not be possible to make even a close guess as to whether the slope will slide or not, usually the rescue party can estimate what will happen to them if it does slide while they are in the middle of it. There may be some justification for a calculated risk if the slope is short and not likely to bury the party deeply at the bottom. If the slope is long, funnels into a gully instead of fanning out, falls over cliffs, or would carry a man into rocks or trees at the bottom, the risk of crossing may be more foolhardy than calculated.

Most of the dangerous avalanches originate on slopes between 30° and 45°. If an avalanche slope must be crossed, clothing should be closed up, hat and mitts should be worn and the parka hood should be raised. The chances of survival, if buried in the snow, are much better if the snow does not get inside clothing to cause chill.

An avalanche cord should be worn, tied to each man's belt and trailing out behind, or use the electronic beeper.

Advantage should be taken of natural protection offered by the terrain. Rock outcrops, clumps of trees, or ridges may offer islands of safety in the avalanche path. The route should be laid out between these. When crossing between these islands of safety, only one man should advance at a time.

If a man is caught by an avalanche he should attempt by a swimming motion to stay on the surface. An attempt should be made to work to one side of the moving snow.

If it is impossible to stay on the top of the snow, the man should cover his face with his hands, which will help keep snow out of the nose and mouth and allow a chance to clear a breathing space, if buried. Avalanche snow often becomes very hard as soon as it stops moving.

If buried, the man should try to avoid panic. Many avalanche victims have been recovered dead, apparently uninjured only after a few minutes of burial. The only explanation doctors can offer is that they were frightened to death.

TEN STEPS TO RESCUE BY THE SURVIVOR

1. DO NOT PANIC - the lives of your buried comrades may depend on what you do in the next hour. Check for further slide danger--pick a safe escape route in case of a repeat.

2. MARK LAST SEEN POINT. Mark the point on the avalanche path where the victim was last seen as he was carried down by the snow. This will narrow the area of your search and that of the rescue party. Use a firmly planted pole, or large branch which will not be lost under a subsequent snowfall.

3. QUICK SEARCH. If there are only two or three survivors, they must make a quick but careful search of the avalanche before going for help. If at all possible, one man should be left at the accident scene to continue the search and guide the rescue party.

4. SEARCH SURFACE BELOW LAST SEEN POINT. Search the surface on the avalanche for evidence of the victim or clues to his location. Mark the location of any pieces of his equipment you may find--these may provide additional indicators of the path taken by the flowing snow. Search carefully and kick up

the snow to uncover anything which may lie just beneath the surface.

5. SOLE SURVIVOR. If you are the sole survivor, you must still make a thorough search of the avalanche before going for help. This may seem obvious, but it is a rule all too often neglected. Even the simplest search may enable you to find the victim and free him alive.

6. THOROUGH SEARCH. If a rescue party can be summoned only after several hours or longer, the survivors must concentrate on making as thorough a search as possible with their own resources. The chances of a buried victim being recovered alive diminish rapidly after two hours.

7. PROBING. If the initial search fails, begin probing with a pole, loading stick or collapsible probe below the last seen point. Trees, ledges, benches or other terrain features, which have caught the snow, are most likely places to search. If there are several survivors, probing of likely spots can continue until a rescue party arrives. If you are alone, you will have to decide when to break off the search and seek help, depending on how far away it is.

8. SEND FOR HELP. If there are several survivors, send only two. The remaining survivors must search for the victim in the meantime.

9. GOING FOR HELP. When going for help travel carefully, avoiding avalanche dangers and injuries from trying to ski too fast. The victim's chance of survival depends on your getting through. Mark your route, especially if fresh snow is falling, so you can find your way back. Try to avoid complete exhaustion. The rescue party normally will expect you to guide them back to the accident scene unless its location is absolutely clear.

10. FIRST AID. If the victim is found, treat immediately for suffocation and shock. Free nose and mouth of snow and administer mouth to mouth artificial respiration if necessary. Clean snow from inside clothing and place victim in sleeping bag with head downhill. Any further injuries should then be treated according to standard first aid practices.

THE CONDUCT OF ORGANIZED RESCUE ACTION

If a human being is buried in an avalanche, prompt and organized rescue operations are the only hope of getting the victim out alive. There are records of persons who lived as long as 72 hours while buried. Ordinarily they are either killed instantly by crushing, or die within a short period from exposure, shock and suffocation.

Suffocation is the most important cause. Investigations of a number of avalanche accidents, fatal and not fatal, lead to the conclusion that two hours is the average survival limit. Snow is porous and ordinarily contains enough air to support life, though not consciousness. It appears that in about two hours an icemask, from condensation of the victim's breath, forms an air-proof seal around his face and he then, of course, dies. Rescue operations are, therefore, designed to get the victim out within the two-hour limit. Due to the special circumstances which prolong the life of the victim--he may be in an air pocket--rescue operations must not be abandoned for 24 hours at least.

Successful avalanche rescue operations depend upon trained leadership, man-power and special equipment.

The team leader is in charge of rescue operations; he sounds a general warning and requisitions any needed equipment or volunteers. Experienced skiers who can be available on short notice are an asset to an avalanche rescue. Snowshoes may be required.

Eye witnesses, if available, should be questioned concerning the exact location of the accident. Even if in poor physical condition, any eye witnesses should return to the accident location with the rescue team to point out where the victim was last seen. This is extremely important.

The rescue team should consist of at least three persons and preferably five. It should proceed to the avalanche area as soon as possible. Speed is important.

At the location of the accident, an avalanche guard should be posted in case there are further snow slides.

If possible, the spot where the victim was last seen should be located on the surface and marked with a pole or a branch. From this point downhill, the rescue team should make a hasty search of the slide surface for the victim or any part of his equipment.

If any indication of the victim is found, the vicinity should be probed. If no indication is found, probing should begin in likely locations. These are obstructions in the slide path, such as trees, boulders or transitions, also the top and edges of the slide. A human body is bulky and all other things being equal, is apt to be thrown toward the surface or the sides.

If the victim is found, first aid should be commenced immediately. Unless there is danger of further avalanches, the rescue team should not attempt to have the victim out of the area before treating for shock and suffocation. If the rescue team is unsuccessful in the first quick examination of the avalanche, additional men should be employed to make a thorough search. Probers are spaced shoulder to shoulder and probe every square foot. If a last seen point for the victim is known, a special group probes any section of the strip from this point downhill left by the rescue team.

Shovel crews should accompany the probers, relieving them at intervals and digging in any likely spots.

Systematic probing of any ordinary slide should not take over three or four hours. If this is unsuccessful, the slide must be trenched.

Trenches are dug parallel to the contour down to ground level or undisturbed snow at intervals of six feet. If sectional probes are available the interval can be increased to ten feet. Digging begins at the tip of the slide and proceeds uphill. It is best to space the shovel crews along one trench with frequent reliefs, in this way snow from one trench can be thrown into the one just completed.

If trenching is necessary, the operation ceases to be of emergency type. A constant system of relief crews must be organized.

Regardless of his physical injuries, the victim must be treated first for suffocation and shock. Get the snow out of nose and mouth. Apply mouth-to-mouth artificial respiration if breathing has stopped. Get the victim warm, with body heat if nothing else is available.

Leaders are responsible for the safety of their men. Avalanche guards must be kept on duty if there is the slightest danger of another slide in the same vicinity. Rescuers must know where to go in case of an alarm. If the danger becomes critical, the team leader must not hesitate to call off operations.

In an avalanche area, the following equipment should be available for rescue team:

12 probes. The best probes and easiest to use are of the sectional types. Wooden or plastic loading sticks make good probes. These should be 12' long. Aluminium conduit also makes good probes.
12 snow shovels.
12 cap lamps.
100' of climbing rope.
First aid kit.
Toboggan with blankets.

A dog may be extremely useful in locating an avalanche victim. A well-trained dog is most effective but even an untrained dog will sometimes instinctively join in a search, and for this reason a dog should always be taken with a rescue team if there is one available.

ROCK AND MUD SLIDES

As the members of the rescue team are familiar with the causes of rock and mud slides, these will not be discussed on the course.

A man caught in a rock or mud slide has much less chance of survival than a man caught in an avalanche, but there have been some remarkable examples of victims surviving being buried by rock or mud.

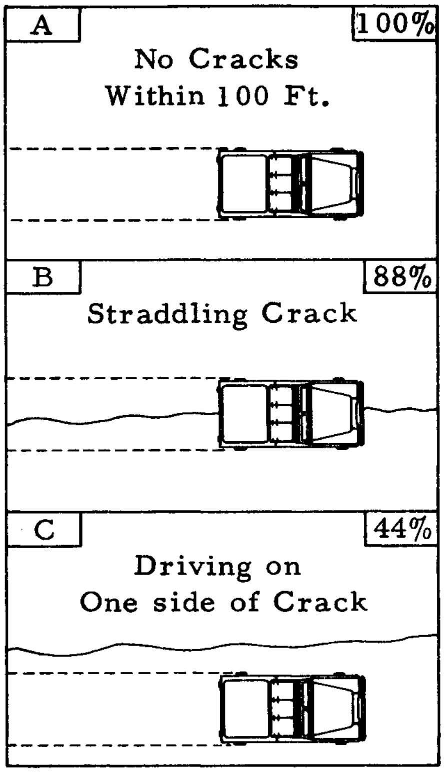
In rescue work, time is vital. The victim must be recovered immediately, if he is not to suffocate.

The search of the slide area should start at the toe and proceed to the edges and the surface. When digging for a victim, great caution must be used in the utilization of power equipment.

As in an avalanche search, a dog may be extremely useful.

ICE TRAVEL

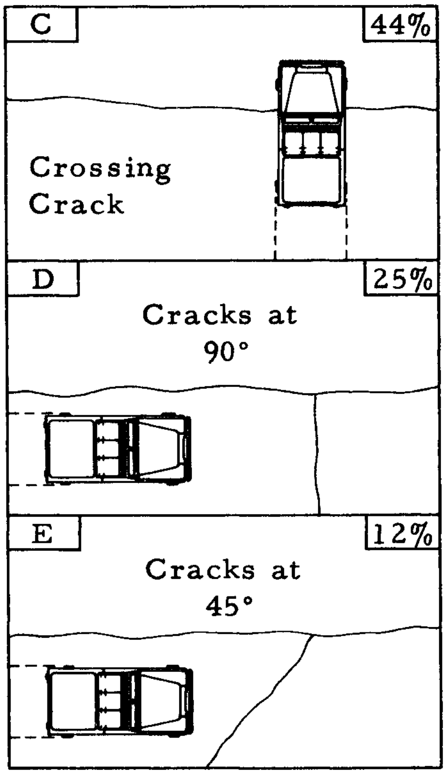
At many mining operations, part of the exploration program is held in abeyance until winter, when freezing conditions have developed sufficient ice to set up diamond drills in order to drill areas



WHAT TO DO IF THE ICE CRACKS UNDER YOU -- SLOW DOWN -- OPEN DOOR -- BE READY TO JUMP.

(A) Several Cracks -- Vehicle standing still: Move it, slowly, in low gear.
(B) Several Cracks -- Vehicle in motion: Slow down to 2 MPH. If cracking continues, head for thicker ice at 2 MPH.
(C) One long Crack -- Straddle crack as in sketch B and keep moving at 2 MPH, following the crack toward the shore.

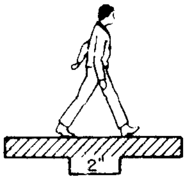
ALWAYS WEAR AN APPROVED LIFE JACKET WHILE WORKING OR DRIVING ON ICE.

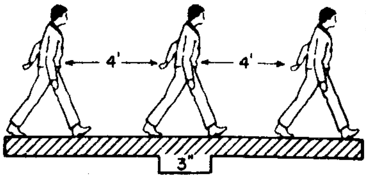


DEPTH OF WATER, FEET	1	2	4	8	16	32	64
MAX. SAFE SPEED, MPH	2	3	5	7	10	14	20

STRENGTH OF ICE

THIS TABLE is for clear, blue ice on lakes. Reduce strength values 15 per cent for clear-blue river ice. Slush ice only has one half the strength of blue ice. This table does not apply for parked loads.



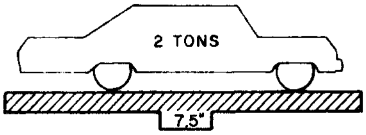


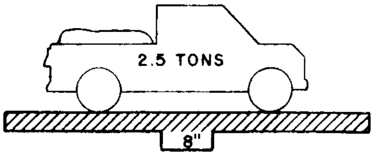
Ice thickness in inches	Permissible Load (clear, blue lake ice)
2	One person on foot
3	Group, in single file (4 feet between)
7 1/2	Passenger car (2 ton gross)
8	Light truck (2 1/2 ton gross)
10	Medium truck (3 1/2 ton gross)
12	Heavy truck (7-8 ton gross)
15	10 tons
20	25 tons
23	45 tons
30	70 tons
36	110 tons

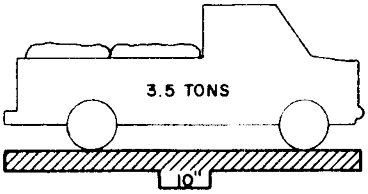
Tractor Weights

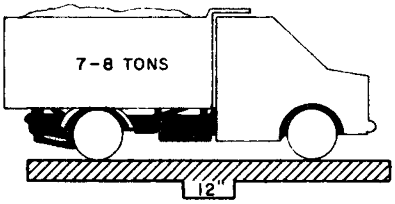
C/W Hyster & Blade

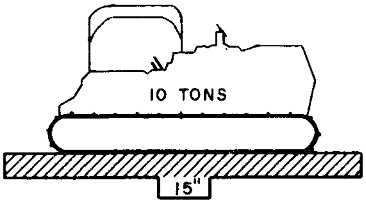
D4 - 10 tons
D_5 - 13 tons
D_6 - 16 tons
D_7 - 23 1/2 tons
D_8 - 33 tons
D_9 - 45 tons

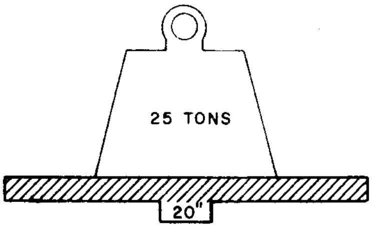


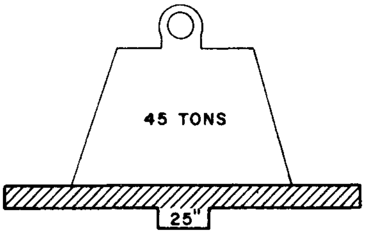


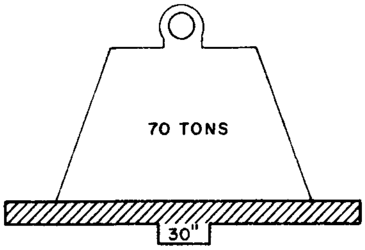


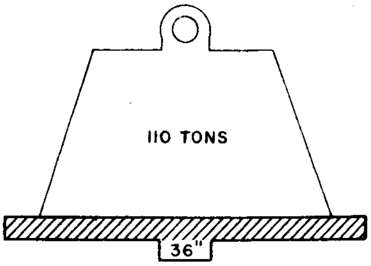












CONTINUOUS TRAVEL WILL FATIGUE ICE AND CAUSE FAILURE
CHANGE ROADS ON ICE LANDING FREQUENTLY

covered by lakes. Elsewhere, exploration programs are held up until the ice is thick enough to take a tractor or other vehicle across lakes to areas inaccessible during the rest of the year.

Before vehicles or any equipment are driven onto the ice, a certain amount of reservations exist as to whether the ice is strong enough. Frequent testing determines the thickness and the attached table will advise if the ice is strong enough to bear the load being taken. The thicknesses are for clear blue ice only. It is said that slush ice has only half the strength of blue ice but this amount will vary according to the extent to which the snow forming the slush has been compacted.

As already stated, the chart indicates the thickness of clear blue ice to support the load. Any cracks in the ice which may have been caused by expansion or loading will reduce the supporting ability of the ice in the vicinity of the cracks. The attached page of vehicle diagrams indicates the ice strength according to the relative directions of the cracks and the rate.

The small block diagram at the foot of the vehicle diagrams indicates the safe travel speed on the ice according to the depth of water under it.

When a load is placed on ice the ice bends downwards towards the load. If the load is capable of motion such as a tractor or truck then dip becomes a wave travelling ahead of the vehicle as it moves. The faster the vehicle moves the angle of dip steepens and will, if the speed becomes excessive, cause a crack and permit the vehicle to break through the ice.

WIND CHILL

Wind chill is a winter phenomenon seldom appreciated when men are working on surface in strong winds and freezing temperatures. As a result, the workmen's efficiency drops, frost bite is frequent and often accompanied by infection. Most operations have one or more thermometers to indicate temperature but very few have an anemometer or wind gauge. This instrument should be standard equipment in order that the supervisor is fully aware of freezing hazards where crews must work exposed to low temperature and wind. With this knowledge, the workmen should be rotated frequently to jobs of lesser exposure and provision made for them to be able to get warmed from time to time while on the job. If frost bite does occur then standard first aid treatment should be given.

The wind chill table should be posted wherever the wind and temperature recorder is mounted.

WIND CHILL INDEX

(EQUIVALENT TEMPERATURE)--Equivalent in cooling power on exposed flesh under calm conditions

TEMP	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
WIND MPH																	
Calm	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	33	27	21	16	12	7	1	-6	-11	-15	-20	-26	-31	-35	-41	-47	-54
10	21	16	9	2	-2	-9	-15	-22	-27	-31	-38	-45	-52	-58	-64	-70	-77
		VERY COLD															
15	16	11	1	-6	-11	-18	-25	-33	-40	-45	-51	-60	-66	-70	-78	-85	-90
				BITTERLY COLD													
20	12	3	-4	-9	-17	-24	-32	-40	-46	-52	-60	-68	-76	-81	-88	-96	-103
						EXTREME COLD											
25	7	0	-7	-15	-22	-29	-37	-45	-52	-58	-67	-75	-83	-89	-96	-104	-112
									EXPOSED FLESH FREEZES								
30	5	-2	-11	-18	-26	-33	-41	-49	-56	-63	-70	-78	-87	-94	-101	-109	-117
35	3	-4	-13	-20	-27	-35	-43	-52	-60	-67	-72	-83	-90	-98	-105	-113	-123
40	1	-4	-15	-22	-29	-36	-45	-54	-62	-69	-76	-87	-94	-101	-107	-116	-126
45	1	-6	-17	-24	-31	-38	-46	-54	-63	-70	-78	-87	-94	-101	-108	-118	-128
50	0	-7	-17	-24	-31	-38	-47	-56	-63	-70	-79	-88	-96	-103	-110	-120	-128

Wind speeds greater than 40 mph have little additional chilling effect
U. S. Army Wind Chill Index

HYPOTHERMIA

COLD KILLS IN TWO DISTINCT STEPS

Step One: Exposure and Exhaustion

The moment your body begins to lose heat faster than it produces it, you are undergoing exposure. Two things happen:

1. You voluntarily exercise to stay warm.
2. Your body makes involuntary adjustments to preserve normal temperatures in the vital organs.

Either response drains your energy reserves. The only way to stop the drain is to reduce the degree of exposure--

THE TIME TO PREVENT HYPOTHERMIA IS DURING THE PERIOD OF EXPOSURE AND GRADUAL EXHAUSTION.

Step Two: Hypothermia

If exposure continues until your energy reserves are exhausted:

1. Cold reaches the brain depriving you of judgment and reasoning power. You will not realize this is happening.
2. You will lose control of your hands.

This is hypothermia. Your internal temperature is sliding downward. Without treatment, this slide leads to stupor, collapse, and death.

YOUR FIRST LINE OF DEFENSE: AVOID EXPOSURE

1. STAY DRY. When clothes get wet, they lose about 90% of their insulating value. Wool loses less; cotton, down, and synthetics lose more.
2. BEWARE THE WIND. A slight breeze carries heat away from bare skin much faster than still air. Wind drives cold air under and through clothing. Wind refrigerates wet clothes by evapourating moisture from the surface. WIND MULTIPLIES THE PROBLEMS OF STAYING DRY.
3. UNDERSTAND COLD. Most hypothermia cases develop in air, temperatures between 30 and 50 degrees (F.).

Most outdoorsmen simply cannot believe such temperatures can be dangerous. They fatally underestimate the danger of being wet at such temperatures.

50 degree water is unbearably cold. The cold that kills is cold water running down neck and legs, cold water held against the body by sopping clothes, cold water flushing body heat from the surface of the clothes.

DO NOT ASK, "HOW COLD IS THE AIR?"
BUT ASK, "HOW COLD IS THE WATER AGAINST MY BODY?"

4. USE YOUR CLOTHES. Put on rain-gear before you get wet. Put on wool clothes before you start shivering.

YOUR SECOND LINE OF DEFENSE: TERMINATE EXPOSURE

If you cannot stay dry and warm under existing weather conditions, using the clothes you have with you, terminate exposure.

1. BE BRAVE ENOUGH TO GIVE UP REACHING THE PEAK OR GETTING THE FISH OR WHATEVER YOU HAD IN MIND.
2. Get out of the wind and rain. Build a fire. Concentrate on making your camp or bivouac as secure and comfortable as possible.

NEVER IGNORE SHIVERING

Persistent or violent shivering is clear warning that you are on the verge of hypothermia. MAKE CAMP.

FORESTALL EXHAUSTION

Make camp while you still have a reserve of energy. Allow for the fact that exposure greatly reduces your normal endurance.

You may think you are doing fine when the fact that you are exercising is the only thing preventing your going into hypothermia. If exhaustion forces you to stop, however briefly:

1. Your rate of body heat production instantly drops by 50% or more.
2. Violent, incapacitating shivering may begin immediately.
3. You may slip into hypothermia in a matter of minutes.

APPOINT A FOUL WEATHER LEADER

Make the best-protected member of your party responsible for calling a halt before the least-protected member becomes exhausted or goes into violent shivering.

YOUR THIRD LINE OF DEFENSE: DETECT HYPOTHERMIA

If your party is exposed to wind, cold and wet, THINK HYPOTHERMIA. WATCH yourself and others for symptoms:

1. Uncontrollable fits of shivering.
2. Vague, slow, slurred speech.
3. Memory lapses, incoherence.
4. Immobile, fumbling hands.
5. Frequent stumbling. Lurching gait.
6. Drowsiness (to sleep is to die).
7. Apparent exhaustion. Inability to get up after a rest.

YOUR FOURTH AND LAST LINE OF DEFENSE: TREATMENT

The victim may deny he is in trouble. Believe the symptoms, not the patient. Even mild symptoms demand immediate, drastic treatment.

1. Get the victim out of the wind and rain.
2. Strip off all wet clothes.
3. If the patient is only mildly impaired:
   a. Give him warm drinks
   b. Get him into dry clothes and a warm sleeping bag. Well-wrapped warm (not hot) rocks or canteens will hasten recovery.
4. If the patient is semi-conscious or worse:
   a. Try to keep him awake. Give him warm drinks.
   b. Leave him stripped. Put him in sleeping bag with another person (also stripped). If you have a double bag, put the victim between two warmth donors. Skin to skin contact is the most effective treatment.
5. Build a fire to warm the camp.

THINK HYPOTHERMIA

If you are outdoors for recreation, you presumably do not intend to jeopardize your life.

Hypothermia may be a new word to you, but it is the only word that describes the rapid, progressive mental and physical collapse accompanying the chilling of the inner core of the human body.

Hypothermia is caused by exposure to cold, aggravated by wetness, wind, and exhaustion. It is the number one killer of outdoor recreationists.

TAKE HEED OF "HYPOTHERMIA WEATHER."

WATCH CAREFULLY FOR WARNING SYMPTOMS.

CHOOSE EQUIPMENT WITH HYPOTHERMIA IN MIND.

THINK HYPOTHERMIA!

HOW LONG CAN YOU SURVIVE?

An important side benefit of cold water research was the development of an uncomplicated method of restoring body heat to people who have suffered a severe loss.

It was found that it was better to keep clothing on, even shoes, hat and gloves, in cold water because it acts as insulation. This assumes that flotation is not a problem.

In rewarming a person's body, the traditional method is to immerse the subject in hot water. But this has its dangers.

Inner body temperature continues to drop even after a person has been removed from the cold.

A hot bath warms the surface of the body and sends cold blood coursing through the vital organs. To a heart already threatened by cold, this could be the fatal strain.

Hayward and his fellow scientists developed a new technique. They found that a portable apparatus much like a bedroom vapourizer can be used to administer heated, moistened air to the rescued person. In this way heat is delivered to the places where he needs it most--the heart, lungs and brain.

When this method was used, subjects' temperatures began climbing after only minimal afterdrops were recorded in eardrums and rectal temperature probes.

Unconsciousness can occur when deep-body temperature falls to about 90 degrees Fahrenheit (32 Celsius) and heart failure is the usual cause of death when the body "core" cools to about 85°F (30°C) or below.

Survival time is increased by extra body fat, decreased by small body size.

It is better to stay still in cold water, if flotation is not a problem, because swimming increases cooling by more than one-third.

Treading water speeds up cooling by 34 per cent but drown-proofing cools the body 82 per cent faster because of heat loss through the head when it is immersed in water.

Drown-proofing works well in warm water. As with treading water, it is a way of staying afloat. It involves floating with the lungs full of air and the heat just below the water. About every 15 seconds the person raises the head to take a deep breath.

By floating in a foetal position with the arms tight against the sides of the chest, and with thighs raised to preserve heat in the groin, cooling is retarded and predicted survival time increases about 50 per cent.

The same effect can be achieved by two or more people huddling together with the sides of their chests held close together.

Although it was believed you could survive only about 30 minutes in water at a temperature of 10 degrees C, the team found that the average-sized male could last 2 1/2 to 3 hours before his heart fails from a body temperature dropping from 38 degrees C to 30.

Most women have slightly more fat than men, but they cool about 15 per cent more quickly because of their smaller size. And children cool even more quickly than women. Alcohol does not retard body cooling. It increases the rate by about 20 per cent.

In water 10 degrees C the average person swimming in a life jacket cools 35 per cent faster than when staying still, and would probably be overcome by hypothermia after swimming less than a mile. Conclusion: Do not try to swim ashore if you are more than three-quarters of a mile from land.

VEHICLES AND DUMPS

In the introductory remarks made at the commencement of this course, attention was drawn to the very large number of fatalities and reported dangerous occurrences involving the use of vehicles. When the fatalities caused by vehicles capsizing are added to those where people have been struck by a vehicle, the total is 29 out of the 54 fatalities, which occurred in the open pits and quarries of this province during the past 20 years. When the dangerous occurrences involving the same situations are added together, the total is 47. In other words, more than one out of every three vehicular accidents has resulted in a fatality.

When the causes of these accidents are analyzed, it would appear that the majority could have been avoided by due consideration having been given to the following items:

(1) Adequate training of drivers.
(2) Improved location, construction and maintenance of roads.
(3) Adequate design and maintenance of vehicles.
(4) Proper dumping procedures.

The first two items are those administered by management, who should ensure that all drivers receive adequate instruction and that all roads are adequately constructed and maintained to minimize loss of life and equipment.

Because many accidents have resulted from inadequate brakes on vehicles, this department has recommended legislation to require any vehicle operating in and around mines be equipped with an adequate braking system capable of stopping and holding the vehicle on any grade that the vehicle, when loaded, is capable of climbing.

Proper dumping procedures involve the location, development and daily operating procedures. This last item involves such details as the use of a dumpman, brow logs, berms, bulldozer, etc. When establishing and operating any dump for either waste or ore, due consideration should be made to the following features:

(1) Do not locate the dump immediately above a highway, railway, water course or dwelling where any subsequent movement of the dump material would endanger these locations.
(2) Determine if the dump base will support the fill without failure.

(3) Divert and keep all water diverted from the dump.
(4) Do not dump into any natural drainage course.
(5) In areas of heavy snowfall, dump at the steepest point during the snow period and when spring thawing starts, dump in the areas of least snow depth. This practice will avoid sudden settling or slumping.
(6) Develop and maintain, through daily checks, a safe dump and safe dumping operational procedures.

RESCUE FROM VEHICLES

INTRODUCTION

This paper will offer suggestions for the handling of casualties in the event of road accidents due to collision or vehicles that have left the roadway because of skids and the like. No attempt will be made to describe in detail First Aid measures that may be required in such accident situations, however, the immediate problem is one of preserving life and a thorough knowledge of First Aid is essential to all those who undertake such rescue missions.

RECONNAISSANCE

It is essential to the success of the mission that the rescue team leader make a rapid summation of the rescue problem in order that it may be tackled in an efficient manner.

PRIORITIES

The following is a suggested order of priorities:

A. Team Safety.
B. Check stability of vehicle.
C. Approach vehicle from a safe angle, care should be taken not to disturb vehicle if precariously balanced.
D. Anchor vehicle.
E. Further danger to the victims due to spilled fuel, fire or leaking batteries.
F. Condition of the victims, check for excessive bleeding and absence of breathing.
G. Ascertain if further assistance is required: cutting gear, wreckers to pull vehicles apart, ambulance, etc.
H. Methods of extracting victims and decide order of evacuation according to seriousness of injuries, and type of vehicle, e.g. Pick-up, 100-Ton, 200-Ton Truck.
I. General First Aid.

REMOVAL DANGERS

A. Use wheel blocks.
B. Control traffic-set out reflector or flares.
C. Spilled fuel or a leaking tank may be extremely

hazardous. Gasoline vapours are heavier than air and will collect in hollows or flow to lower ground but are easily blown about by the wind. An explosive mixture may be set off by:

  i. Steel clad boots striking a spark from a stone.
  ii. Cigarette butts carelessly dropped into the vapour.
  iii. Electrical circuits in the car.
  iv. Hot engine parts.

D. Disconnect and remove battery, if possible. This action will eliminate the making of accidental sparks in any part of the car electrical circuitry.

FRACTURES

If there is any doubt in the mind of the senior first aid attendant that necks or backs may be dislocated or broken, then the victim must be treated as though the spinal column is fractured and a "fracture board" must be used to handle the patient. The rescue vehicle should carry a half length fracture board and a complete one as well, also a "cervical collar" for a broken neck.

Fracture Board

This stretcher is made from 3/4" plywood and should be 6'6" by 20" with hand holes round the sides and straps attached to it for tieing the patient in position. It has been found that where a whole board cannot be used due to confined space, a half board is a necessary first step. The patient's head, chest and hips are held firmly to the board by straps and the patient can then be manoeuvered out of the vehicle and onto the whole board for moving to hospital (both boards together). The stretchers need plenty of padding correctly distributed.

Splints

Where broken bones occur, they must be correctly splinted before the victim is moved.

REMOVAL FROM DRIVER'S SEAT

After completing all possible first aid, then:

a. Slide the seat back as far as possible.
b. One man gets into back of car behind victim,

passes his arms under victim's shoulders, crosses his forearms, and hold wrists.

c. Second man at side of car holds stretcher board ready and passes it under victim as first man lifts him clear of the seat.
d. Third man at opposite side of car helps to slide victim lengthwise onto board for removal.

REMOVAL FROM UNDER DASHBOARD

Four men required.

a. First aid is applied.
b. Back board placed on front seat on edge against the back.
c. First man supports victim's head, controlling it through manoeuver.
d. At signal from leader, victim is gently raised keeping back and hips against front seat and up and over to a position so that the victim is lying on the seat on his side. Care must be taken to ensure that the victim is kept held in contact (therefore in a straight line) with the board which is then turned so that it lies flat on the seat, then removed.

REMOVAL FROM BACK OF CAR

After a car accident, sometimes a victim is found lying between the back seat and the back of the front seat on the floor, render first aid, then:

a. If possible, remove the back seat.
b. Two men lean over back of front seat and grasp victim by his clothes at the shoulder, chest, waist, and thigh; two more men must control the head and legs.
c. A stretcher board is placed on the floor or on the seat if this has not been removed.
d. Carefully log roll the victim onto the board if on the floor, or raise him onto the board at seat level with every precaution and remove.

GAINING ACCESS

Where vehicles are so damaged that means of access must be made by an emergency method, the following alternatives are suggested:

a. Removing the wind screen or back window.
b. Forcing open the trunk and removing the barriers of metal and upholstery.
c. Cutting through the bottom or top of the passenger space, or cutting away the doors.

Oxy-Acetylene Cutting

This method is rapid and effective but fraught with dangers.

i. The head of the cutting flame produces fumes from the paint, oil, grease, and upholstery in the car. The roof lining and upholstering catches fire.
ii. The cutting operation can only be carried out if the trapped victims are protected from the sparks and cutting flame with asbestos blankets.

Carbon dioxide extinguishers cannot be used to control any fire that may be caused as the gas will displace air in the passenger space and does not support life. Only dry chemical extinguishers should be used, and then only with care.

Other Cutting Devices

A car body cutter (like a large can opener) can be used quickly and effectively without the dangers outlined above, but is only good for thin sheet metal.

A wheel saw is also effective and the sparks given off are not so hot as with gas cutting, but may ignite gasoline fumes.

CONCLUDING REMARKS

Vehicle accidents where persons are injured have problems that are nearly always unique and so varied that no description could cover all circumstances. The few suggestions below lay down some principles to be followed, namely:

A. Check, approach and stability of vehicle.
B. Restore breathing if not present.

C. Control bleeding.
D. Treat fractures.
E. If fire is present, victims must be removed to a safe distance immediately, regardless of their injuries.

Practice with a vehicle is essential. "Victims" should be removed from all types of vehicles used on a property.

Casualty simulation of the "victim" or "victims" will provide more realism and better training.

SPINE BOARDS

Spine boards are of great value in extricating all types of injured, particularly the most frequently mishandled injury, fracture of the spine with actual or impending damage to the cord.

The spine board is ideal for the victim with such an injury, but once again, preparation of this patient so that he can be removed is a step-by-step procedure.

A sitting victim with cervical injury, for example, is secured to the short spine board and then removed. The collar is applied first. This is fashioned easily from two or more universal dressings, folded lengthwise and held in place by safety pins or soft roller dressings. The short board then is slid behind the patient on an angle and positioned. As the board is waxed, it slides easily. The victim's head then is secured to the board by using the headband and chin strap. A neck roll may be necessary in some cases to allow fixation in the optimum position.

Next the victim is secured to the board. Two nine-foot long straps are passed through the upper handholds, behind the board, out the lower handholds and around the thigh from outside to inside, and finally under and over the thigh to the chest buckle, staying as high as possible in the groin. The injured and the board are now a unit.

The victim then is turned in the seat so that he faces the side of the car, and his feet and legs are outside. If his leg is fractured, the legs are tied together with triangular bandages before the victim is turned. Three ties are sufficient--a figure eight about the foot and ankle and ties below and above the knee.

Once the victim is turned, his legs will be accessible, allowing definitive splinting with blanket rolls, padded boards or inflatable splints.

If the victim is small so that two average men can lift him, he then is lifted out of the car. Each attendant uses the upper handhold on the board and passes his forearm under the buttocks of the victim and grasps the other attendant's hand. They place the victim, his thighs still flexed in the straps, on a litter or stretcher. The straps then are released and used to secure the victim, still on the short board, to the litter or stretcher.

The victim is taken to the hospital on the board, which should be removed only by a physician.

If the victim is too large to be lifted out, then he may be removed as a unit on the long board. First, he is secured to the short board, placed flat on the seat and the long board is pushed beneath him and the short board. The victim then can be lifted out on the long board, and he should remain on it, secured by straps. Straps are passed easily through the handholds or strap holes as the board has one-inch half rounds on its underside.

Removal of many victims, even though they may have no evidence of spine injury, is easier with the long board, instead of pulling, tugging, and lifting them out. This patient may be turned and slid onto the board, or the board may be pushed under him.

One of the most difficult to remove is the victim who has been thrown on the floor between the front and rear seats. Here again the long board is valuable. Being beveled and waxed, the board can be pushed under the injured by attendants at both sides of vehicle.

The first step towards removal of such a victim is to obtain more space by lifting out the back seat. The victim is then examined and given whatever care is necessary at this point.

The long board is positioned under the victim's shoulders and head, and guided from foot end, he is then placed onto the long board.

An ejected victim suspected of having spine injuries traditionally is lifted by blanket lift, by three-, four- or six-men lift and placed on litter, face up or face down. It is common practice that after such a patient is hospitalized he is turned on his side if necessary for examination.

Using the long board, the same method of turning is valuable at the accident scene, and the victim will not sag. By grasping the victim's clothing, attendants can turn him part way, place the long board alongside of him, and turn him back on the board. The straps are passed across the victim, fastened, and he is ready for transport.

Usually the ejected victim is out in the open, but on occasion he is found under the vehicle and he can be extricated with relative ease with the long board.

Use of the long and short spine boards definitely lessens the potential damage to the victim, especially one with an injured spine, and makes difficult tasks relatively easy.

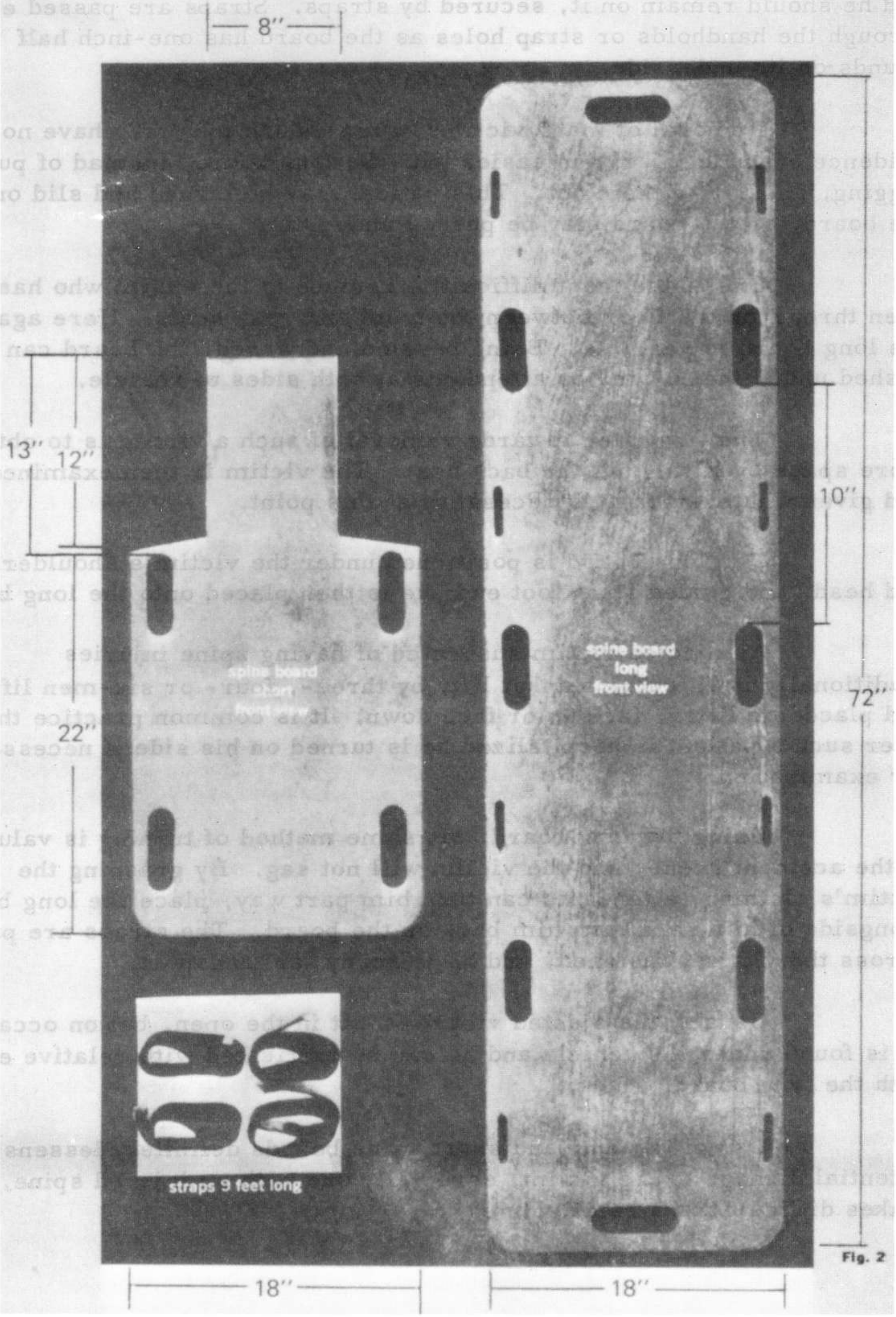

8″
13″
12″
22″
spine board
short
front view
straps 9 feet long
spine board
long
front view
10″
72″
18″
18″

Fig. 2

THE RESCUE DRUM

The Rescue Drum is to assist in the rescue of persons trapped by sand, gravel or similar material in hoppers, bunkers or stock piles.

Around mines and gravel pits where the materials mentioned above are stored in hoppers, bunkers or stock-piled and extracted from the bottom, there is the danger of persons being trapped by falling into the draw point, or the sudden collapse of material due to hang up of material.

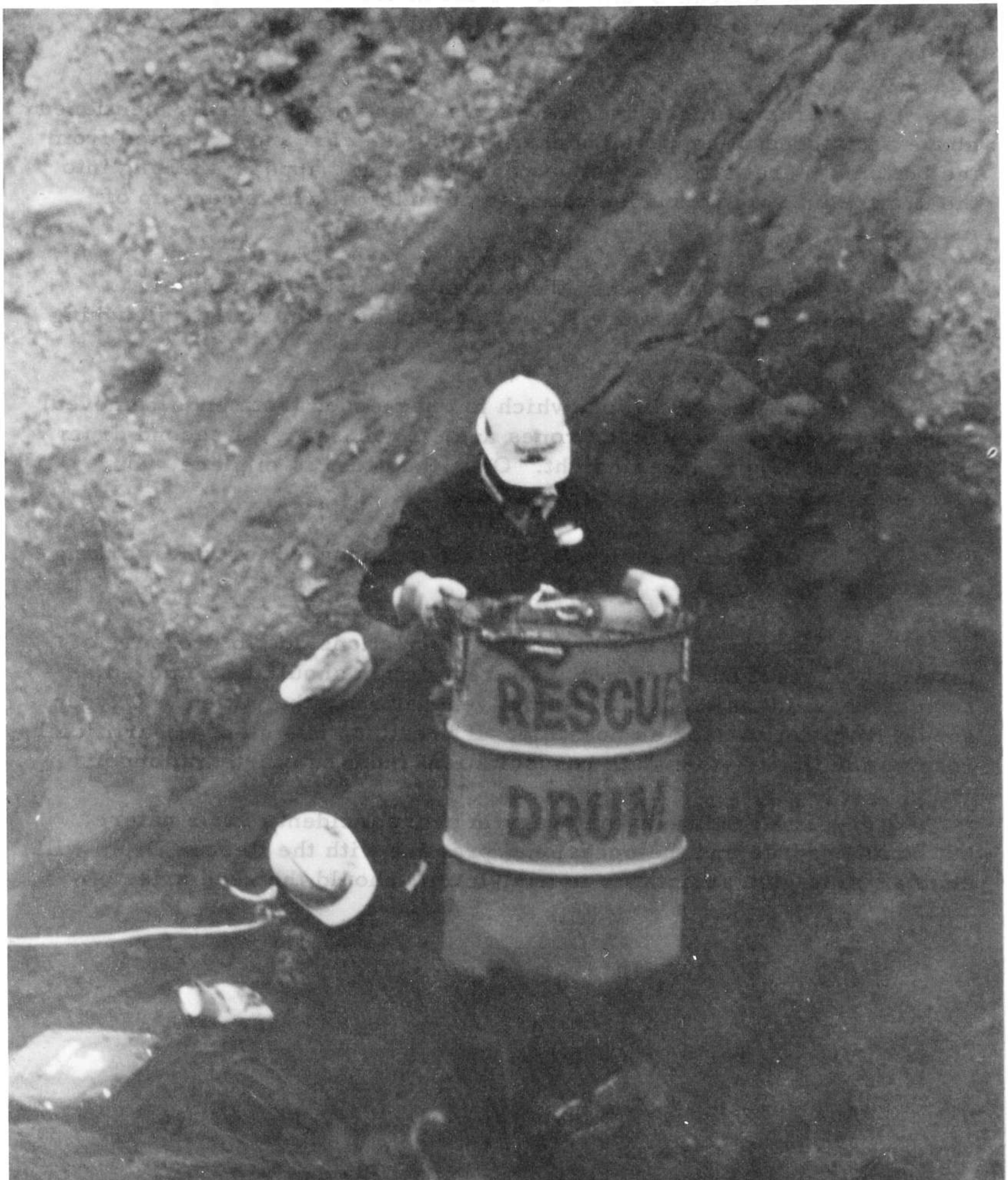
When this happens, the victim may not be completely covered by the material and will need protection from further sloughing while being rescued.

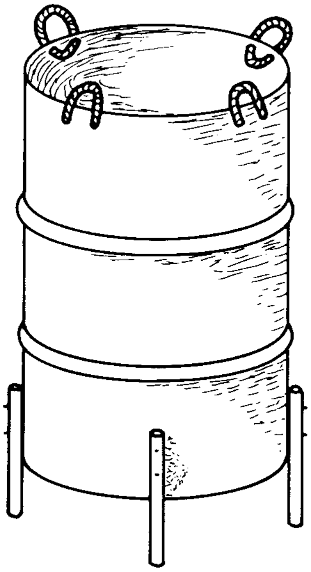
The Rescue Drum, which is open-ended (both ends removed) can be lowered over victim by ropes and, if necessary, a second drum may be added to give more height. Once the drum is in place, you should make sure it is as secure as possible.

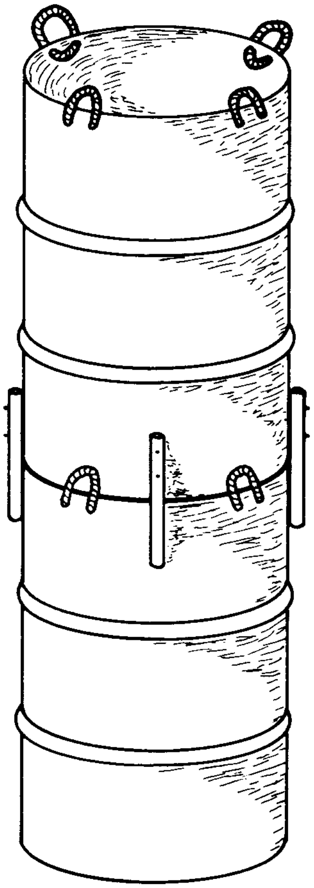
The sides may now be blocked or sloughed for safe working conditions.

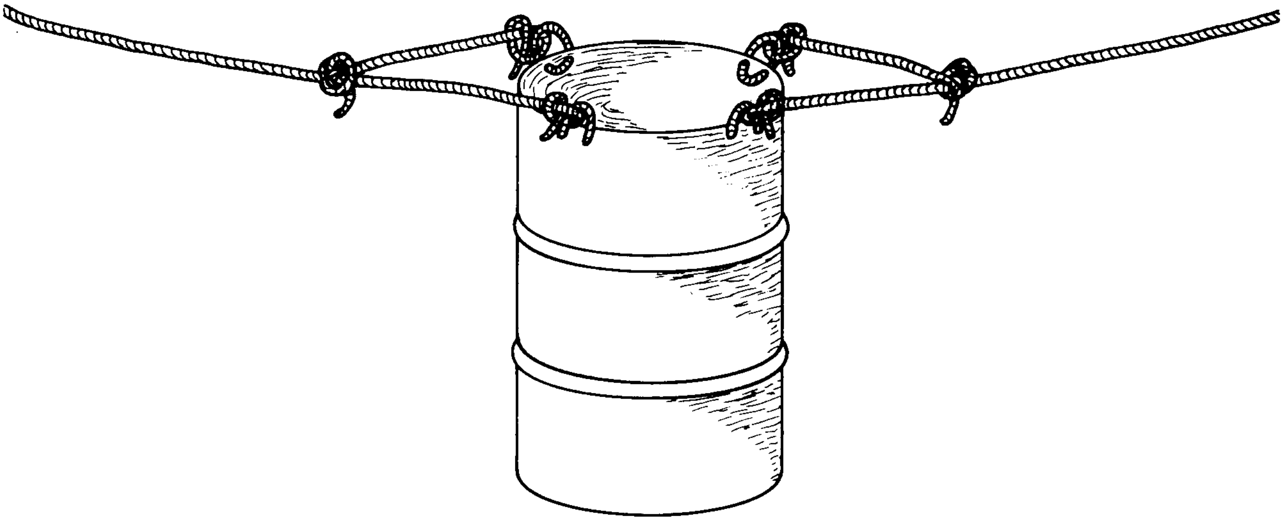
If the victim has breathing restrictions due to pressure of material on chest and abdomen, this restriction should be removed as soon as possible as this will restrict ventilation to the patient. Oxygen should be given as soon as possible. If breathing has stopped, artificial respiration (mouth-to-mouth resuscitation) must be started at once.

The conditions may vary in every incident of this nature, but commonsense and the occasional practice with the Rescue Drum will enable you to give assistance to any victim, should the need arise.


RESCUE
DRUM







FIBRE ROPES

Rope is used to rescue persons from trapped areas and is one of the most important pieces of equipment in such operations. Therefore a solid knowledge of its characteristics and thorough training in its care and handling are essential.

They are used in many ways to release victims from trapped areas and to move heavy objects.

Fibre ropes are made up a number of fibres of manila, sisal or hemp, or other plant, animal or synthetic material spun into yarns. The yarns are then twisted into strands, and three or more strands are twisted into a rope.

STRENGTH OF FIBRE ROPES

The strength is governed by the size (diameter), condition, and by the care in which it is used. The greater the diameter, the greater the (stress) load. (Check S.W.L.).

SIZE AND USES

There are 3 sizes used in rescue work: 1/2" - 3/4" - 1"

1/2" rope is used for Lashing and Guy lines.
3/4" rope is used for life saving from upper or lower levels and guy lines.
1" rope is used for moving heavy material and lifting devices, and also as Life Saving lines in certain circumstances.

SAFE WORKING LOAD (S.W.L.) OF FIBRE ROPES

The Safe Working Load is established in order to ensure a wide safety margin for both rescue workers and casualties in all circumstances. Federal specifications have established the safe working load as being 1/5 the minumum breaking strength. The breaking strength is determined by taking several breaking tests on the rope.

$$\text{S.W.L.} = \frac{\text{Min. breaking strength}}{5}$$

Example: (a) To determine the S. W. L. of a 1" diameter manila rope with a minumum breaking strength of 9,000 pounds:-

$$\frac{9{,}000 \text{ lbs.}}{5} = 1{,}800 \text{ lbs. S.W.L.}$$

(b) 3/4" manila rope with minumum breaking strength of 5,400 pounds:-

$$\text{S.W.L.} = \frac{5{,}400}{5} = 1{,}080 \text{ lbs.}$$

(c) 1/2" manila rope with minumum breaking strength of 2,650 pounds:-

$$\text{S.W.L.} = \frac{2{,}650}{5} = 530 \text{ lbs.}$$

Ropes used in pulley blocks should have a diameter not less than 1/8th the diameter of the pulley block, i.e. an 8-inch diameter block should be supplied with a rope one inch in diameter.

A splice reduces the strength of a rope to 90% of its normal strength.

A knot reduces the strength of a rope to 50% of its normal strength.

Wire ropes are approximately 9 times as strong as fibre ropes of the same diameter.

DO'S AND DON'T'S IN USE OF ROPES

Don't pull ropes over rough edges.
Don't use Blocks or Pulleys of too small diameter.
Don't pull a rope around a sharp bend.
Don't drag a rope along the ground when not necessary.
Don't kink a rope.
Don't keep same running position of rope on block, etc.
Don't allow a rope to come to a sudden stop or jerk.
Rope strength is weakened if it is <u>wet</u> - <u>knotted</u> - treated with oil, tar, etc.
Don't pile your rope in a heap, coil clockwise and avoid kinks.
Dry your rope out before storing away (if wet) and clean same.

Hang your rope up when storing away.
Coil and hang your rope on wooden racks or pegs.
Keep ropes stored away from strong sunlight.
Store ropes in dry, normal temperatures.
Chemical wastes will destroy or weaken your ropes.
New ropes should be stretched before put into service.

WIRE ROPE

Safe Load in Pounds for New Improved Plow Steel Hoisting Ropes-
6 Strands of 19 Wires, Hemp Centre - based on a safety factor of 5/1

Diameter in Inches	Weight per Foot in Pounds	Safe Load Pounds	Diameter in Inches	Weight per Foot in Pounds	Safe Load Pounds
1/4	0.10	1,100	1	1.60	16,000
5/16	0.16	1,800	1-1/8	2.03	21,200
3/8	0.23	2,500	1-1/4	2.50	26,000
7/16	0.31	3,300	1-3/8	3.03	31,400
1/2	0.40	4,300	1-1/2	3.60	37,000
9/16	0.51	5,400	1-5/8	4.23	43,200
5/8	0.63	6,600	1-3/4	4.90	49,600
3/4	0.90	9,400	1-7/8	5.63	56,800
7/8	1.23	12,800	2	6.40	64,400

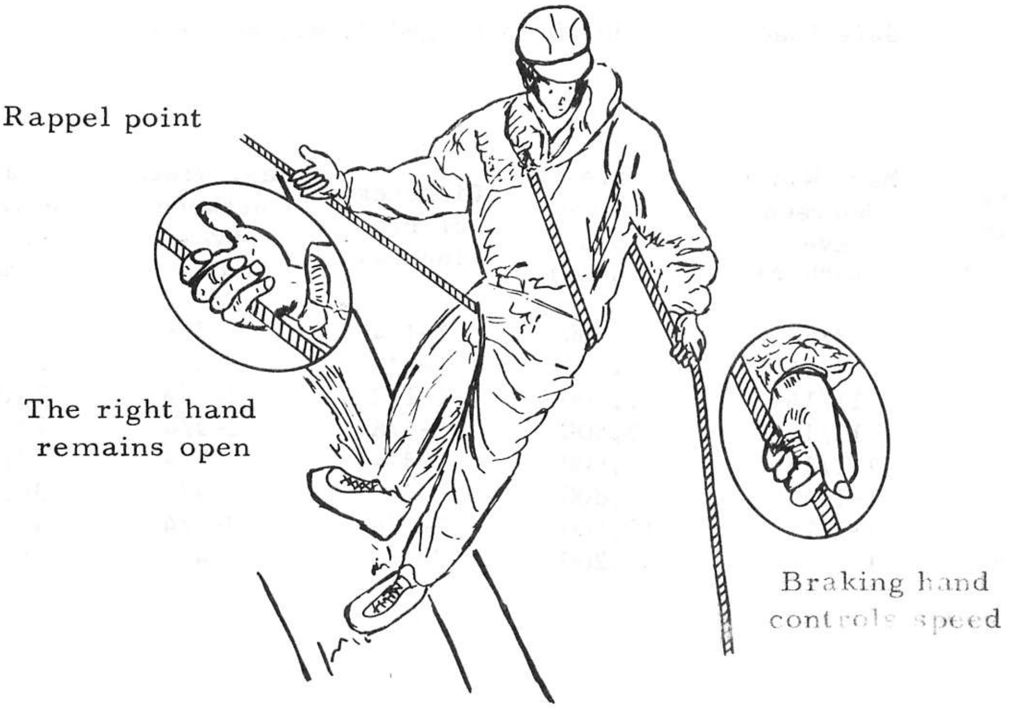
SHACKLE OR CLEVIS

Safe Load in Pounds, Drop Forged Steel, Weldless

Diameter of Pin (Inches)	Max. Width Between Eyes (Inches)	Safe Working Load (Pounds)	Diameter of Pin (Inches)	Max. Width Between Eyes (Inches)	Safe Working Load (Pounds)
1/4	3/8	560	1-1/4	1-7/8	16,000
3/8	9/16	1,400	1-3/8	2	20,000
1/2	11/16	2,700	1-1/2	2-1/8	24,000
5/8	13/16	3,600	1-5/8	2-1/4	28,000
3/4	1-1/16	5,600	1-3/4	2-3/4	32,000
7/8	1-1/4	7,800	2	2-3/4	36,000
1	1-1/2	10,400	2-1/4	3-1/4	46,000
1-1/8	1-5/8	13,200	2-1/2	4	56,000

RAPPELLING

Several rappelling techniques may be used; only the body rappel is given here: The climber should face the rappel point and straddle the rope. From the rappel point the rope goes between the legs, under the left buttock, up and in front of the left hip, across in front of the chest, over the right shoulder, and across the back to the left, or braking hand. The right hand grasps the rope running to the rappel point at about shoulder height. It is used only to steady the body and hold it in the desired position. Trying to support the weight with the right hand will result in a rope burn. The left hand can be held to the rear wherever comfortable, so long as the arm is nearly straight. Friction can be increased if the hand is moved forward, reduced if moved backward. Control of speed will be learned more easily, however, if the hand itself is used as a brake. The climber then leans away from the rock just far enough for his feet to hold, with his weight supported by the rope, and descends slowly, leading with the left leg to make certain that the rope stays in place. He soon learns to rappel in longer and longer bounds, and to use insulation against heat on the shoulder and under the buttock.



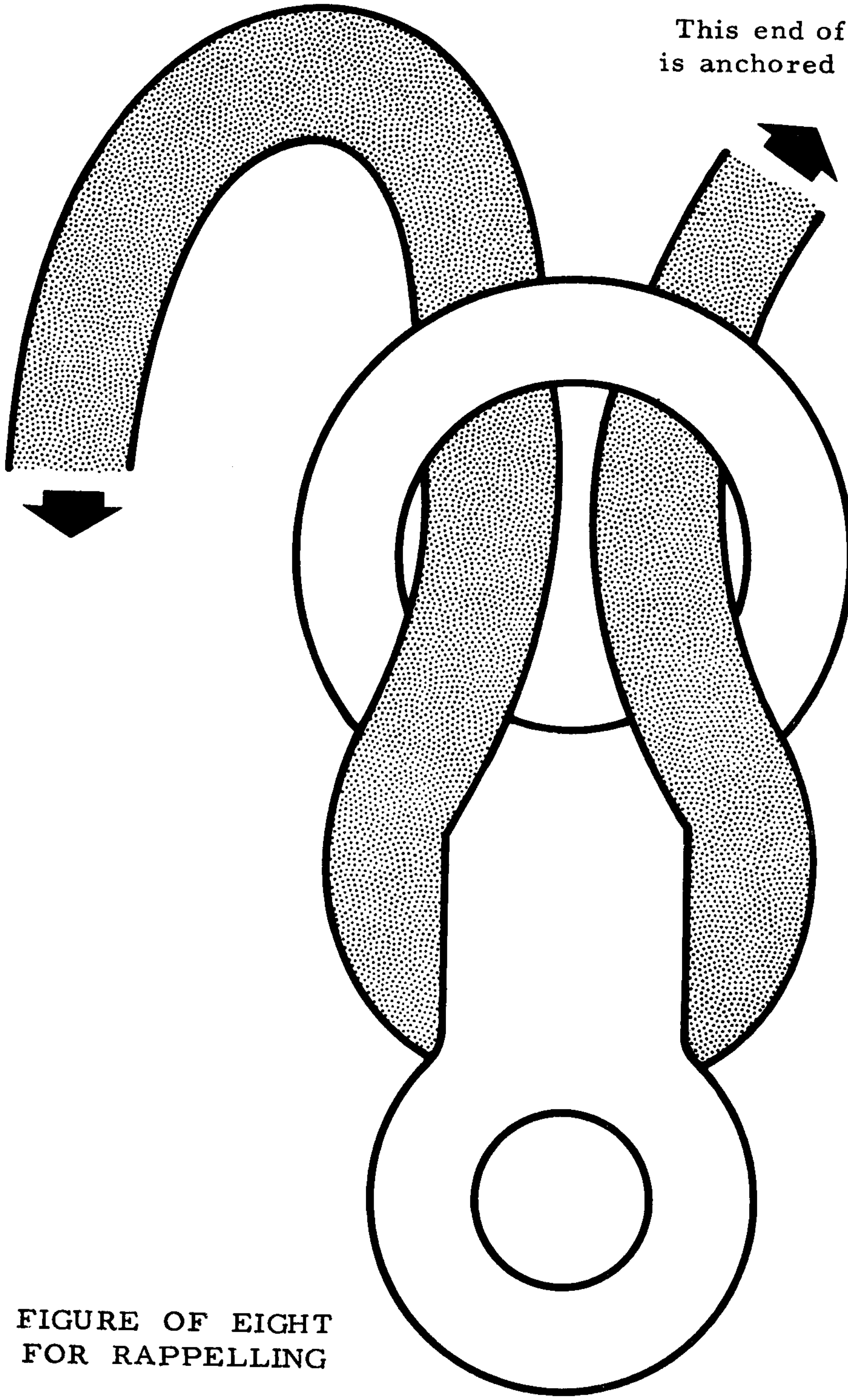
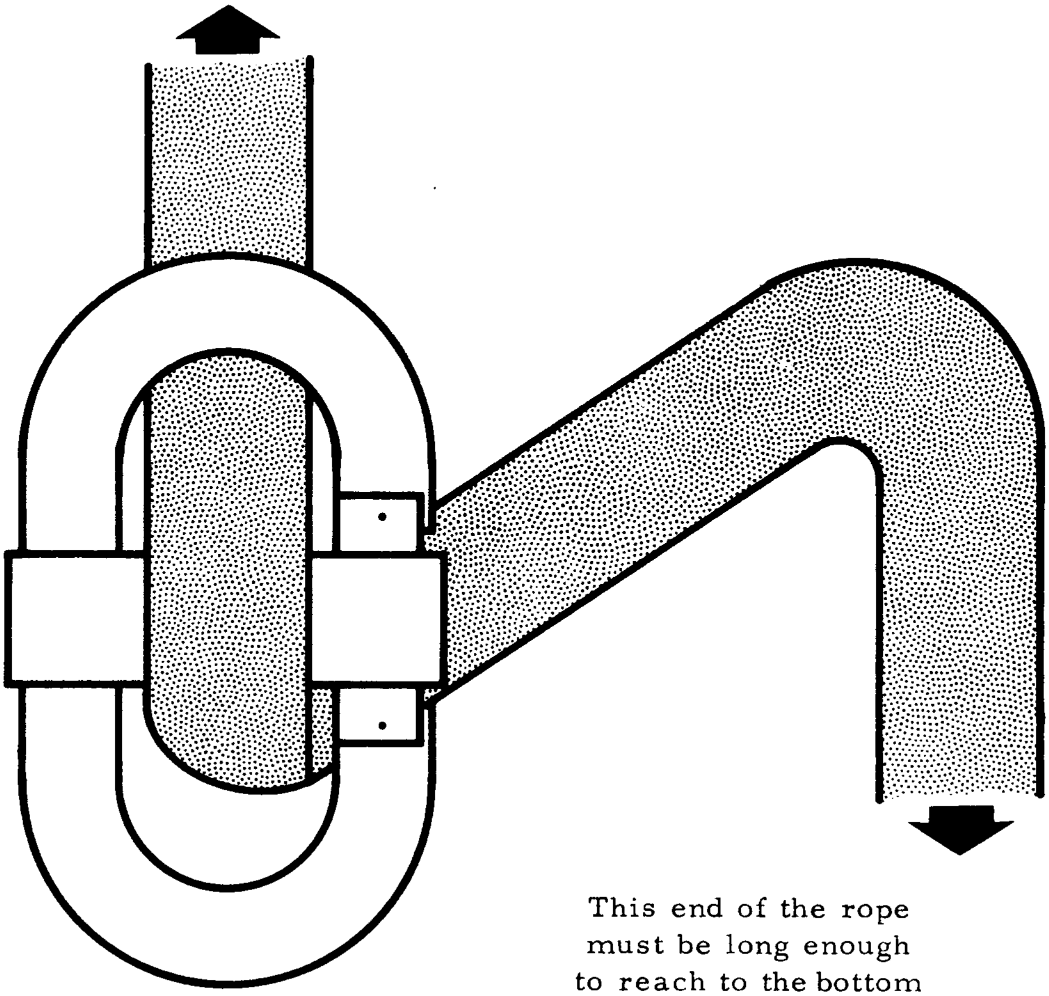


FIGURE OF EIGHT
FOR RAPPELLING

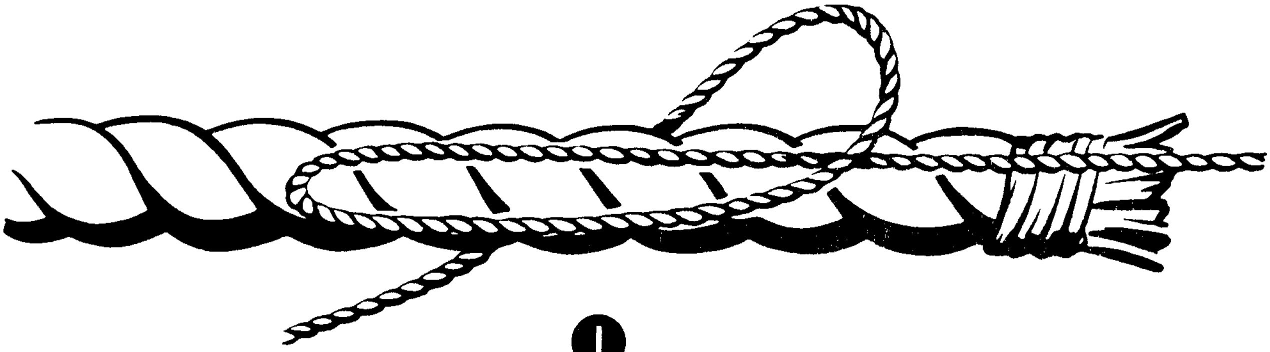


This end of the rope
is anchored at the top

This end of the rope
must be long enough
to reach to the bottom

BAR-KARABINAR
FOR RAPPELLING

WHIPPING ENDS OF A ROPE



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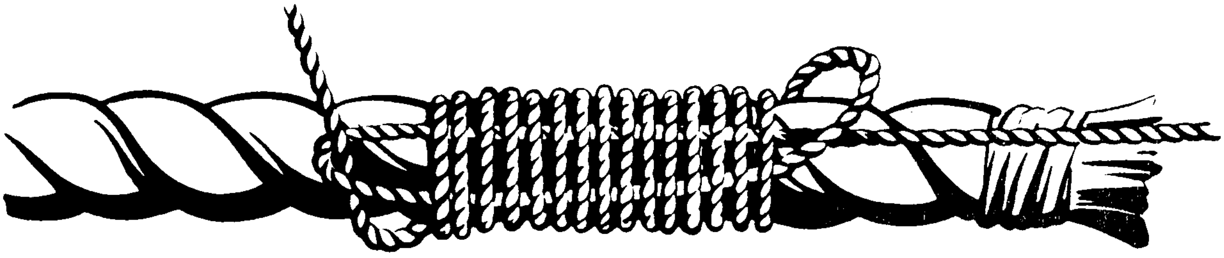

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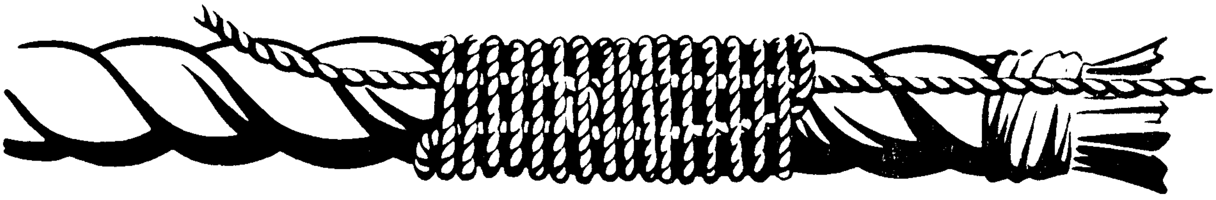

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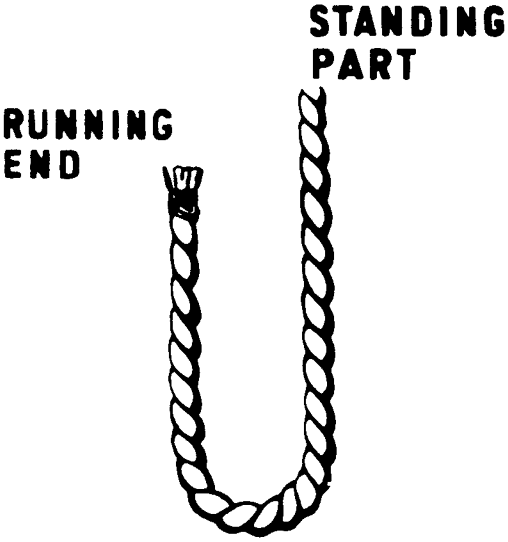
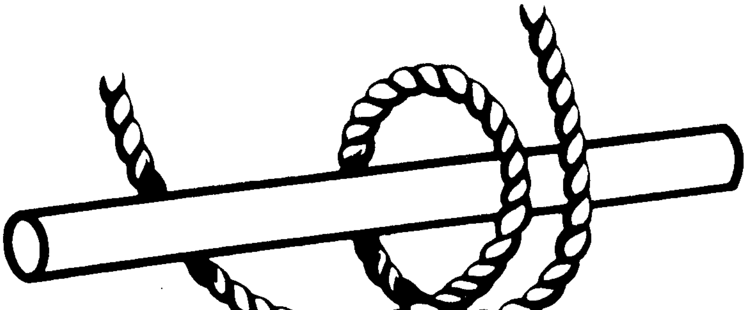
TERMS USED IN CONNECTION WITH ROPES



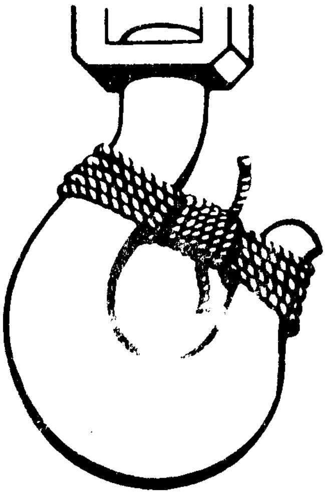
BIGHT

HALF HITCH

HITCH



ROUND TURN

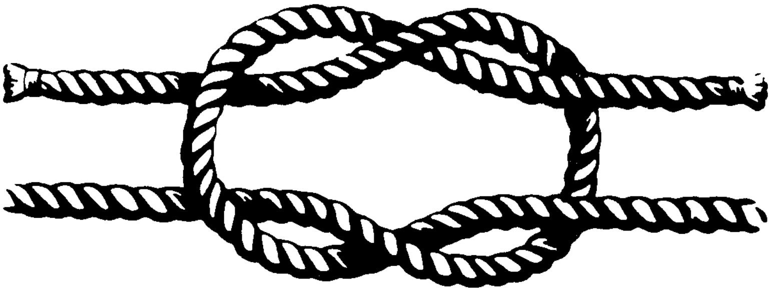


MOUSING

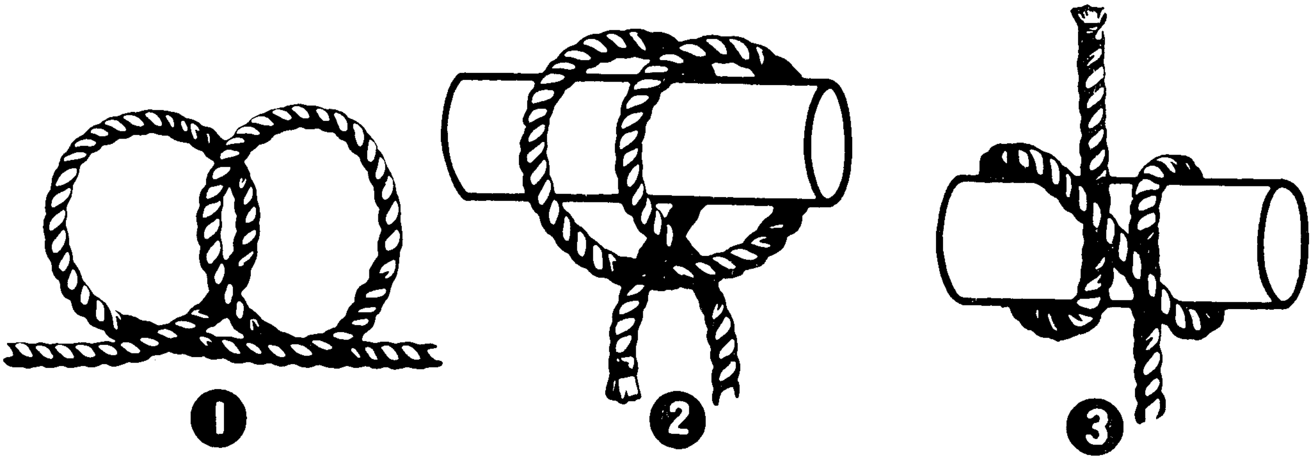
KNOTS USED IN RESCUE

THUMB KNOT

FIGURE-OF-EIGHT KNOT



REEF KNOT



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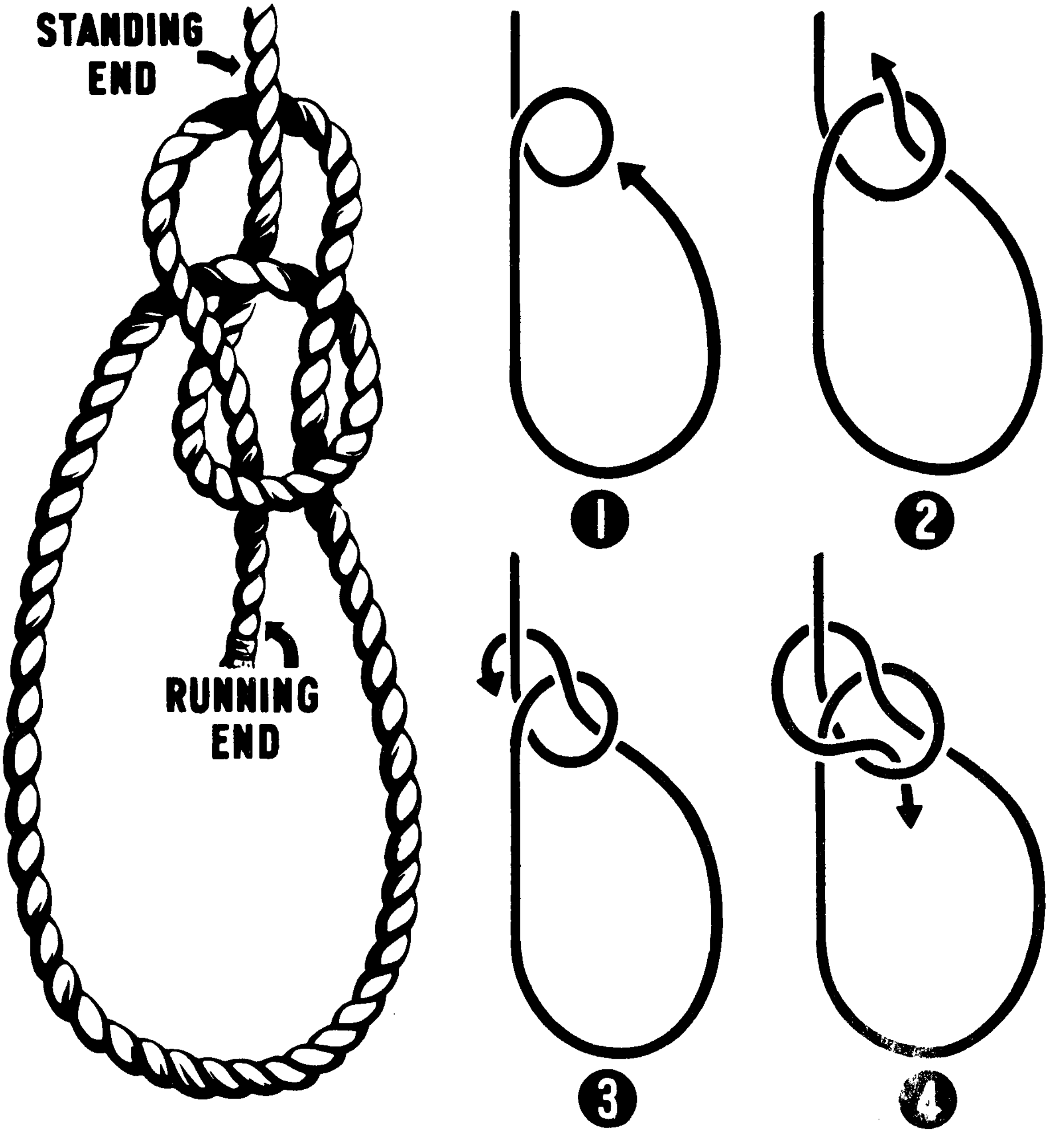
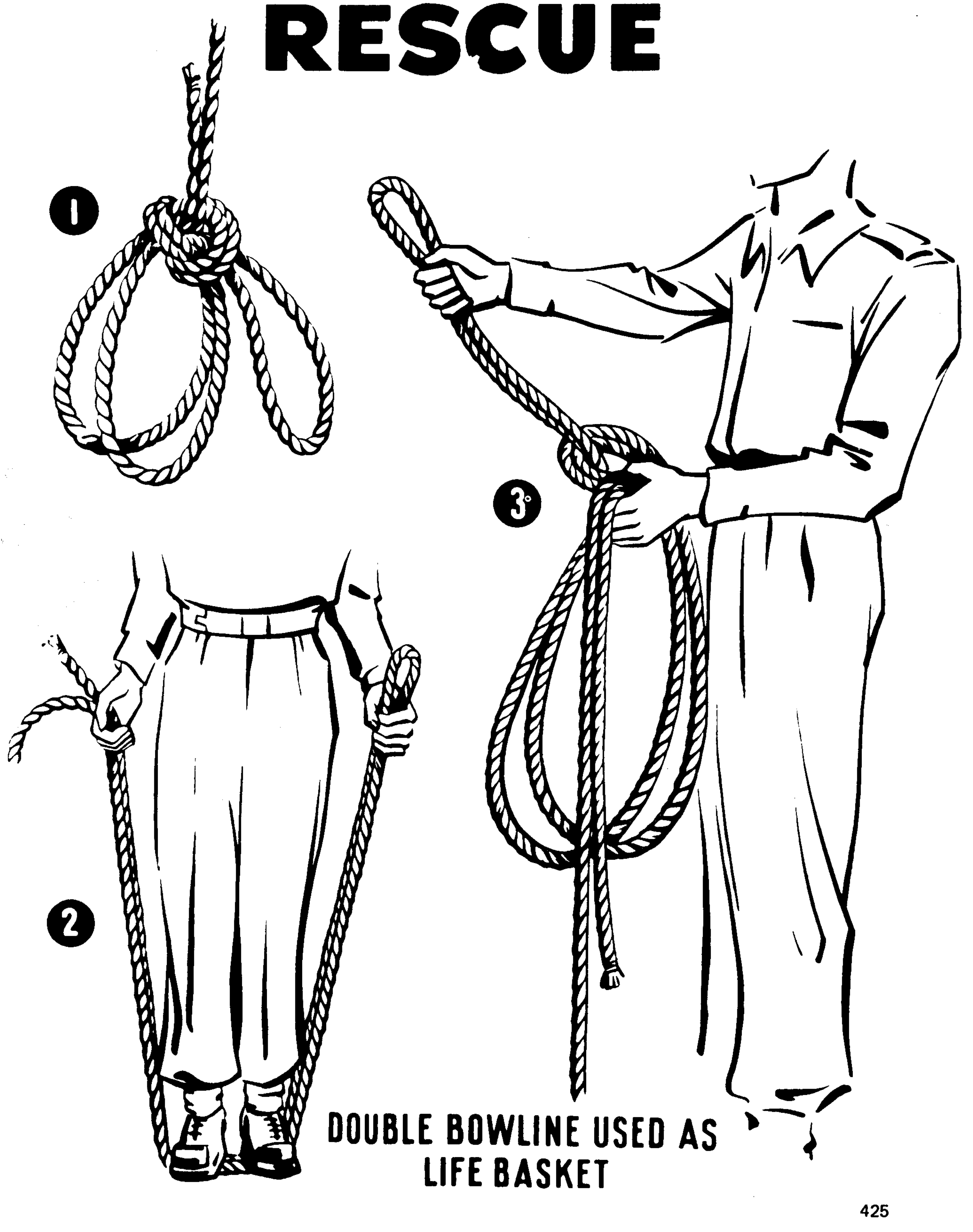
CLOVE HITCH

KNOTS USED IN RESCUE



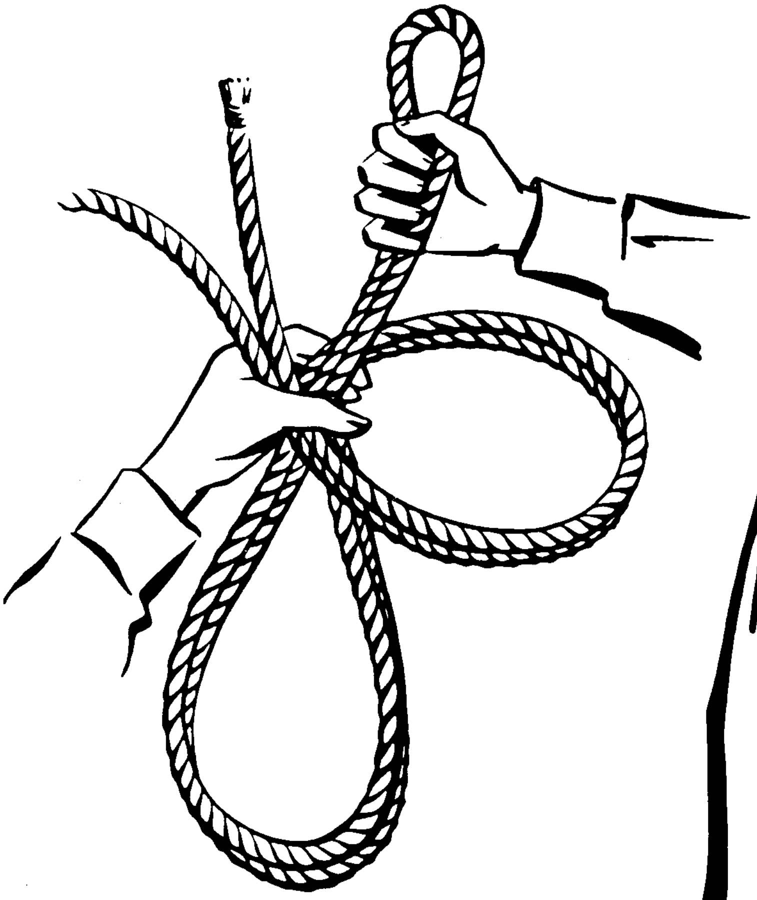
BOWLINE

KNOTS USED IN RESCUE



DOUBLE BOWLINE USED AS LIFE BASKET

KNOTS USED IN RESCUE



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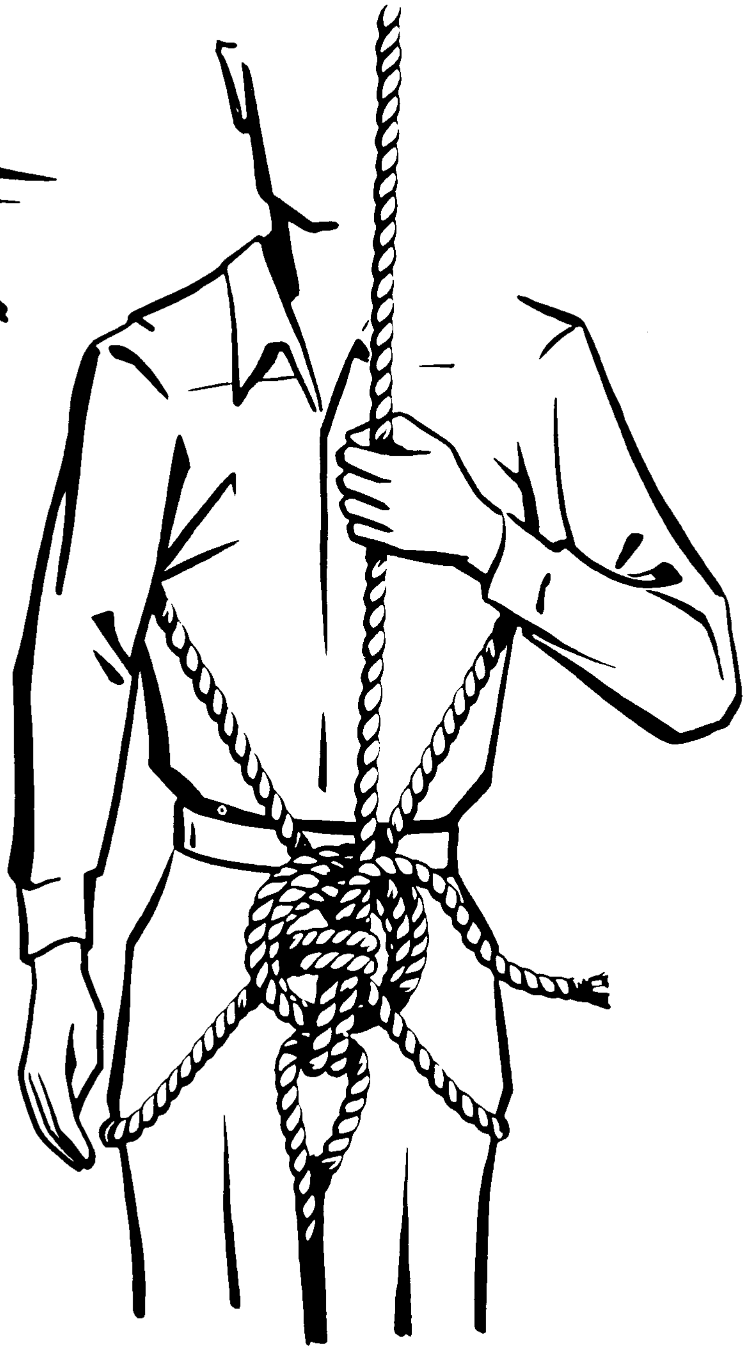
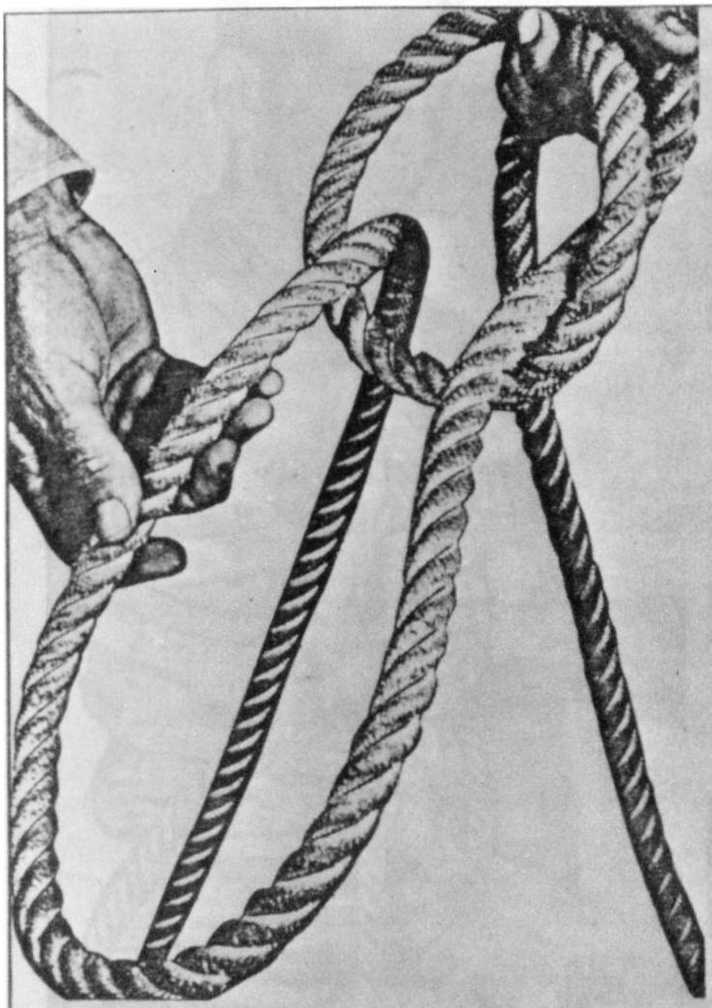
DOUBLE BOWLINE USED AS LIFE BASKET



5

Step No. 1: Measure four double arm lengths across the body in order to supply enough working line and tie an ordinary slip knot to form the first loop for one of the victim's legs, Example A.

Step No. 2: Place the loop thus formed around the victim's right thigh well up into the crotch. With the left hand, hold the eye of the slip knot in the centre of the victim's body just below his chest, Example B.



Example A

Example B

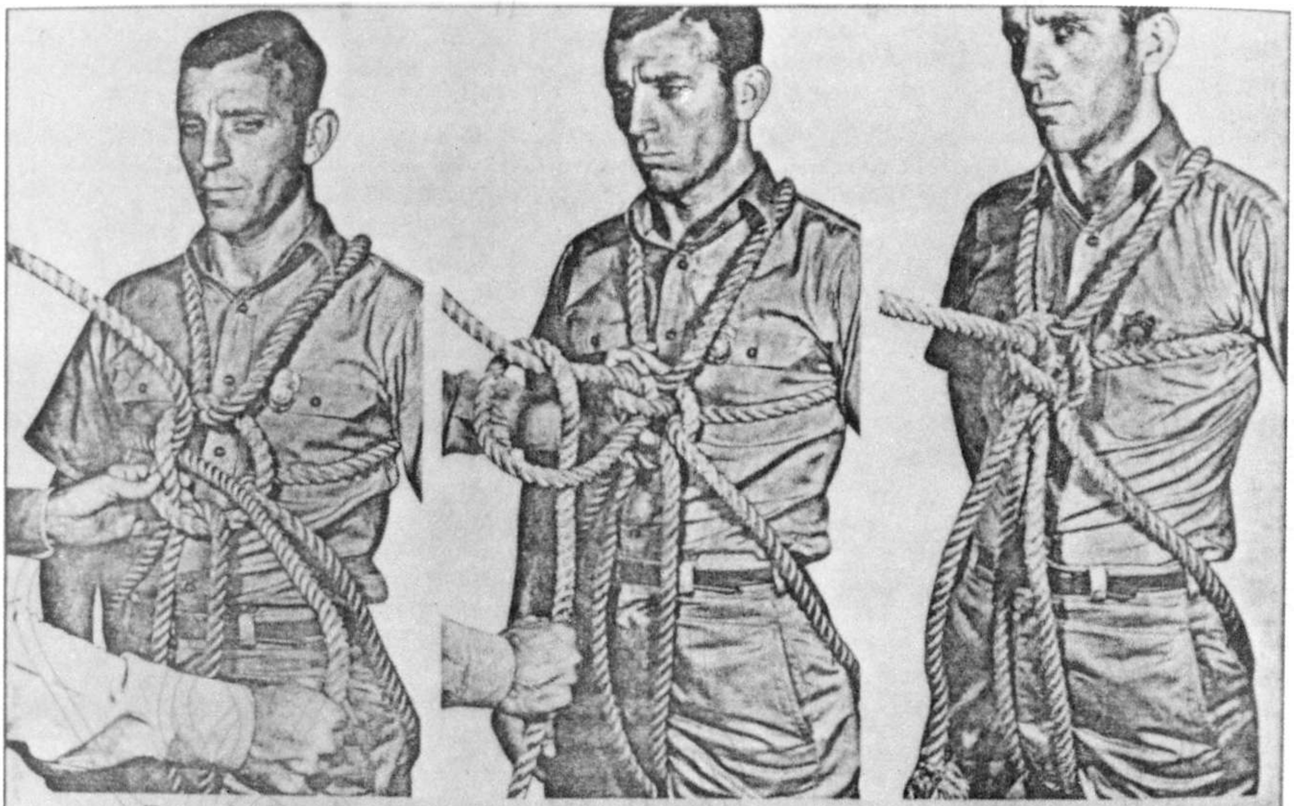
Step No. 3: Place the second loop around the victim's left thigh well up into the crotch and start forming the third loop through the eye that is held secure by the left hand, Example C.

Step No. 4: Place the third loop under the victim's left arm and over his right shoulder then back through the eye, making sure the rope enters through the eye from the underside, Example D.

Example C Example D

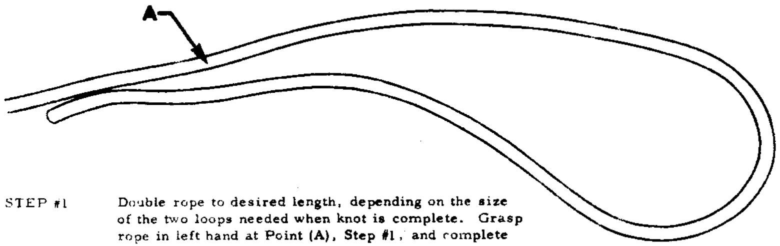
Step No. 5: Continue the line across the left side of the victim's neck across the back and under the right arm and bring the line back through the eye on the chest, thus forming the fourth loop, Example E.

Step No. 6: Tighten the eye snugly on all four loops by pulling on the lifting line and working the loops. Secure the eye to the loops with two half-hitches to prevent slipping and tightening of the knot on the victim's body, Example F. The completed knot is shown in Example G.

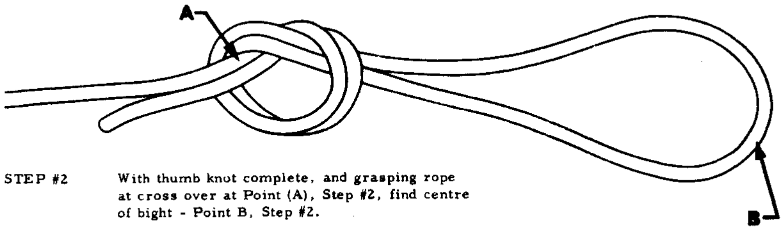


Example E Example F Example G

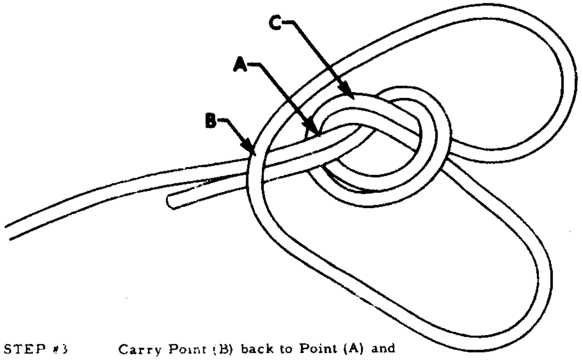
INSTRUCTIONS FOR TYING BOWLINE-ON-A-BIGHT



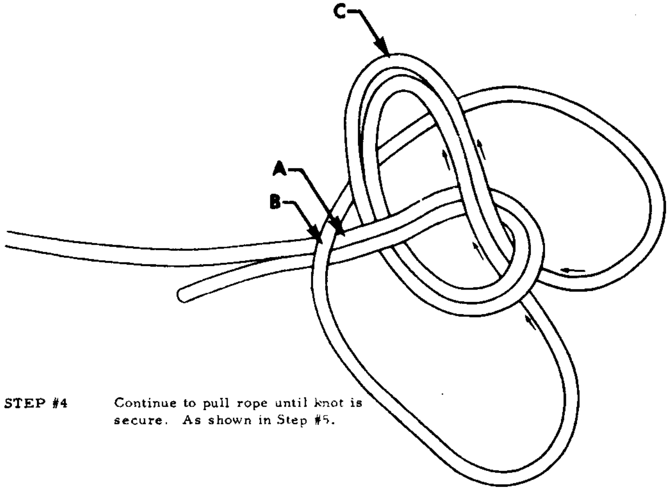
STEP #1 Double rope to desired length, depending on the size of the two loops needed when knot is complete. Grasp rope in left hand at Point (A), Step #1, and complete thumb knot as in Step #2.



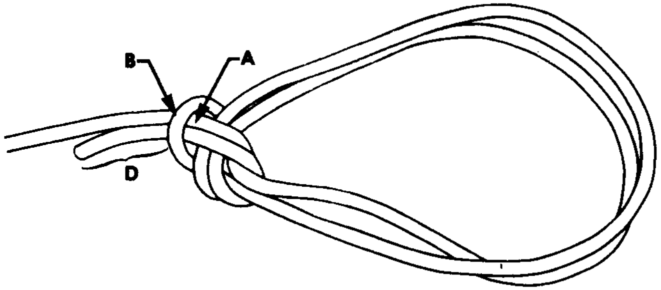
STEP #2 With thumb knot complete, and grasping rope at cross over at Point (A), Step #2, find centre of bight - Point B, Step #2.



STEP #3 Carry Point (B) back to Point (A) and hold under thumb of left hand as shown in Step #3. Grasp double rope at Point C and pull up through thumb knot as in Step #4.

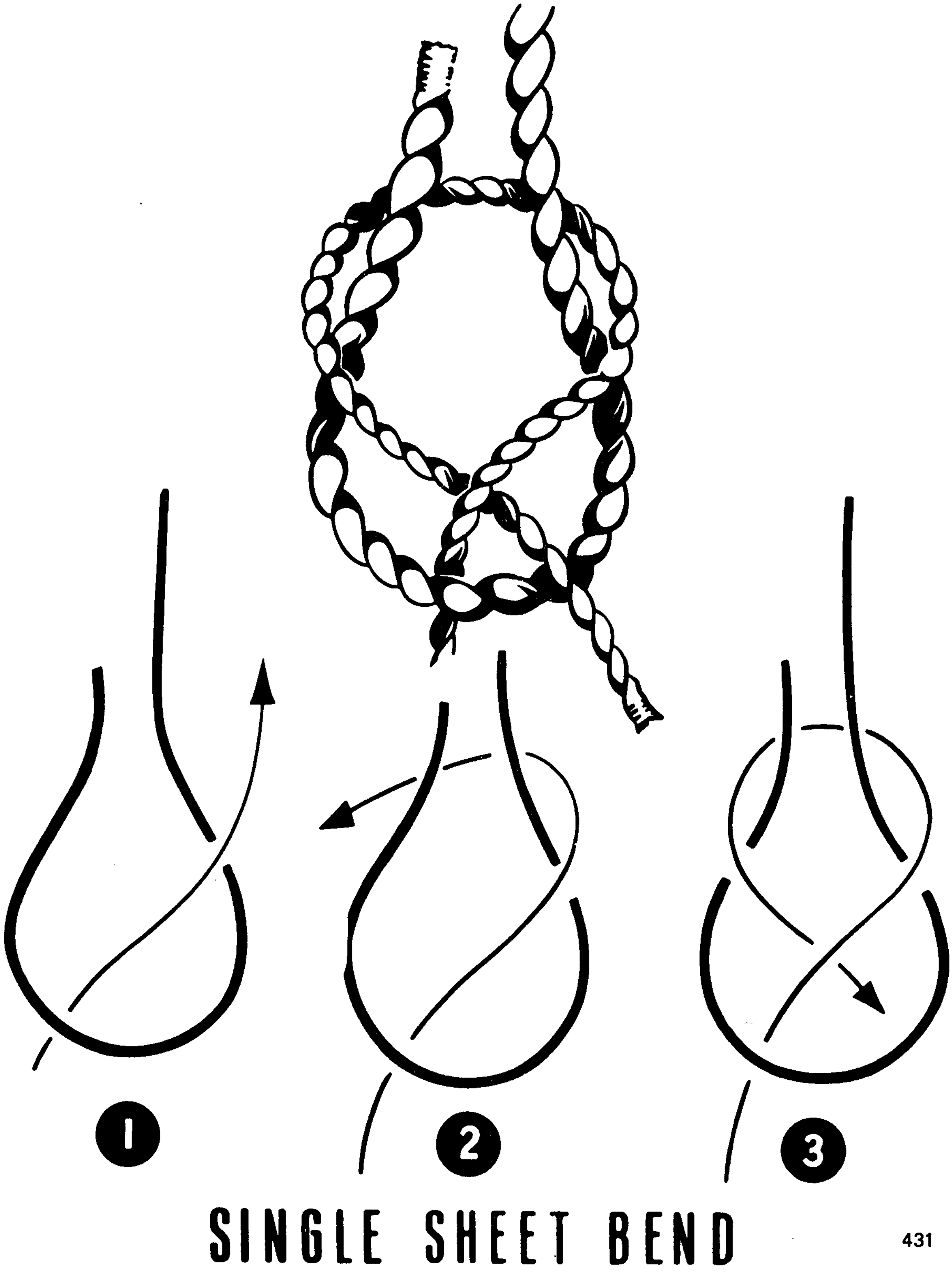


STEP #4 Continue to pull rope until knot is secure. As shown in Step #5.



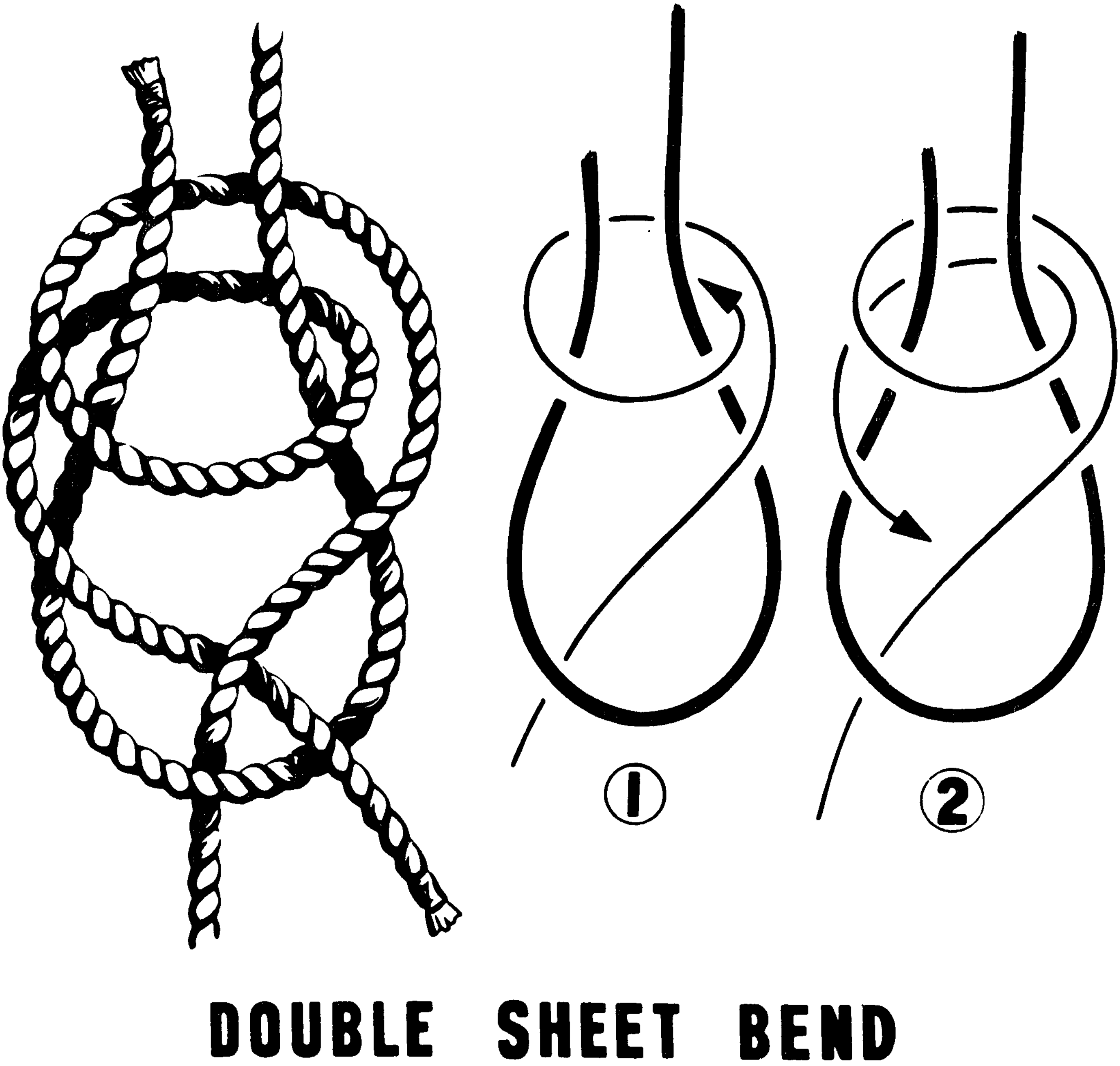
STEP #5 With completed knot, you should be left with two equal loops as long as you have held the rope secure with no slippage where Point (B) crosses over Point (A). Note dead end of rope at Point (D) should be at least 12" long.

KNOTS USED IN RESCUE



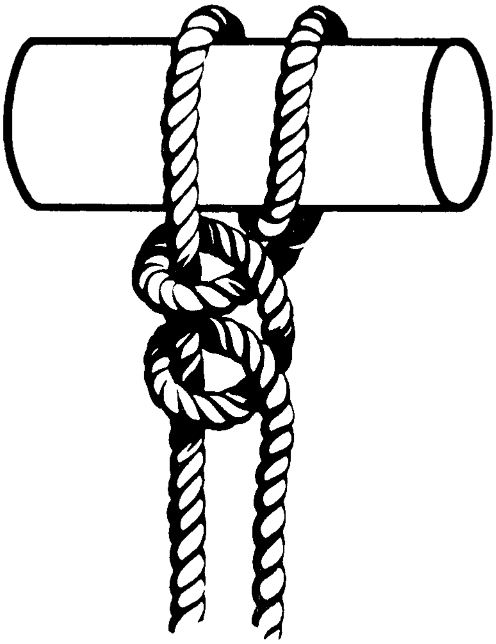
SINGLE SHEET BEND

KNOTS USED IN RESCUE

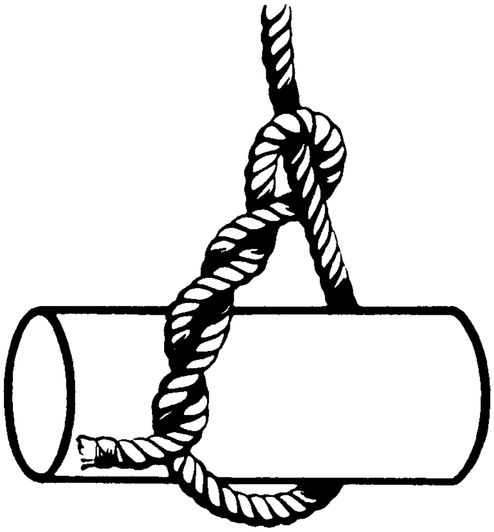


DOUBLE SHEET BEND

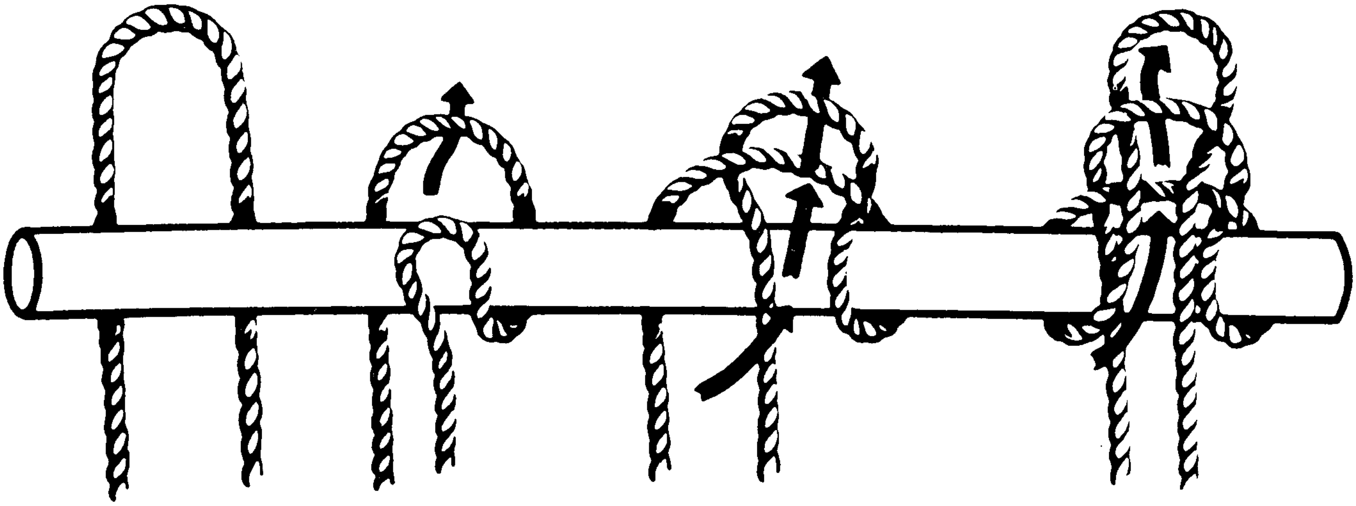
KNOTS USED IN RESCUE



ROUND TURN AND TWO HALF HITCHES

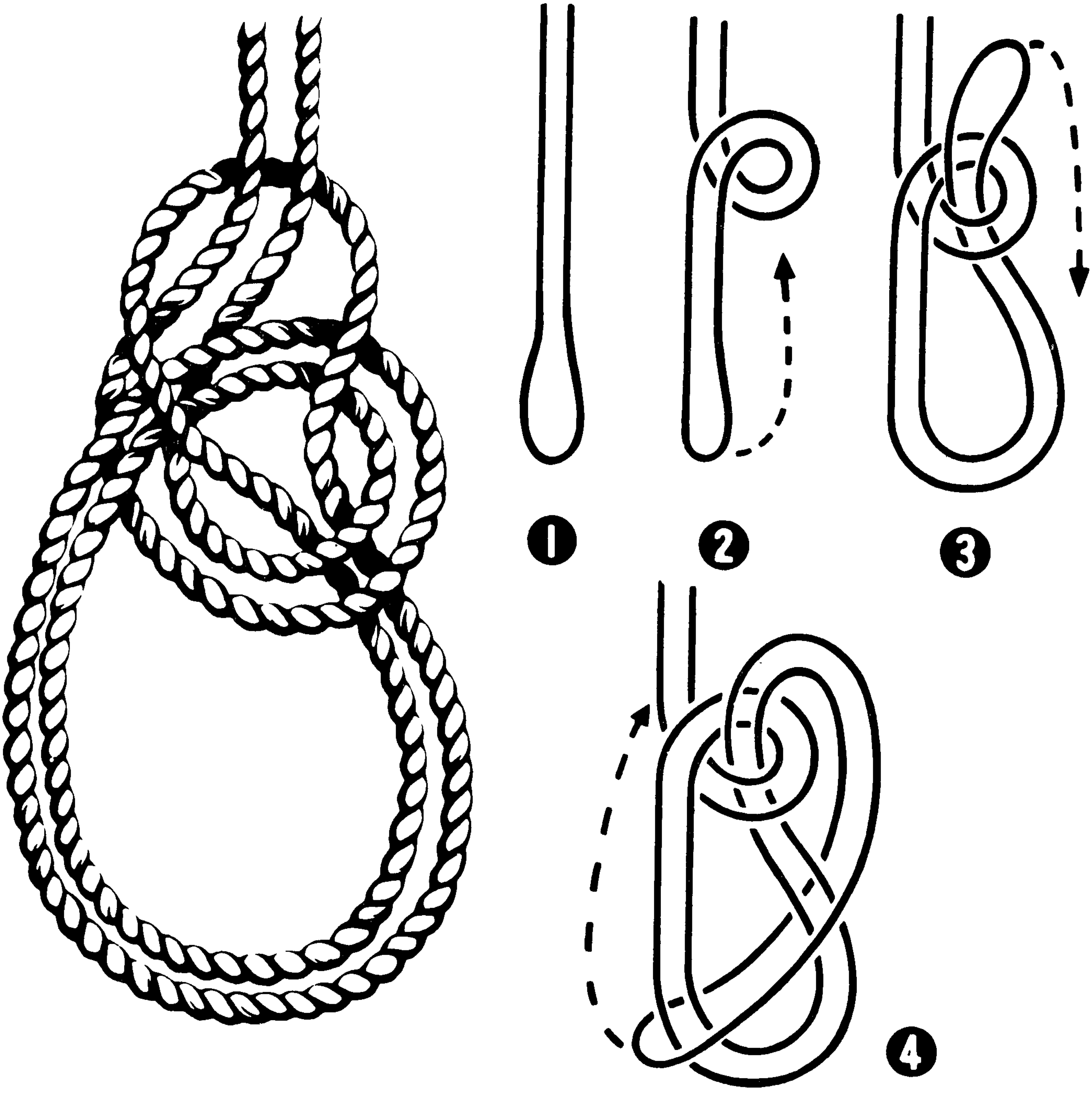


TIMBER HITCH



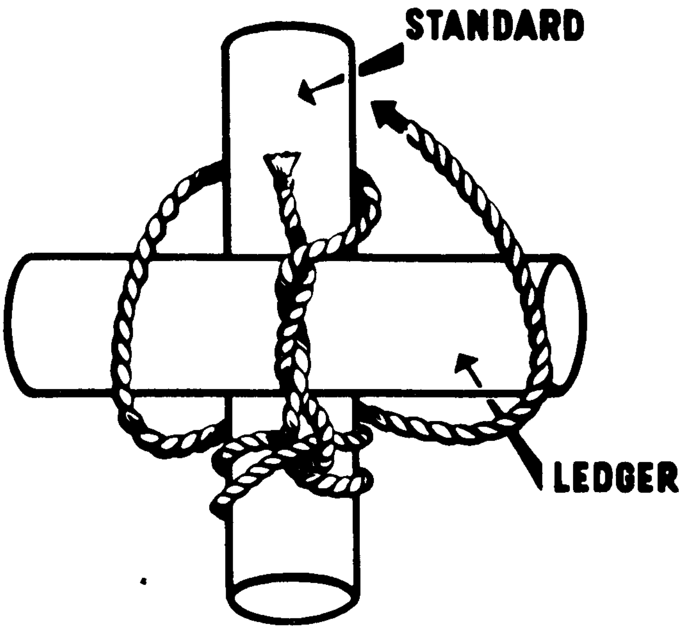
DRAW HITCH

KNOTS USED IN RESCUE



BOWLINE-ON-A-BIGHT

SQUARE LASHING



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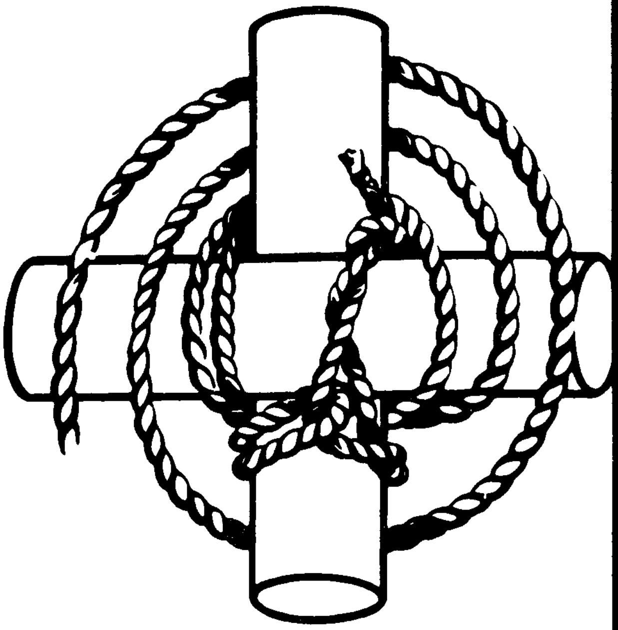

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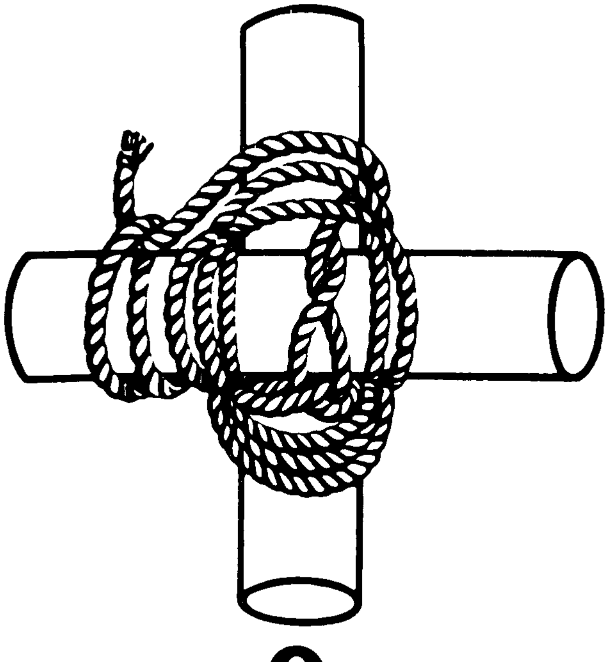

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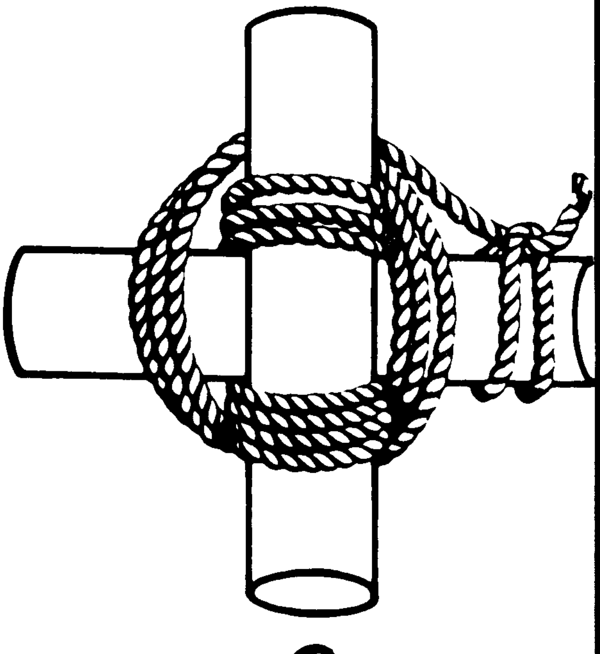

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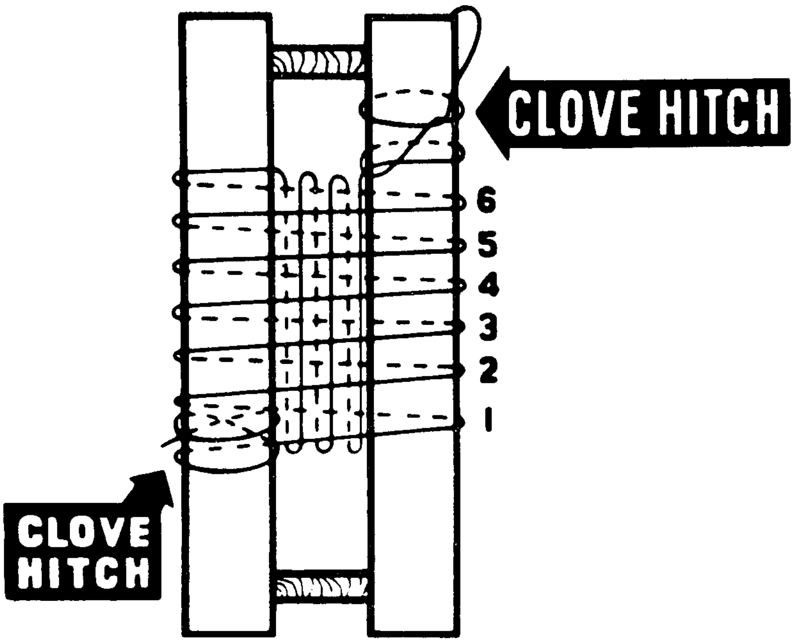
ROUND LASHING



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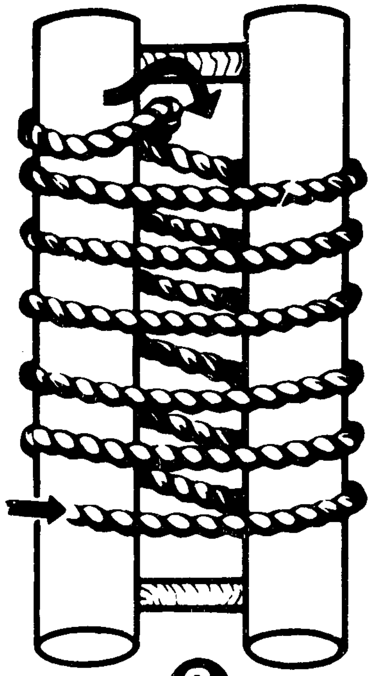

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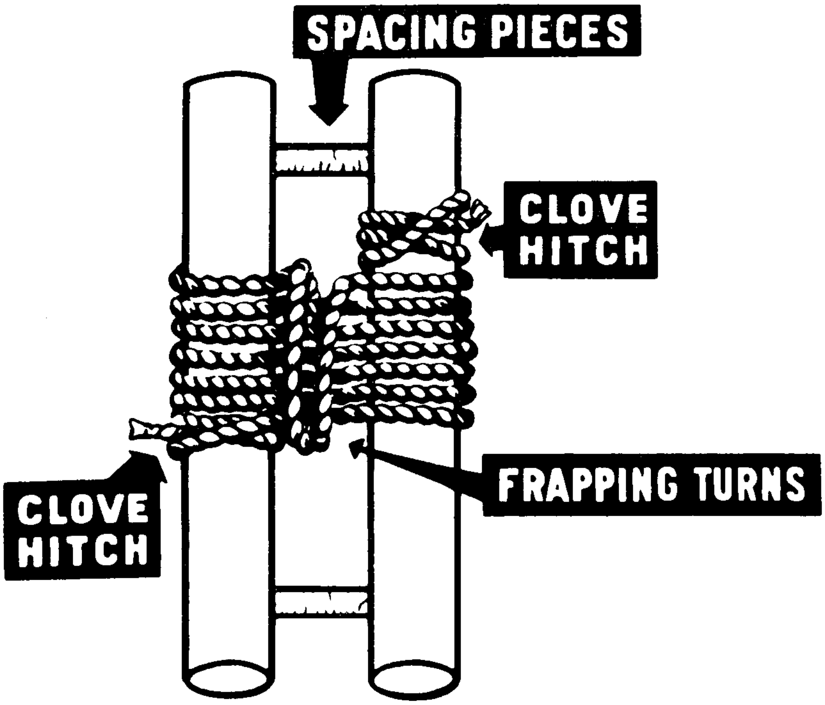

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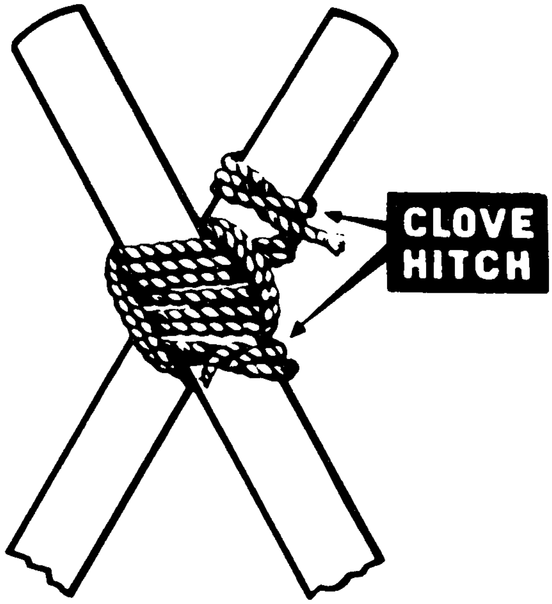

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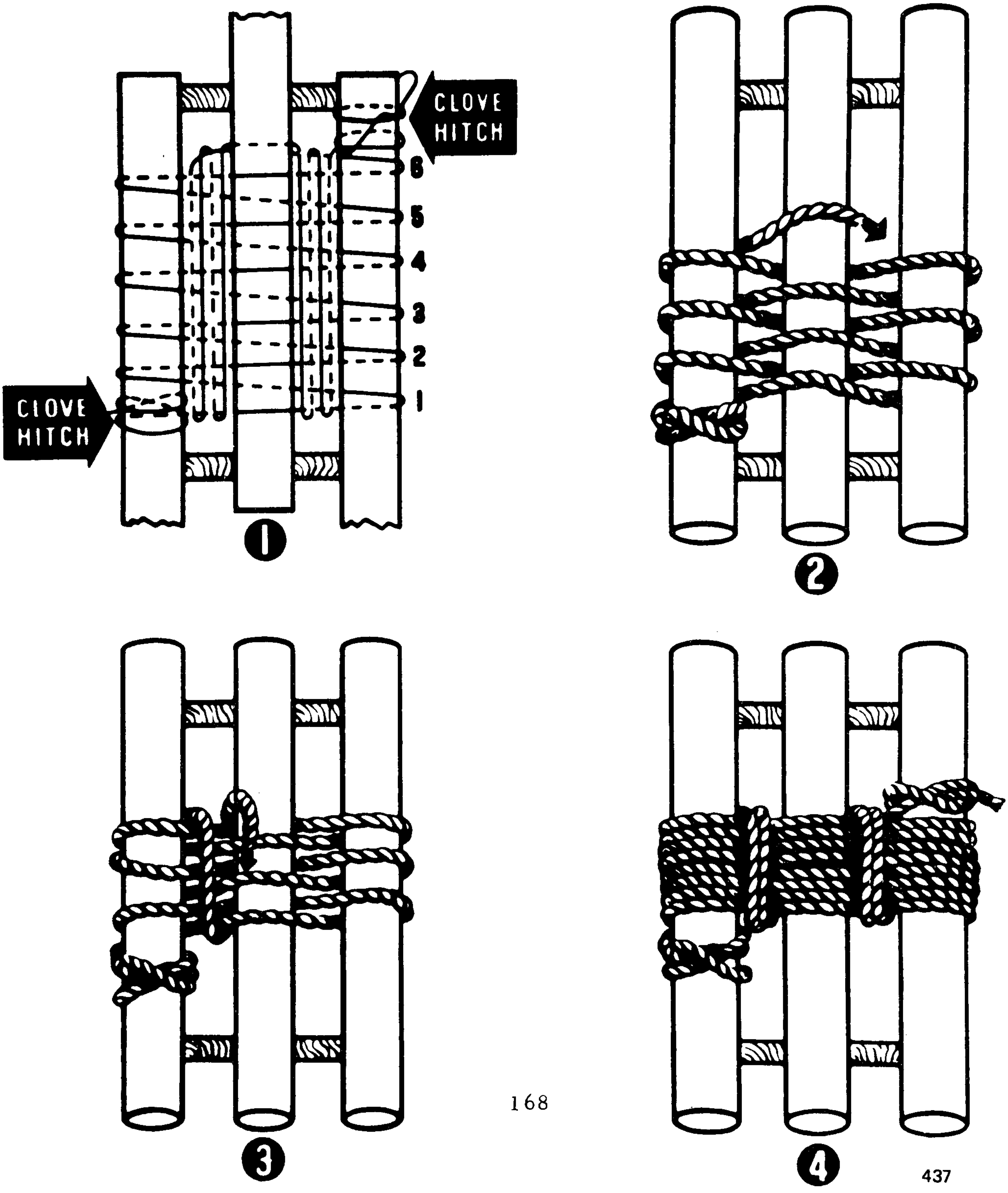
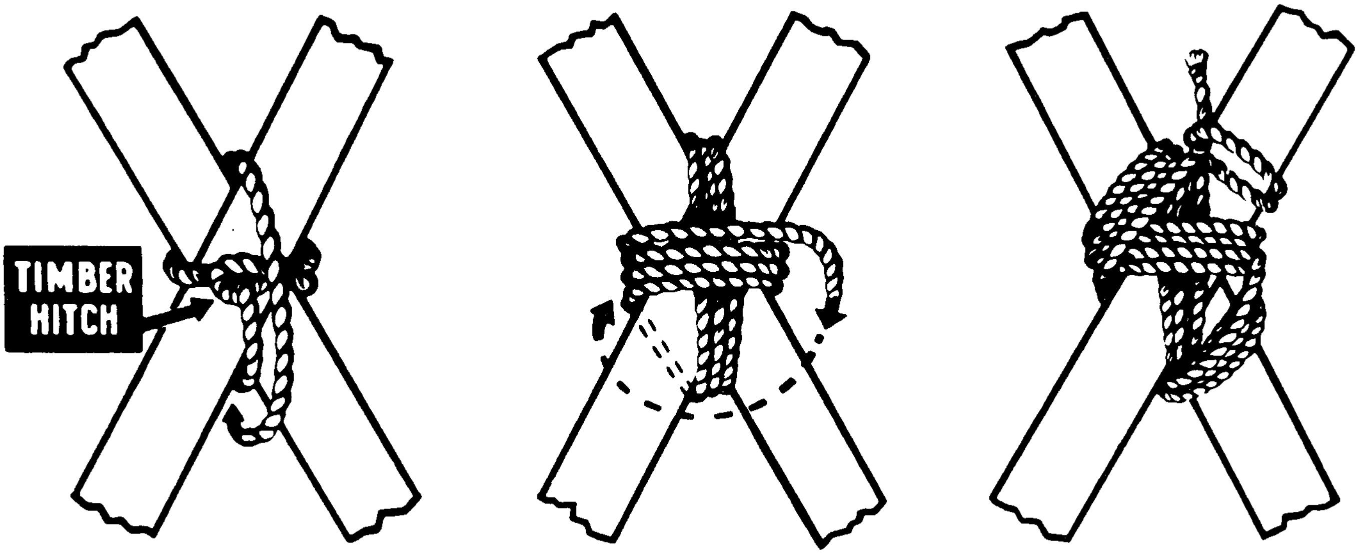
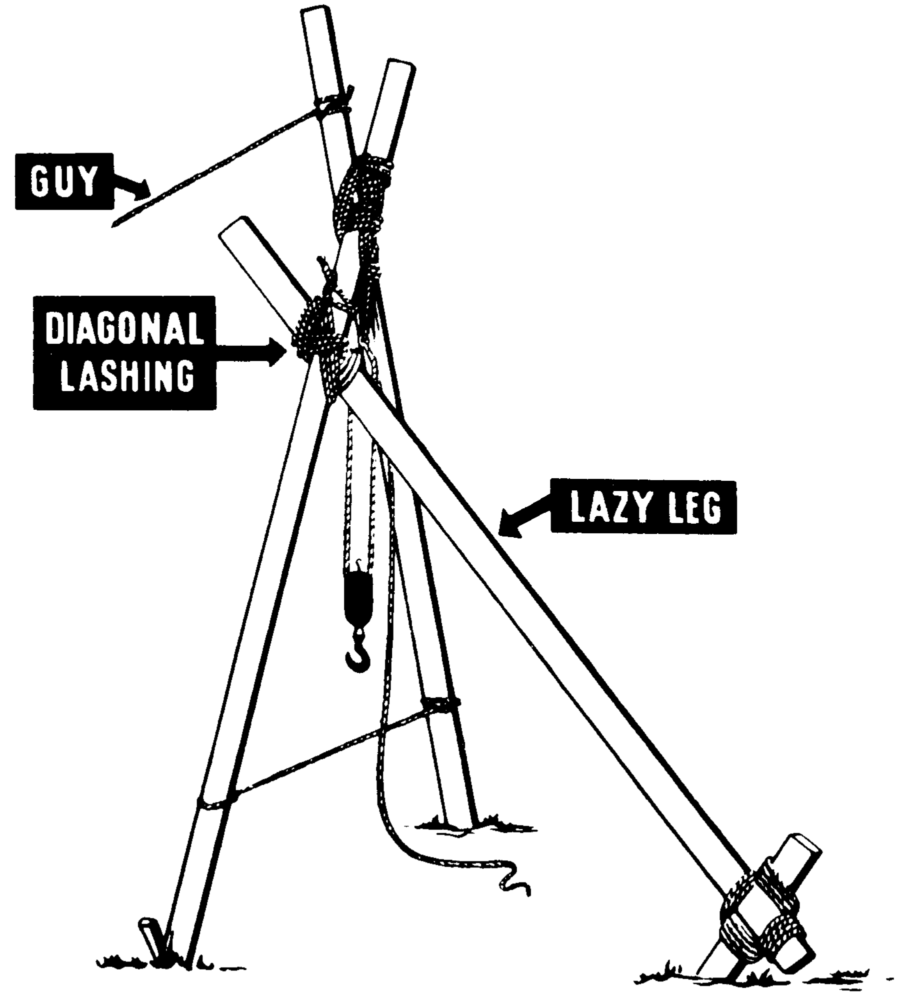
FIGURE OF "8" LASHING

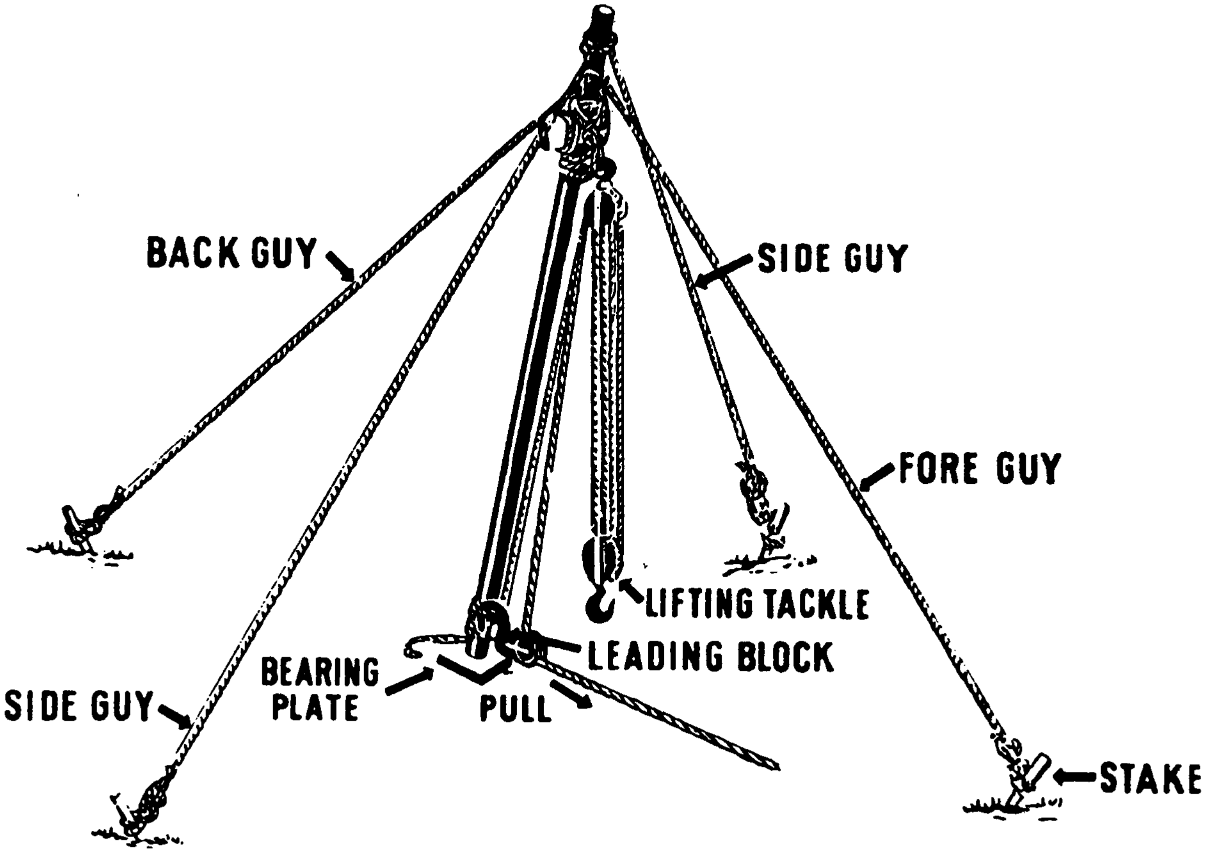


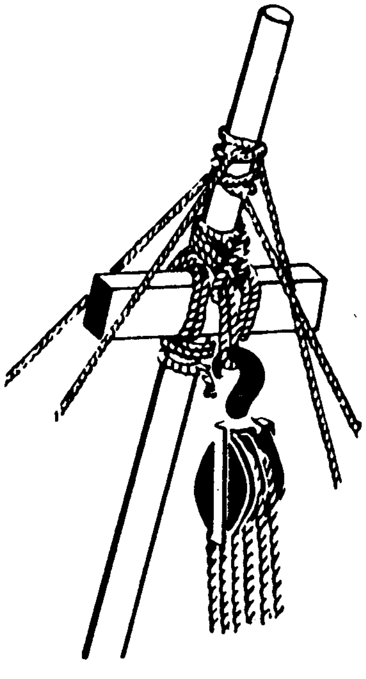
DIAGONAL LASHING

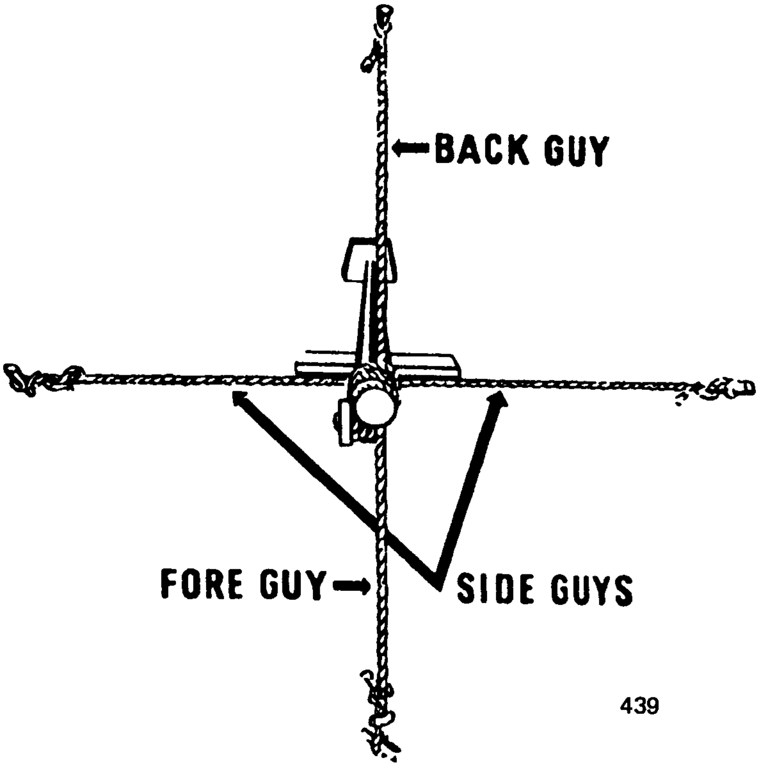




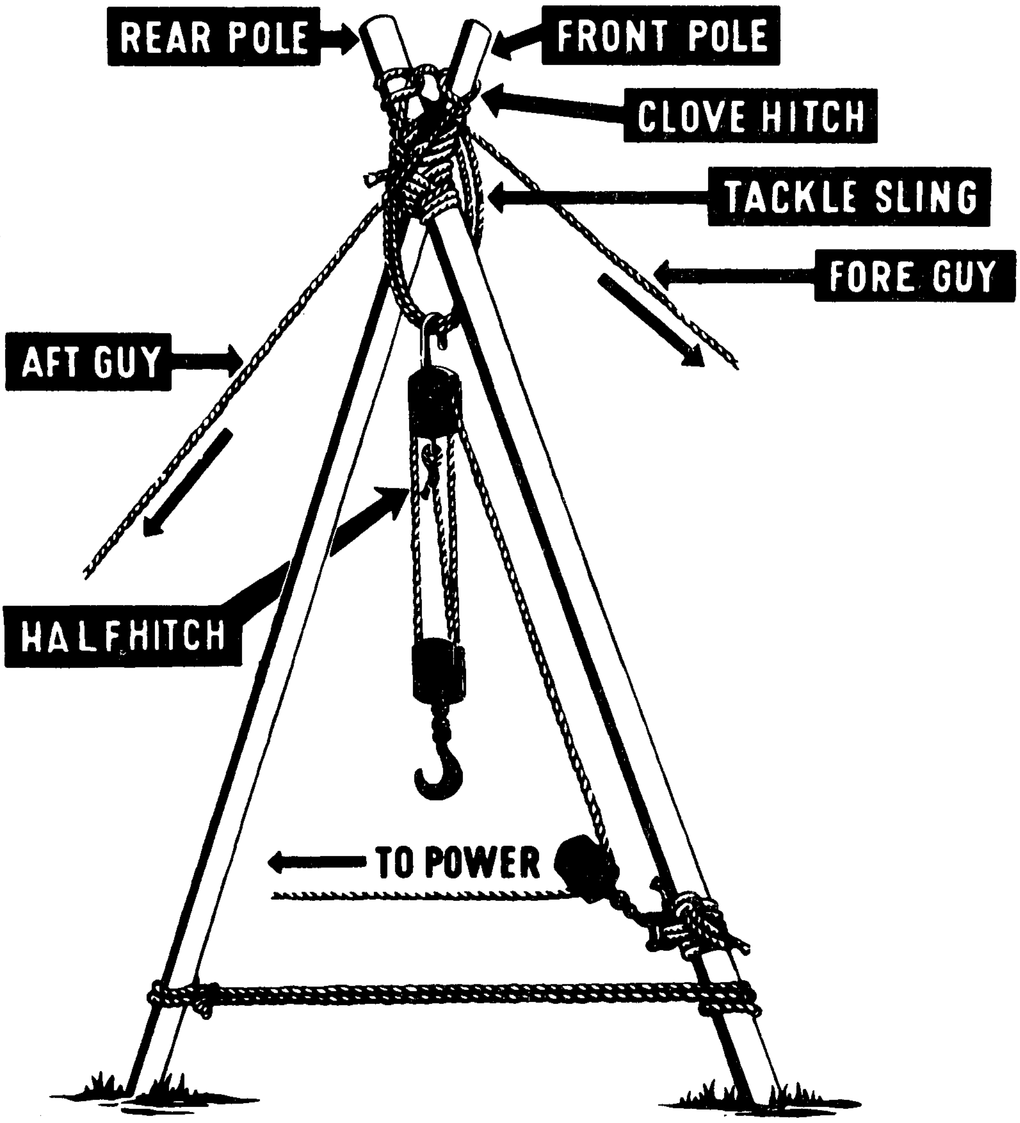
STANDING DERRICK

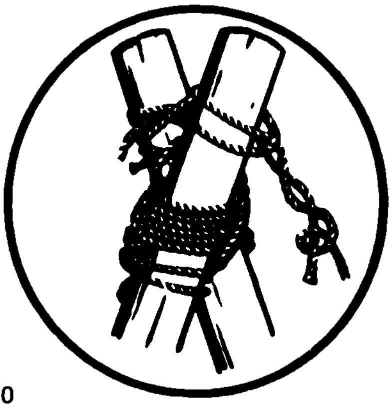


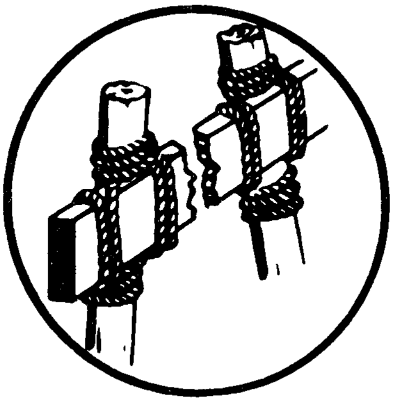




"A" FRAME

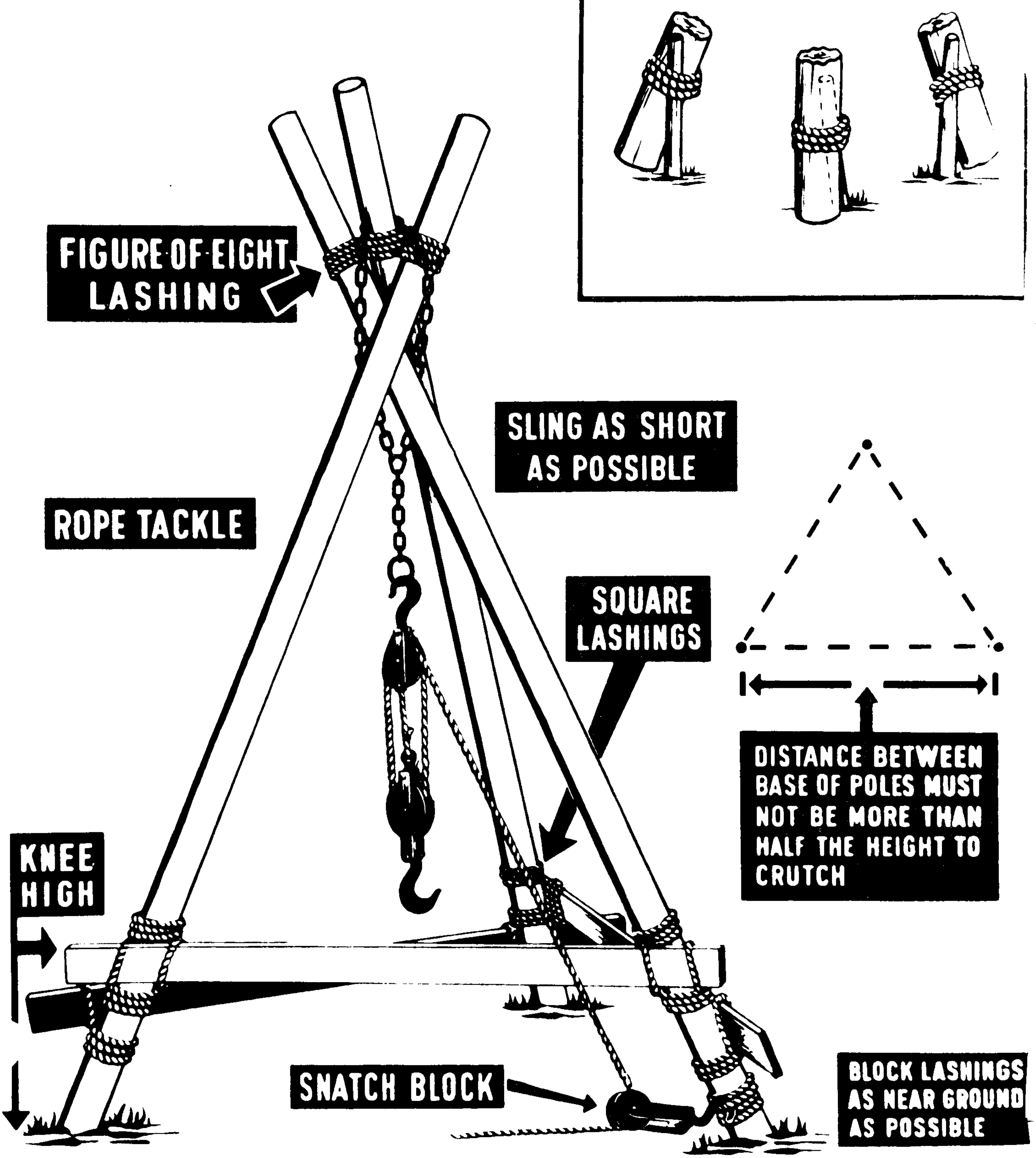





ALTERNATE METHOD OF SECURING BASE

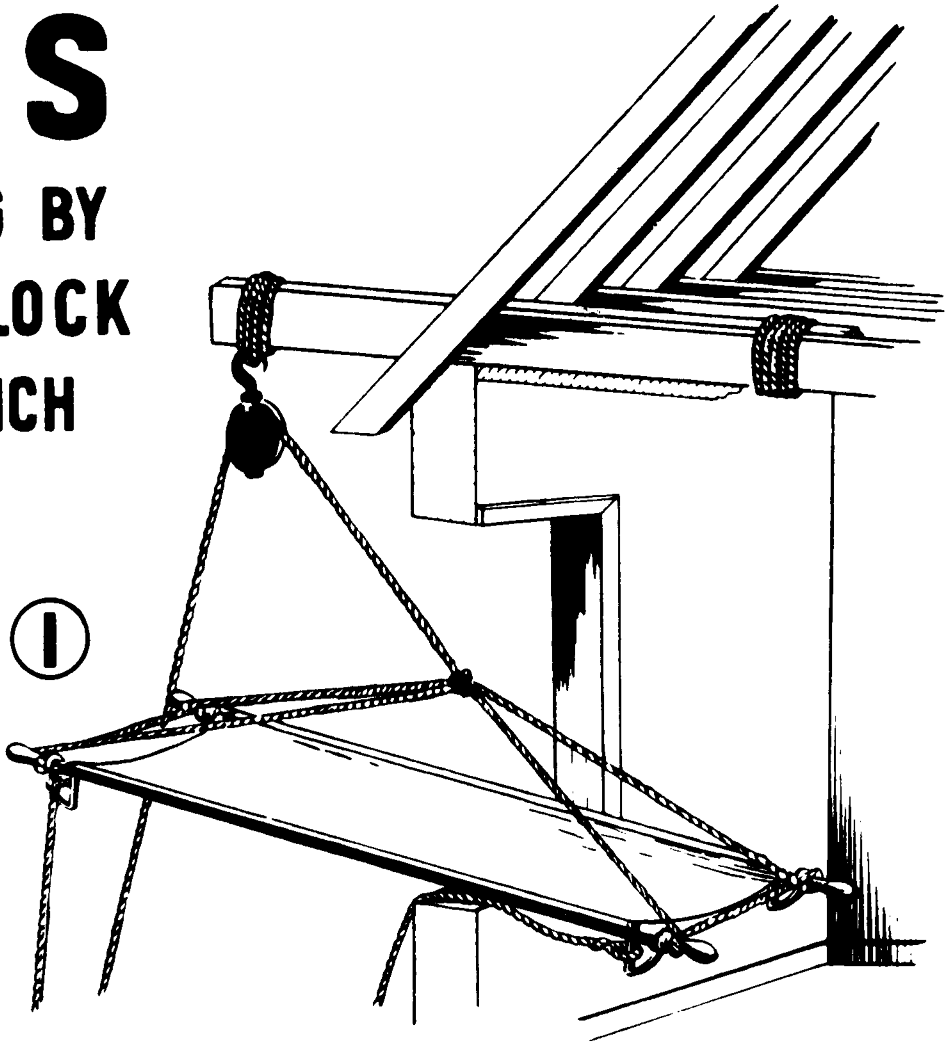
TRIPOD

ALTERNATIVE METHOD OF SECURING BASE



JIBS

LOWERING BY SNATCHBLOCK AND ONE INCH ROPE



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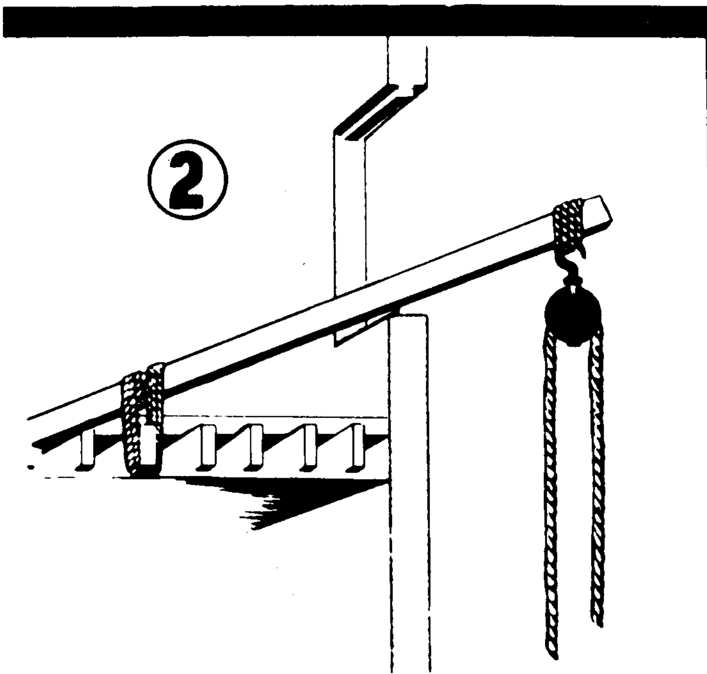

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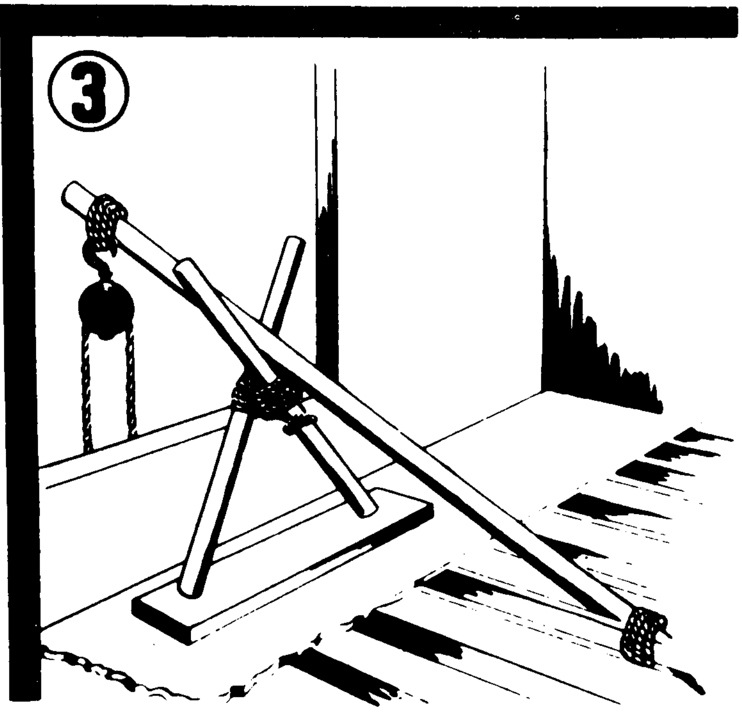
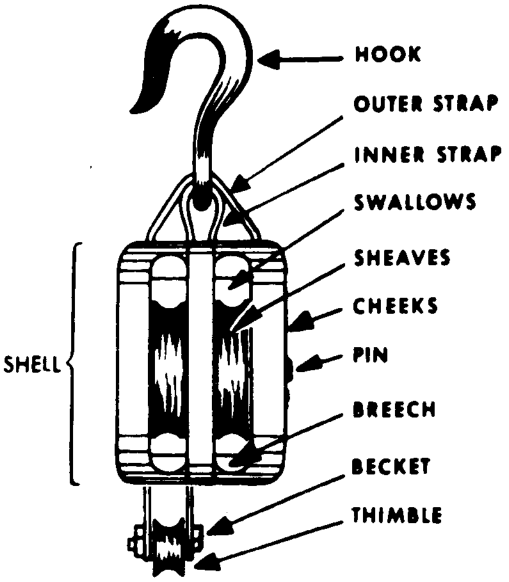
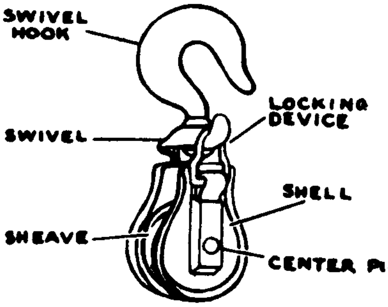


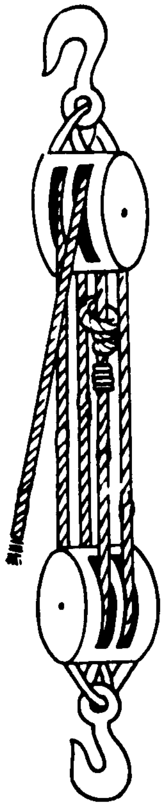
③

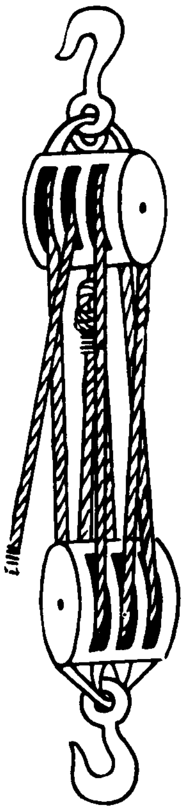
BLOCKS AND TACKLE IN RESCUE

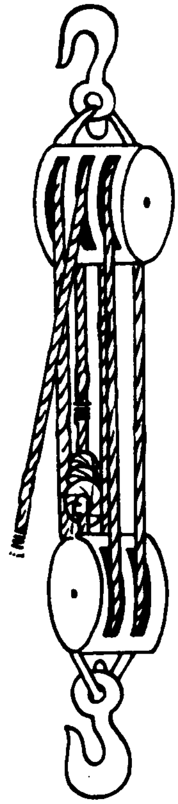


STANDARD TWO-SHEAVE BLOCK

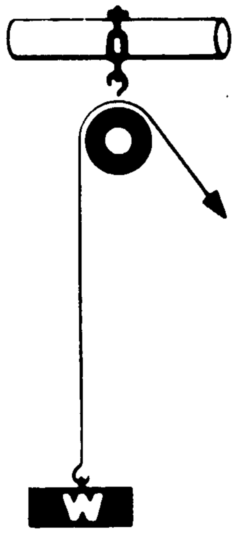
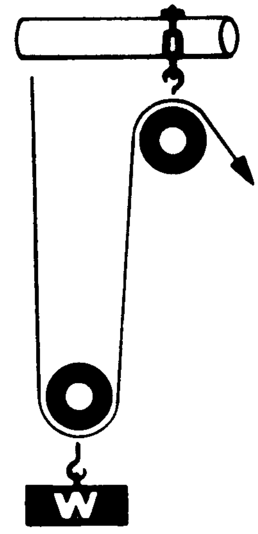
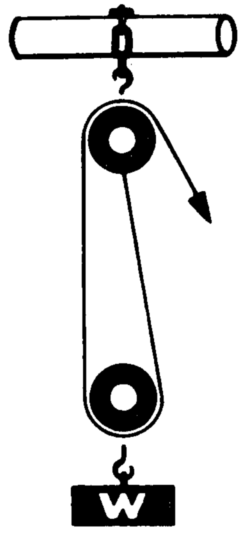
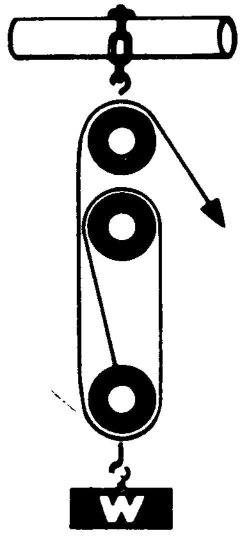
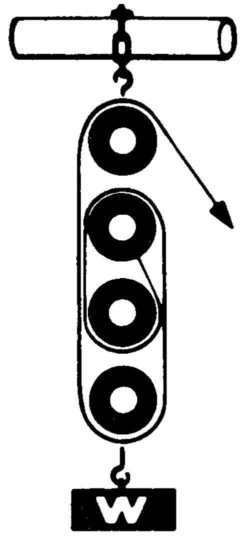




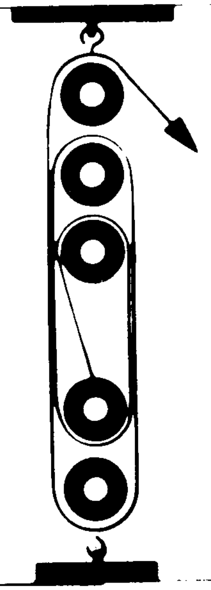
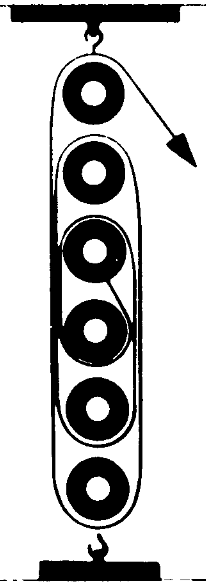




PRINCIPLES OF LIFTING & METHODS USED FOR RESCUE TRAINING

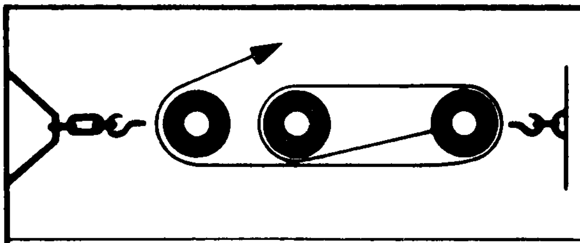
	SINGLE	TWO SINGLE	WHIP	LUFF	DOUBLE LUFF
					
THEORETICAL ADVANTAGE	1 TO 1	2 TO 1	2 TO 1	3 TO 1	4 TO 1
ACTUAL ADVANTAGE	9/10	1 2/3		2 1/3	3

LIFTING TACKLE

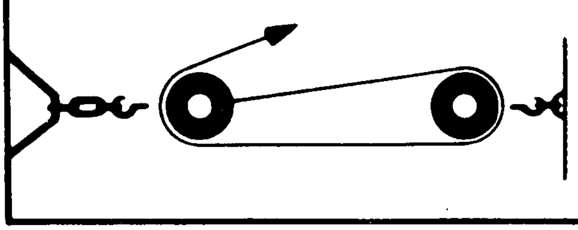
	LIGHT GIN	HEAVY GIN
		
THEORETICAL ADVANTAGE	5 TO 1	6 TO 1
ACTUAL ADVANTAGE	3	3 3/8

RUNNER TACKLE

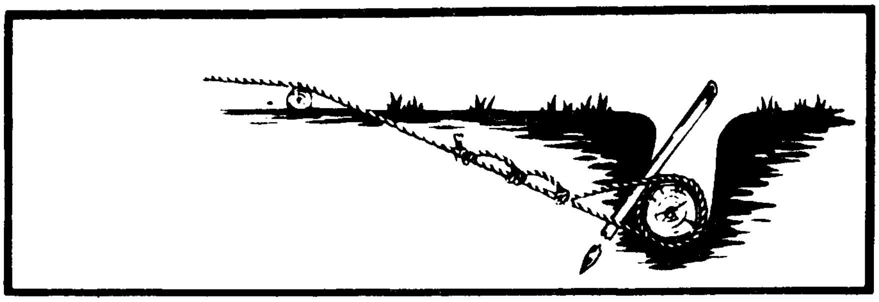
LUFF TACKLE

	THEORETICAL ADVANTAGE	ACTUAL ADVANTAG
	4 TO 1	3½

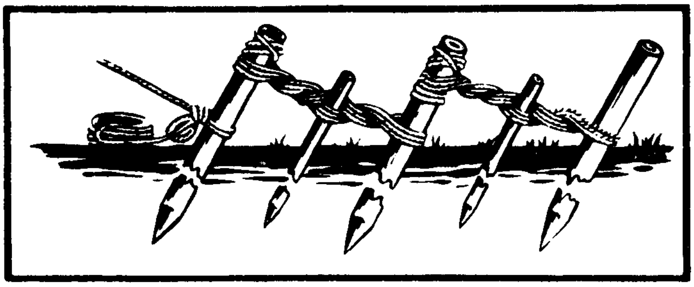
TWO SINGLE

	THEORETICAL ADVANTAGE	ACTUAL ADVANTAG
	3 TO 1	2 3/8

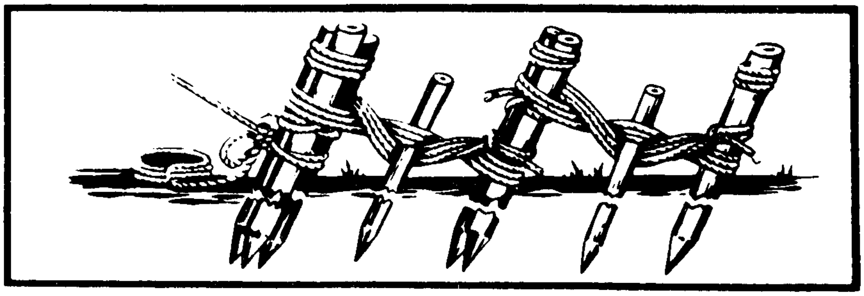
HOLDFASTS

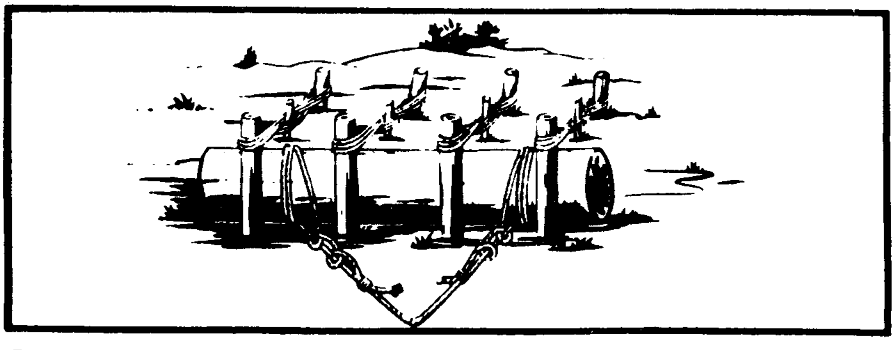


THE DEADMAN



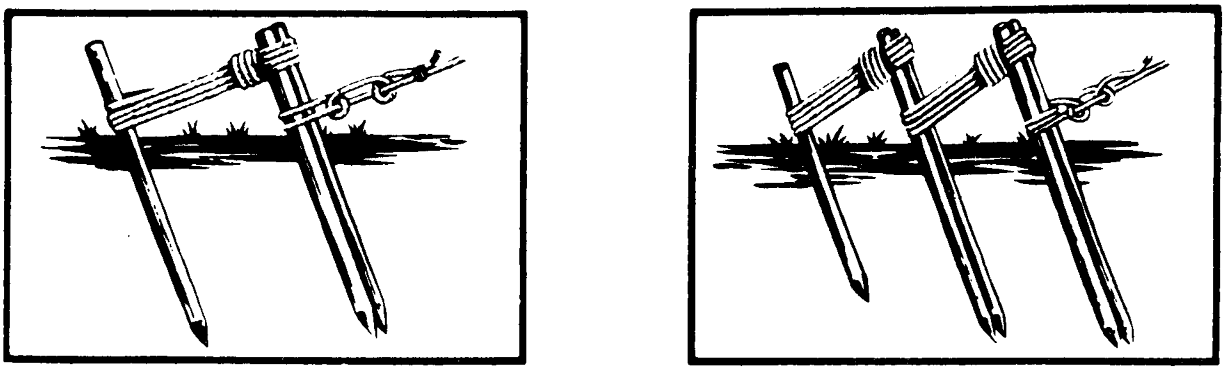
PICKET HOLDFASTS





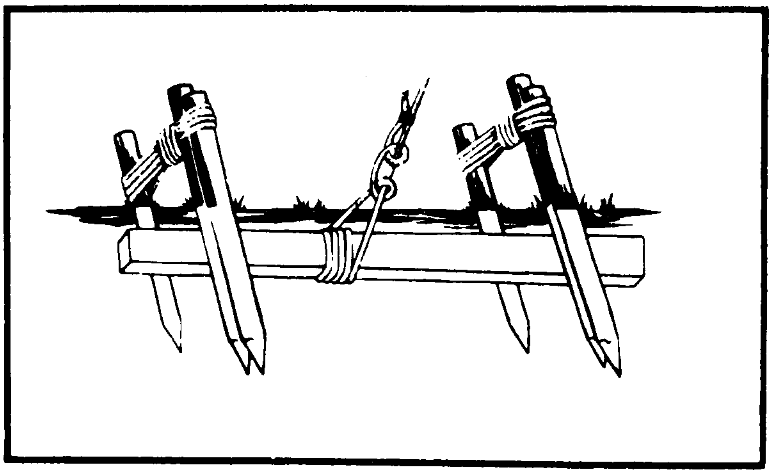
COMBINATION LOG PICKET HOLDFAST

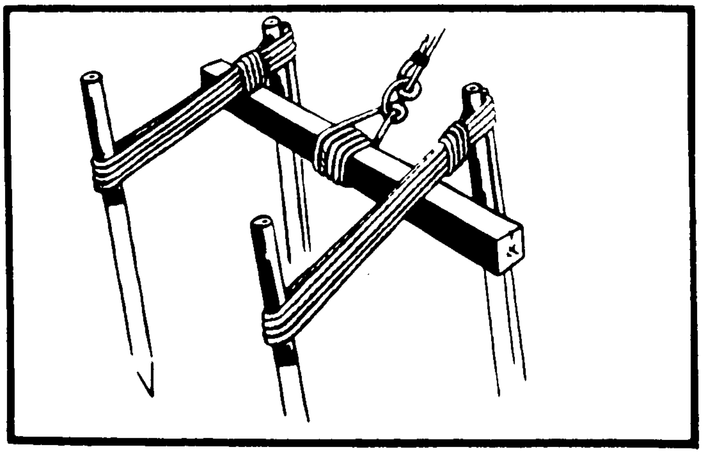
HOLDFASTS AND PICKETS



PICKETS USED AS HOLDFAST

BURIED HOLDFASTS

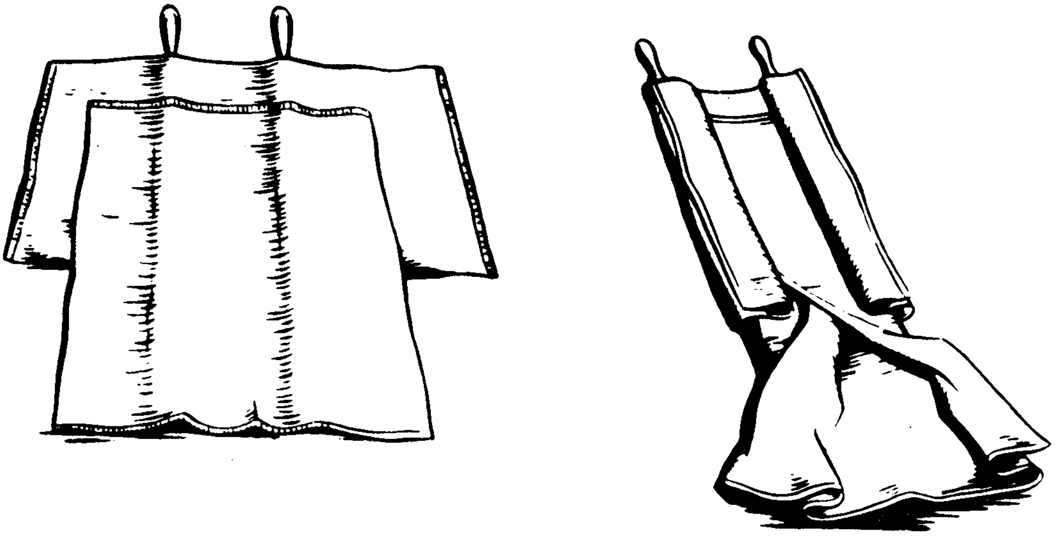




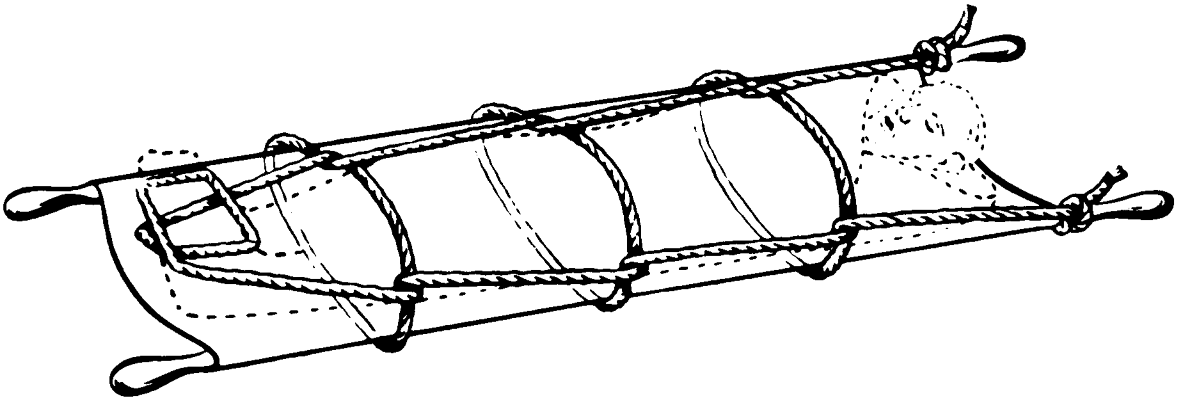
BAULK HOLDFASTS

TRANSPORT OF CASUALTIES

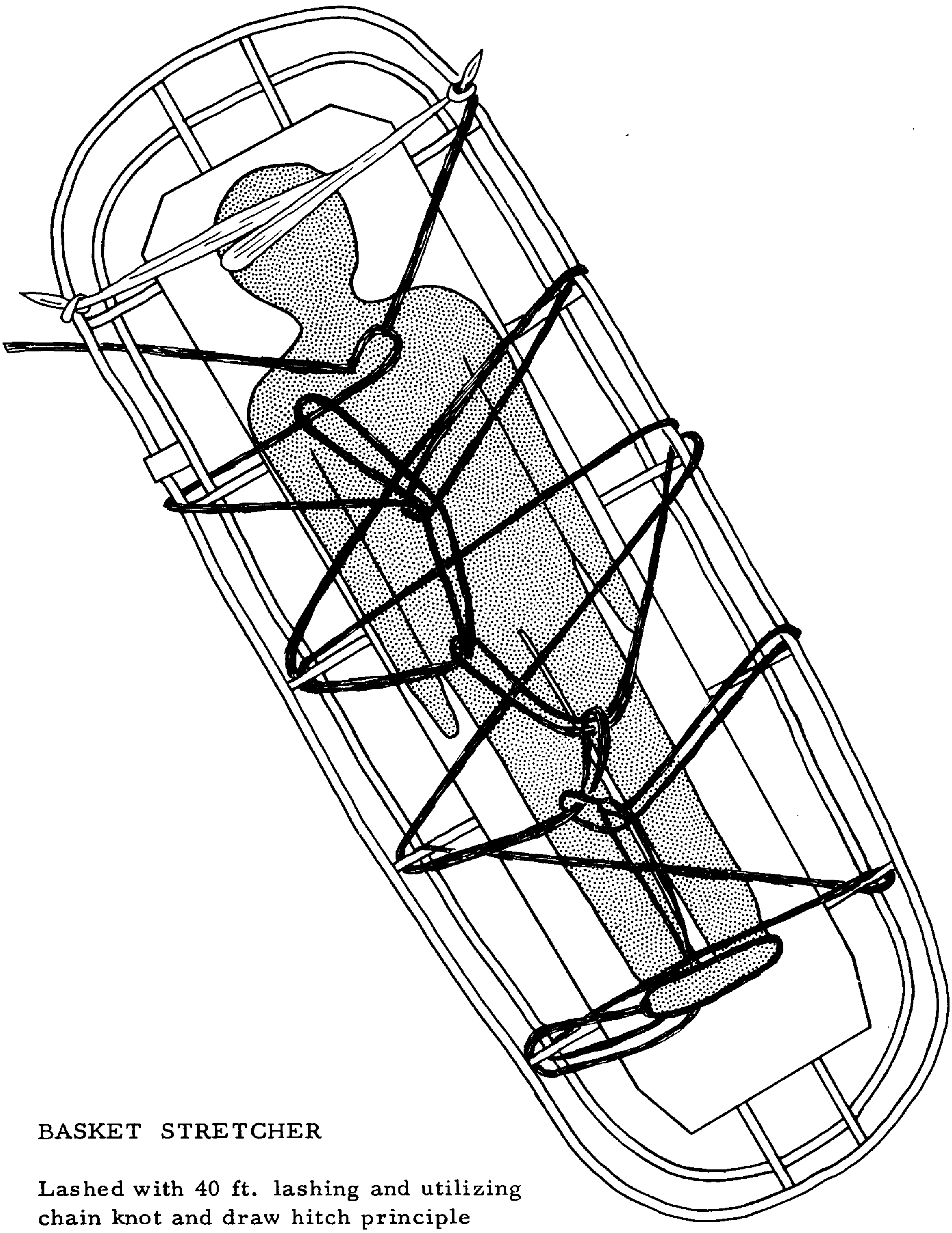
BLANKETING A STRETCHER



SECURING TO A STRETCHER



AN IMPROVISED LASHING

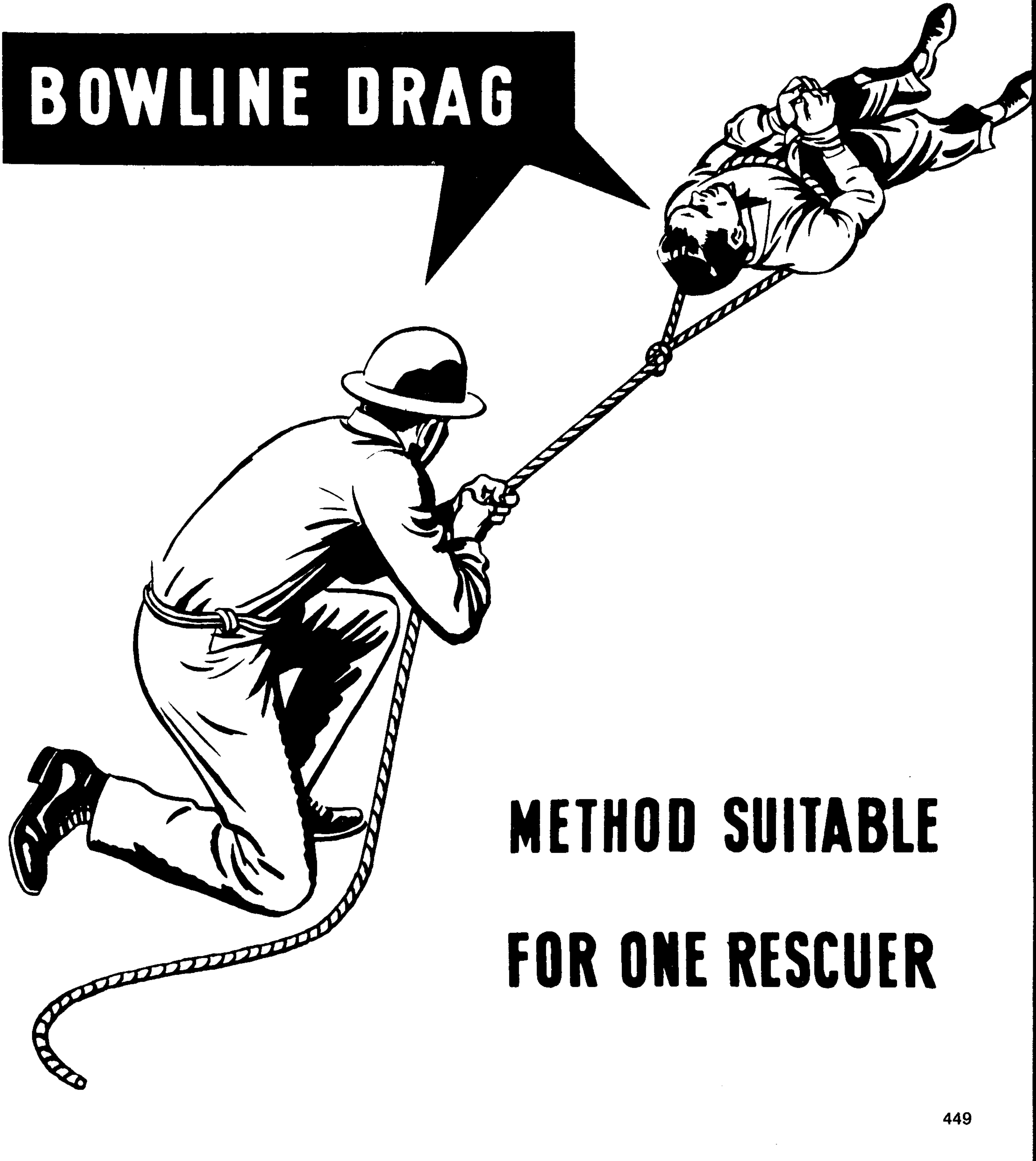


BASKET STRETCHER

Lashed with 40 ft. lashing and utilizing chain knot and draw hitch principle

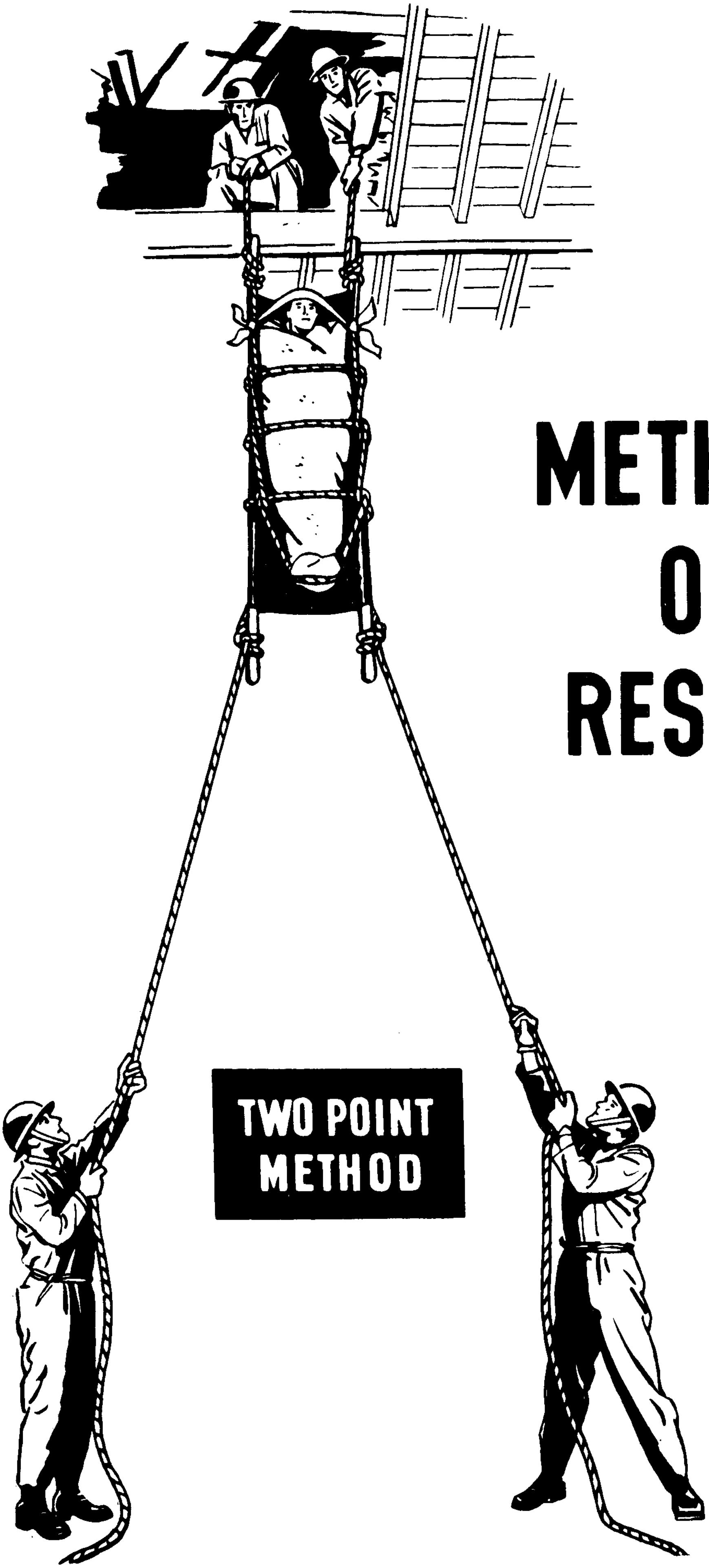
TRANSPORT OF CASUALTIES

BOWLINE DRAG



METHOD SUITABLE

FOR ONE RESCUER



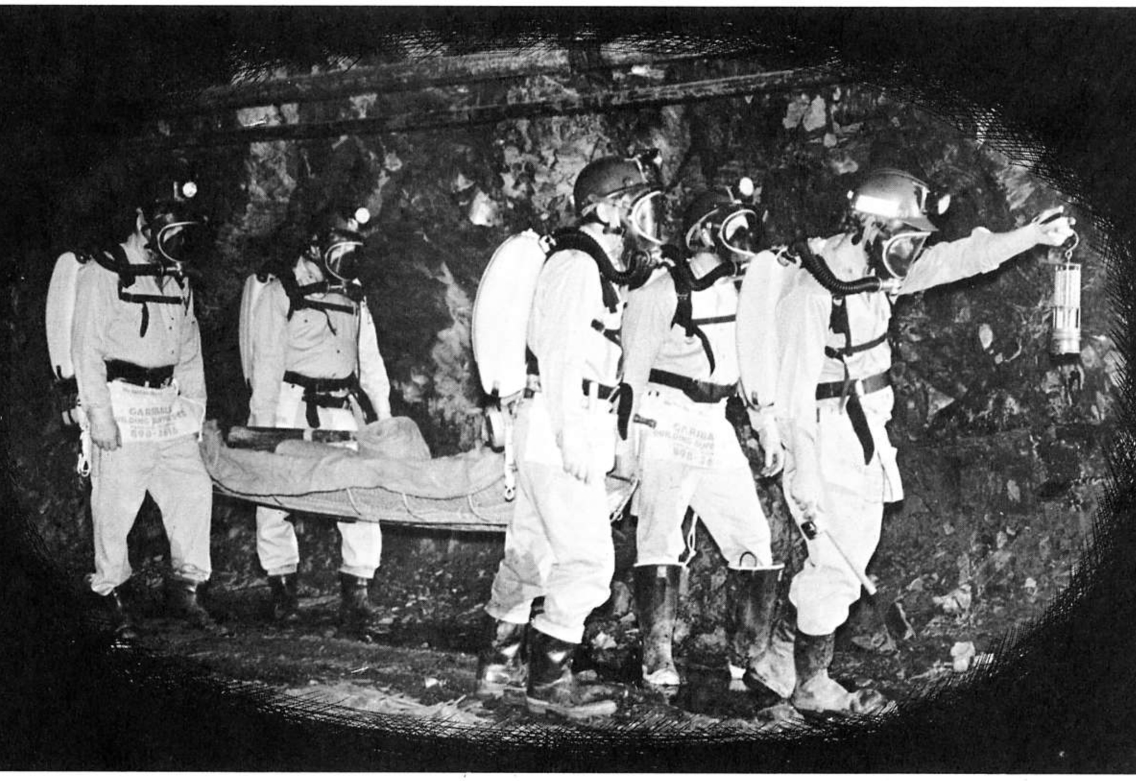
METHODS OF RESCUE

TWO POINT METHOD

APPENDIX 13

GENERAL UNDERGROUND MINE RESCUE MANUAL

Province of
British Columbia
Ministry of
Mines and
Petroleum Resources



General Underground Mine Rescue Manual

INSPECTION AND ENGINEERING DIVISION

VICTORIA, BRITISH COLUMBIA

CANADA

February, 1977

TABLE OF CONTENTS

INTRODUCTION

In 1958 a major coal mine disaster occurred at a mine in Springhill, Nova Scotia. The newspapers, radio and television carried reports of the tragic loss of life and destruction caused by the disaster. There were many newspaper photographs and television scenes of the grief-stricken families of missing men waiting near the mine for news of their loved ones.

As soon as the disaster occurred, mine rescue teams were assembled at the mine and there was the task of entering the mine to search for and rescue survivors and to recover the bodies of the less fortunate.

After several days of mine search and rescue operations the news media began to carry stories to the effect that hope was fading for the chance of rescuing any more trapped miners.

Under the direction of the disaster co-ordinator, the rescue teams, however, continued their task of exploring the mine. Then, after seven days of being trapped in the mine, another miner was found alive and was brought to the surface. The mine rescue team continued their laborious and dangerous task.

All hope of finding additional survivors now indeed seemed lost. Even the mine management issued statements that there was virutally no chance of finding more survivors. Mine rescue crews continued their work, but their task now seemed that of recovering bodies.

And then the seemingly impossible happened. After fourteen days a group of miners was found alive in a remote part of the mine. These men were weak and hungry, but they had not given up hope as they knew the mine rescue men would find them. And find them they did after many, many days of searching and working their way through the rubble and debris of the mine explosion. After many days of hazardous, demanding, physical exertion they had the knowledge that they, through their skill and training in mine rescue work and through their dedication to the principles of mine rescue, had saved the lives of their fellow workmen.

What further reward is needed than to know that without their efforts these men would not have lived. What further incentive to take mine rescue training is required than to know that you may someday rescue a miner from death in a mine disaster and to know that another man will be there to help you should you be the one who is trapped.

There have been, over the years, many accounts of mine disasters and always the attention of the world is focussed on the mine entrance where the mine rescue teams emerge with news of survivors and of conditions in the mine.

Mine rescue teams are highly trained, skilled personnel. Their work is demanding and, at times, dangerous. It requires men in good physical condition and of a calm temperament. They must have an intimate knowledge of their equipment and possess the many other skills required to accomplish their rescue missions.

They may never be required to put their training to use, in fact only a small percentage of trained mine rescue men will ever be called on for actual rescue work. If, however, the need should arise, mine rescue men will be ready to go to the aid of their fellow workmen.

The mining laws in British Columbia require that trained mine rescue personnel and mine rescue equipment be maintained at all mines. To this end, basic mine rescue training courses are conducted at mining properties so that miners will have the opportunity of learning the skills necessary to the mine rescue man.

Once the basic skills of the mine rescue man are learned, many hours of team training and practice are required to develop a competent mine rescue team, a team that can work together and, with other teams, to accomplish rescue objectives in the event of a mine disaster.

On several occasions in recent times, British Columbia Mine rescue men have been called on to assist in disasters both in British Columbia and in other areas. It is a tribute to the skill, training, and courage of these men that they have always performed in an exemplary manner, which has brought praise and recognition of their efforts.

The Mine Rescue Certificate and the "MINE RESCUE" sticker on your hard hat are things to be proud of, for they tell the world that you are concerned and that you really care about your fellow workmen. You care to the extent that you have been willing to devote many hours of study and work to acquire the skills of the mine rescue man.

J. W. Peck, P. Eng.,
Chief Inspector of Mines.

THE MINE RESCUE TEAM

In British Columbia a full mine rescue team consists of six qualified mine rescue men. Each man must hold a valid mine rescue certificate, be in good physical condition with a current certificate of fitness and should have had recent practice with rescue breathing apparatus.

Six qualified mine rescue men do not, however, make a mine rescue team unless they regularly practice and drill as a team. It is only through regular practice together that the men can work effectively as a team and it is only through regular practice that each team member will develop the confidence he must have in his fellow team members.

Team work is important in any team endeavour, but in mine rescue work the life of every member of the team is dependent on the actions of each man.

If a basketball team or a hockey team does not work well together they will probably lose a game, but if a mine rescue team does not work effectively as a team, then their very existence is at stake. The importance of co-operation and team work by the various members of a mine rescue team cannot be over-emphasized.

THE TEAM CAPTAIN

One member of the mine rescue team will be the team captain and he will direct the actions of the team at all times.

As the general safety and operation of the team and the rescue work to be carried out are under the supervision and direction of the captain, the qualifications of a team captain are very demanding.

The team captain must have an excellent knowledge of mine gases. He must know the physiological effects of the gases, the explosive range and flammability of the gases. He must know the relative weight and sources of gases, how to test for them and he must know how to treat persons affected by them. Many of the decisions made by a mine rescue captain in search and rescue work are dependent to a great extent upon the gaseous conditions in the mine and, unless he has an intimate knowledge of gases, the captain cannot make intelligent decisions.

One of the most important single factors affecting the safety of mine rescue personnel and men trapped in mines is mine ventilation, although in actual disaster work the major decisions of fire fighting and re-establishing mine ventilation will be made by the disaster co-ordinator. The mine rescue team captain must also have a good knowledge of this subject.

The mine rescue team's travel through the mine is affected by the ventilation existing at the time and actions taken by the team will affect ventilation. The team captain's knowledge of ventilation must be such that he can make correct on-site decisions and thereby not endanger his team or others in the mine.

The team captain must know how to use the various instruments required for measuring air flows and air pressures in mine workings and he must be able to do basic interpretations of the results of such readings. He must know if he should open a door or close it, what effects a seal on a fire will have on air flows and what effect the fire will have if it is not sealed. He must, in other words, have an excellent basic understanding of the factors that affect air flows in mine workings.

The mine rescue team captain must know how to fight fires, how to erect mine timber, how to build fire stoppings, he must be able to quickly assess hazards, he must know how to treat injured men and how to transport them. He must have a good practical knowledge of mining.

The team captain has other men on his team, some of whom may have more detailed knowledge of certain subjects than he, but he must be able to make the decisions and direct the work of the team.

The most important quality required of a mine rescue team captain is that of "Leadership". He must have the confidence and respect of his team members. He must be calm and cool-headed. He must be able to think clearly under pressure and he must be able to instill a feeling of "esprit de corps" or of each team member belonging to and being a vital part of the team. Each member of a team must have the utmost confidence in his captain and should be willing to follow him to "hell", if need be.

The mine rescue team captain is No. 1 man on the team and must, first and foremost, be a competent leader.

THE VICE-CAPTAIN

The vice-captain of a mine rescue team is the No. 5 man.

In the event that something should happen to the captain, the vice-captain must take over control of the team and he, therefore, must have similar qualifications to the captain.

When a mine rescue team travels through a mine, the team is led by the captain and the vice-captain generally brings up the rear. One of the vice-captain's main functions while travelling is to keep an eye on all members of the team and to warn the captain, should any member show signs of distress. The vice-captain is a second pair of eyes for the captain and, in addition to watching the team members, the vice-captain will keep a sharp look-out for any condition missed by the captain. He should keep in mind that the captain has a heavy responsibility and that his mind is occupied by many matters and, therefore, may not notice all the details that the vice-captain may notice. The captain should be advised by his vice-captain if it appears that a significant factor has been missed.

The actual distribution of jobs amongst team members may vary from team to team, however, it is very common practice to have the vice-captain assist the captain in gas tests and ventilation tests. He also makes close checks of team members during rests and does what he can to relieve the captain of routine duties so that the captain can devote his efforts to the heavy responsibility which he carries.

NO's. 2, 3, and 4 TEAM MEMBERS

Various other duties are distributed amongst the other team members. One man usually has special expertise in first aid and he will carry out most of the first aid work required. Another man may be assigned to fighting small fires and will have extra training in the use of fire extinguishers. Someone will probably be more competent in mine timbering work and someone will have special knowledge of electricity, etc.

As mine rescue teams are being assembled, consideration must be given to the special skills that may be required and team members should be chosen with these factors in mind. The special skills required will vary from mine to mine.

THE FRESH AIR BASE MAN

Although a complete mine rescue team consists of six men, only five men normally proceed beyond the "Fresh Air Base".

A Fresh Air Base is, as the name implies, a base at which good respirable air has been established. It is the point of departure for the mine rescue team and no one should proceed beyond the fresh air base unless they have respiratory protection apparatus with them.

When the mine rescue team leaves the fresh air base, the fresh air base man is under instruction given to him by the captain in charge of the base.

It is the fresh air base man's responsibility to guard the fresh air base and to assure that no one travels beyond this point and to take charge of anyone who should reach this base from within the mine workings.

If communication lines are used by the rescue team, the fresh air base man will keep in touch with the team, will record information sent out by the team and relay messages to them.

When the captain is present at the fresh air base the base man will carry out duties assigned by the captain. Such duties will probably include assembling, packing, and preparing supplies needed by the team.

The Fresh Air Base Man should have a good knowledge of first aid and especially of oxygen therapy procedures. When men are brought out of the mine workings to the fresh air base, the base man will immediately take over treatment of injured men so as to relieve the rest of the rescue team for further work or to allow them to rest.

If the mine rescue team does not return to the fresh air base within the specified time, the fresh air base man must see to it that back-up teams are sent to their assistance.

The Fresh Air Base Man has a very important function and requires a decisive personality with the ability to maintain control and order at the fresh air base. He must have an excellent knowledge of first aid and of the equipment and supplies used by the team.

In summary then, the mine rescue team consists of:

NO. 1 MAN - The team captain, who is in charge of and directs all actions of the team.

NO. 2, NO. 3, AND NO. 4 MEN - The men who have the various skills that may be required of the team. These men work under the direction of the captain to accomplish the objectives of the team.

NO. 5 MAN - The Vice-Captain, who keeps a constant watch on the team and who assists the captain in any way he can. He must be capable of taking over direction of the team in the event of an emergency.

NO. 6 MAN - The Fresh Air Base Man, who is in charge of the fresh air base and will record information sent out by the Captain. It is desirable that he be a senior staff supervisor.

COMMUNICATION BY TEAM MEMBERS

All members of a mine rescue team must observe very strict discipline and must, without question, obey all directions given by the team captain.

Most modern mine rescue breathing apparatus is equipped with a speaking diaphragm, which makes limited voice communication possible between members of the team.

Circumstances can arise in the mine when voice communication is not possible and many team captains find that better discipline is achieved if voice communication is kept to a minimum at all times.

In order to assure that good communication is always possible a standard set of horn bell or whistle signals has been adapted in British Columbia.

The captain and the vice-captain will both carry a horn bell, whistle or whatever is used for signalling and, although most signals will be given by the captain, it may, from time to time, be necessary for the vice captain to signal.

The standard code of signals adopted in British Columbia are as follows:

One - To advance if stopped or at rest.

One - To stop if in motion.

Two - To rest.

Three - Distress, this signal will often by given by the vice-captain as he is observing the team members during travel and will be first to notice signs of distress.

Four - Attention: At his signal all team members will look at the person giving the signal for further instructions.

Five - Retreat: At this signal the team will immediately retreat in the direction from which they have just come.

These basic signals are generally used in conjunction with various hand signals given by the captain to indicate what functions he wishes the team to perform.

Hand signals are not standardized, but are worked out by each team to best suit their operating techniques. The proper use of hand signals is another reason why teams must practice regularly. All team members must know the team's hand signals so that they can be quickly acted upon and so that there will be no confusion as to what is required.

TEAM DISCIPLINE

It is of the utmost importance that the mine rescue team be well trained in the use and care of their apparatus. They must be efficient in performing the various duties they will be called on to do. Their morale must be of the highest, such as constant training and expert knowledge of their apparatus will provide.

The team must act as a unit and obey the signals of the captain and vice-captain promptly and efficiently. The captain must give his signals distinctly and with authority. There must never be any arguing or dissention among the team members while performing their duties.

The captain and his team must have every confidence in their ability to handle any situation with which they may be confronted.

TEAM SAFETY

The safety of the team is of primary importance and is the first principle of mine rescue. The captain must keep his team's safety foremost in mind at all times.

It is, of course, understood that any team that enters a mine after an explosion or to fight a mine fire is taking a calculated risk. The captain must, however, give each situation careful thought before proceeding and must keep the odds in favour of his team at all times.

The captain should advance his team through the mine cautiously, paying particular attention to the roof and sides and to the condition of the mine atmosphere.

The team must be rested regularly and be constantly observed for signs of distress in any member. Work must be distributed as evenly as possible amongst all members.

ROUTE OF TRAVEL

It is fundamental that a rescue team should explore a mine via the fresh air route, wherever possible. There are two good reasons for this practice:

1. The danger to an exploring team is lessened.

2. The fresh air base can be located nearer to the scene of action.

Circumstances prevailing may make it impossible to travel by a fresh air route, but the team captain must always be sure that he has a safe route of retreat for his team and must not chance having his team "cut-off" from a means of retreat.

The route of travel must always be properly marked by an advancing mine rescue team. The two principal reasons why this is done are:

1. So that the team can retrace their travel route on the way out of the mine. Under conditions of poor visibility or in complicated mine workings it is not difficult to lose one's way. Marking the travel route will prevent the team from becoming lost.

2. If the team should get into trouble and cannot get out of the mine, a team coming to their assistance can find them by following their route markers.

The travel route is marked by either trailing a communication line or by marking the route with chalk or paint at key points on their route. If chalk is used, an arrow should be positioned on the walls at key points and the arrow should point in the direction from which the team has come.

If the team should retrace their steps route markers should be cancelled.

The details of the method of route marking must be understood by all back-up teams.

All team members must remain in visual contact with one another at all times and if this is not possible, due to poor visibility, the members must keep in physical contact by using life lines or by some other means, such as holding hands, carrying a stretcher, etc. Team members must never become separated.

Extreme caution must be used when travelling under conditions of poor visibility as any hazard is compounded if it cannot be seen.

When any work is being performed by the team, such as building stoppings, timbering, baring, etc., the captain or vice-captain must keep a constant vigilance to be certain that team members are not exposed to danger and, once again, work should be distributed as evenly as possible amongst the team members so that no individual becomes unduly fatigued.

TESTING THE MINE ATMOSPHERE

One of the most important considerations of mine rescue and recovery work is the condition of the mine atmosphere. The captain, possibly with the vice-captain's assistance, makes all gas tests and keeps a detailed record of the conditions encountered. All team members should be kept informed of the condition of the atmosphere.

In addition to checking the atmosphere, the amount and direction of air movement must be noted and nothing must be done to change ventilation until the results are known.

STRETCHER PROCEDURE

When exploring a mine, the supplies, tools, etc., used by the team are usually carried on a stretcher. The stretcher is then, of course, available for transporting casualties.

Whenever the width and condition of the roadway permit, the Nos. 2, 3, 4, and 5 team members should share the weight of the stretcher. Tests should be made frequently and team members allowed to change hands on the stretcher. At times, of course, only two men may be able to carry the stretcher. Under such circumstances more frequent rests will be required and the members should spell one another off.

CARE OF MEN FOUND IN THE MINE

When injured men are found in the mine they must be properly treated and given the necessary respiratory protection. If they are found in a dangerous atmosphere, breathing apparatus should be supplied to them and, if possible, they should be moved to an area of good air. They should be taken to the fresh air base if safe to do so or they should be isolated in an area where there will be the minimum possible exposure to dangerous gases. Refuge stations may be used for this or it may be necessary to seal men in temporary refuge stations.

The mine rescue team must be certain the men know how to use any breathing apparatus supplied and, if necessary to leave them temporarily, they must be assured that they will be safe and that they must remain in one place.

What is done with men who are found will depend on prevailing conditions, but they must not be exposed to further danger and they must know that they will be looked after. Proper first aid procedures must be followed for all injuries.

All men found should be identified and their locations indicated on mine plans.

If dead persons are found they must be identified and left in the mine until the living are taken care of.

It may be necessary to physically restrain irrational persons to prevent them from injuring themselves. Persons who are not irrational should never be tied up or otherwise restrained.

When men are being brought from the mine they should be closely watched and prevented from "bolting" as fresh air is neared.

Persons being rescued should always travel between rescue team members.

MINE FIRES

Small controllable mine fires should, of course, be extinguished when they are encountered.

Larger fires in dead end headings can be isolated by temporary seals when they are encountered and when it is certain that the seal will not affect overall mine ventilation.

Large uncontrollable fires can only be reported to the co-ordination centre and no attempt should be made to seal these until directed by the co-ordination centre.

In general, the initial job of the mine rescue team is to explore the mine, doing the work necessary to facilitate the exploration, to treat and rescue, if possible, or to isolate persons found in the mine, to note and record conditions found in the mine, and to report the findings to the disaster co-ordination centre.

When mine rescue teams have provided the co-ordination centre with the necessary information about the mine disaster, the persons directing the operation will give teams specific tasks to do, with the objective first of saving men in the mine and then, of preventing further damage to the mine and of restoring it to operation.

The team then will explore and report, rescue, control, and rehabilitate.

This brief summary of the make-up and duties of a mine rescue team will make the importance of the subjects in following chapters more apparent to the student.

FUNDAMENTAL PRINCIPLES OF MINE RESCUE TRAINING ARE, IN ORDER OF IMPORTANCE :

1. Ensuring the safety of the Rescuing Team.

2. Endeavouring to rescue or ensuring the safety of the lives of the trapped men.

3. Protecting the mine property from further damage.

4. Rehabilitating the mine.

THE MECHANICS AND FUNCTION OF BREATHING

Many gases found in a mine during normal times can have a harmful effect on the human body if breathed for a period time in concentrations above the recognized safe limit for that time period.

At the time of a fire in an underground mine great quantities of deadly gases can be given off. The biggest problem confronting the miner at the time of a mine fire is the protection of himself from such gases.

Even during normal times certain circumstances can cause the accumulation of gases or conditions of the air that would make the air harmful to breathe.

Most dangerous gases have a harmful effect on us after they have entered the body as we breathe. If we have an understanding of what happens when we breathe we can better realize what we must do and why we must do it to protect ourselves from the various dangerous gases.

MECHANICS OF BREATHING

When we wish to breathe in, the muscles of our chest surrounding the lungs and our diaphragm lying below the lungs pull away from the lungs. This has the same effect as the bellows on an accordion when they are pulled open. A vacuum is created in the lungs by this chest expansion and the outside air rushes in to fill the vacuum.

The air enters the body by way of the nose and throat (pharynx), passes through the voice box (larynx), and then down the wind pipe (trachea), and bronchial tubes to the lungs.

When we breathe out, the muscles of the chest and the diaphragm push inward against the lungs. Once again this has the same effect as when we push in on the accordion bellows. The air is forced out of the lungs and takes the same path to the outside air as it took on entering.

It can be seen then that air can only get to the lungs if the passage ways are clear of obstructions and if the muscular action takes place to cause the expansion and contraction of the chest cavity.

Some gases when breathed can cause the air passages to swell and become obstructed or they can cause an interference with the muscular action that moves the chest and diaphragm.

The muscular action which causes us to breathe is controlled by a portion of the brain at the base of the skull. This portion of the brain is stimulated and controlled by the amount of carbon dioxide gas in the blood.

In summary then, the mechanics of breathing can be likened to a set of bellows. When contracted the air is forced out and when expanded the air is pushed into the bellows by the pressure of the atmosphere. The bellows of our lungs are expanded and contracted by our chest muscles and diaphragm. These muscles must be free to work and before air can enter the lungs the passage ways must be clear.

THE FUNCTION OF BREATHING

The preceding pages have outlined in a simplified way how we breathe, that is how we get air in and out of our lungs. But why do we breathe? What is the purpose of pumping this air in and out?

Everyone knows that normal air contains a certain amount of oxygen and that oxygen is required for life. It is the oxygen content of the air that our body requires and the lungs have a way of making the oxygen content of the air available for use by the body.

Just as a fire cannot burn without oxygen so the human body cannot "burn" or use digested food stuffs to produce energy unless it has a supply of oxygen.

When oxygen enters the lungs it is distributed to the millions of tiny air sacs of which the lungs are composed. These tiny air sacs or compartments have walls so thin, that the oxygen in the air can pass through the walls of the sacs into the blood itself.

Blood is composed of red and white cells carried in an almost colourless liquid called plasma. A part of the red cell is called haemoglobin (pronounced heem-o-glow-bin) and the haemoglobin attracts oxygen to it.

As the blood circulation brings the red cells into contact with the air sacs of the lungs the oxygen is attracted to the haemoglobin. The haemoglobin then carries the oxygen throughout the body where it does its part in the energy-producing combustion of the digested food stuffs.

On the blood's return trip to the lungs it carries with it the carbon dioxide that is produced as a waste product of the combustion. As the blood passes the air sacs in the lungs it picks up more oxygen and the carbon dioxide is forced out of the bolod into the air sacs. The carbon dioxide is then breathed out with our exhaled breath.

We can see then that as we breathe, fresh oxygen is carried to the blood by way of the air sacs in the lungs and carbon dioxide is picked up from the blood by the air sacs and is breathed out into the air.

As the energy-producing combustion and body-building processes cannot carry on without oxygen, just as a fire cannot burn without oxygen, it is obvious that without oxygen our bodies cannot continue to live.

Anything that interferes with the steady flow of oxygen to the tissues of the body will slow down or damage the body's function.

OXYGEN THERAPY

This is a method of administering 100 per cent oxygen by inhalation, to victims of asphyxia from gas, carbon monoxide, smoke, fumes, and suspended respiration from electric shock, drowning, collapse, and other causes.

The approved oxygen equipment consists of the following:

A. Control Assembly (regulator) with approved Pin Indexed Yoke
B. 2 Oxygen Bottles (either D or E bottles accepted)
C. 2 Plastic Type Masks (disposable)
D. 2 Airways (adult size and small size)
E. Suitable Wrenches for Medical Post
F. Carrying Case or Pack Board

When the bottles have been received from the supplier, or have been returned after being recharged, there is usually a piece of plastic tape covering the oxygen aperture. (There is usually a new gasket under this tape.) N. B. Use ONLY approved Gaskets as supplied. This part of the bottle is known as the medical post. You will have noted the aperture for the flow of oxygen, and directly below this are two small holes; this is known as pin-indexing. The purpose of this pin-indexing is to prevent the use of other gases. All different gases are contained in bottles with appropriate pin-indexing, and the equipment used can only be attached to the appropriately pin-indexed bottle. Before attaching the unit, you must first remove the tape and "crack" the bottle. (Literally this means to open the valve on top of the medical post to allow some oxygen to escape.) The reason for this is to clear out any dust or foreign material that may be lodged in the aperture.

The yoke is now placed over the medical post, and when it is in position and gasket in place it is tightened with the hand screw. BEFORE OPENING VALVE ON THE BOTTLE MAKE SURE THE REGULATOR IS TURNED OFF. TURN COUNTER CLOCKWISE. When the valve on the bottle is turned on, you will get a reading on the high pressure gauge which tells you the amount of pressure in the bottle.

Attach the tubing from the mask to the unit, and open the regulator valve clockwise to the required flow, usually six litres is adequate, and allow this to flow through the mask and tubing for a few seconds before placing the mask on the patient. It is advisable to allow this flow in order to clear out any fluid or dust that may be lodged in the tubing. It is difficult to wash and sterilize the mask without having some of the fluid fouling the mask or tube. Many patients have never seen oxygen equipment and it may cause some uneasiness or alarm; to minimize this with a conscious patient it is probably reassuring to the patient to allow him to hold the mask to his face with the oxygen flowing and when he is accustomed to it slip the elastic band of the mask over his head to hold the mask in position. It is always advisable to have the oxygen flowing when applying the mask.

When the patient's respiration and pulse are normal, or nearly so, you can discontinue the use of oxygen.

The equipment must be stored until further need for it. THE OXYGEN FROM THE BOTTLE IS SHUT OFF (VALVE ON TOP OF MEDICAL POST) "BLEED" OUT THE OXYGEN IN THE GAUGE SO THAT THE GAUGES READ "NIL". This is very important as the gauges can be damaged if left continuously under pressure.

The mask is now sterilized. PLASTIC MASKS OF THIS TYPE CANNOT BE AUTOCLAVED OR BOILED. Cold sterilization is done by carefully washing the mask with some good soap, then using a good antiseptic such as Zephiran Chloride 1/1000 solution as recommended by the manufacturer. Lacking this, a strong solution of Dettol is acceptable. NEVER USE ALCOHOL AS IT WILL DAMAGE THE MASK.

SAFE PRACTICES IN OXYGEN THERAPY

THE FOLLOWING RULES SHOULD BE STRICTLY OBSERVED:

1. Keep oil, grease, greasy clothing, and similar substances away from oxygen regulators, mask, or patient. Remember that oil coming in contact with oxygen under high pressure can explode violently.

2. No smoking should be permitted in a room where oxygen therapy is proceeding. Make sure your patient does not possess matches or smoking material. This NO SMOKING rule should be rigidly enforced and signs to that effect should be posted conspicuously in your First Aid Room.

3. Do not use Electrical heating devices or infra red lamps on a patient while oxygen therapy is in progress.

4. UNQUALIFIED PERSONS SHOULD NEVER attempt to refill a cylinder with makeshift equipment, or under any other circumstances. The refilling of small cylinders from larger ones is extremely hazardous and should be avoided. Return your empty cylinders to qualified charging plants for refilling under recognized safety and control procedure.

5. Do not store Oxygen cylinders near flammable or combustible materials such as oil, grease, gasoline, alcohol or ether, or near sources of heat such as boilers or steam pipes. Store in a cool place. Although oxygen itself does not burn or explode on contact with flame, it violently supports combustion.

6. Keep Oxygen cylinders in service or in storage secured in an upright position. Do not permit them to be dropped or to strike each other violently, as a valve might be opened whereupon the cylinders could become a dangerous projectile.

7. Before attaching gauges or regulator to cylinder, "crack" the cylinder valve in order to clear out any foreign matter which may be in aperture. Turn opening away from you while doing so.

8. After regulator is in place, attach the facepiece, making sure that the litre flow regulating valve is in the "off" position. Then turn on cylinder valve. This should give the tank pressure reading on the pressure gauge. When assured that this gauge is operated properly, turn on litre flow valve to desired flow. This will clear out any moisture or foreign matter which may be in the tubing. You may then apply the face piece or mask to the patient.

Observance of these rules may prevent serious and utterly unwarranted accidents.

ON THE THRESHOLD OF UNDERSTANDING

A great deal of attention will be paid to the toxicity of chemicals as they affect the human body. All chemicals used in industry that have a toxic effect on workers will have a maximum allowable concentration to which the employee can be exposed for an eight hour day. These concentrations will be expressed in parts per million (P. P. M.)

For many of us, "1 ppm" is about as hard to visualize as the national debt. The following from Forestry Facts helps indicate what one part per million really represents under various conditions:

1 ounce of sand in 31 tons

1 inch in 16 miles

1 minute in 1.9 years

1 ounce of dye in 7,503 gallons

1 square inch in 1/6 acre

1 pound in 500 tons

1 cent in $10,000 dollars

1/6 inch thickness in a pile 1 mile high

Keep these comparisons handy somewhere--they might sharpen your threshold limit sense of values.

MINE GASES, THEIR OCCURRENCES, PROPERTIES, EFFECTS ON HUMAN BEINGS, AND TREATMENT OF PERSONS AFFECTED BY THEM

AIR

Air is the transparent medium surrounding the earth in which plants, animals, and human beings live and breathe. It is a mixture of several gases which, though ordinarily invisible, can be weighed, compressed to a liquid, or frozen to a solid.

Pure dry air at sea level contains by volume the following gases: Oxygen (O_2), 20.94%; Nitrogen (N_2), 78.09%; Carbon Dioxide (CO_2), 0.08%; and Argon (Ar), 0.94%. Traces of other gases such as hydrogen, helium, etc., are also present.

The air in a well-ventilated mine seldom shows any depletion of the oxygen content.

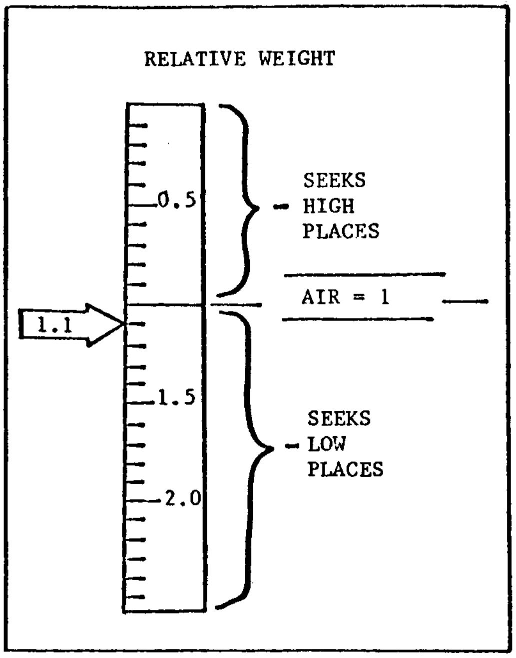
Mine air may be contaminated by the presence of other gases such as carbon monoxide, sulphur dioxide, hydrogen sulphide, methane, oxides of nitrogen, and excess carbon dioxide. The presence of these gases may be due to any of the following:

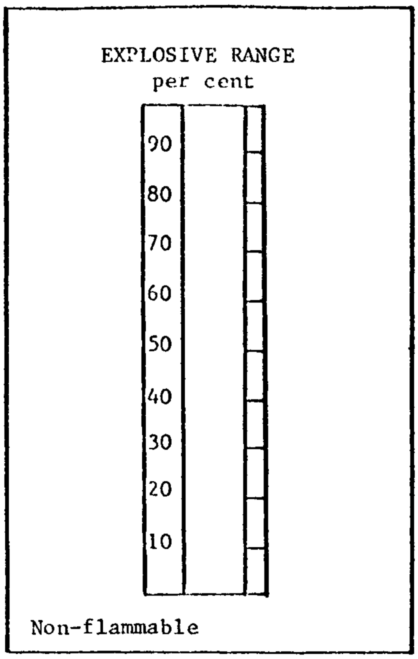
1. after effects of blasting or other explosions
2. after effects of mine fires
3. exudations from ore or country rock, as with methane
4. decay of mine timber
5. absorption of oxygen by water or oxidation of timber or ore
6. use of diesel motors underground
7. gas carried with thermal water - carbon dioxide

Except in the case of fire, positive ventilating currents of sufficient quantity will prevent any dangerous accumulation of these gases. Gases may affect people either by their combustible, explosive, or toxic qualities, or, if inert, by the displacement of oxygen. The effects may be due to varying atmospheric conditions and may be classified as follows:

ALTITUDE: Breathing becomes more laborious due to the decrease in oxygen content as the altitude increases. This is not dangerous unless conditions are extreme or the labour arduous.

GAS OXYGEN (O_2) and oxygen deficiency





OTHER PROPERTIES

COLOUR: NONE

ODOUR: NONE

TASTE: NONE

OTHER: Detected by candle, safety lamp, these go out at approximately 16 per cent oxygen

HOW DEPLETED

Oxygen deficiency caused by humans breathing in confined space, absorption of oxygen by water, oxygen being consumed by fire, etc.

THRESHOLD LIMIT VALUE AND EFFECT ON HUMANS

Mine air should have at least 19.5 per cent oxygen. High concentration not harmful. Essential to life. Early symptoms of oxygen deficiency - buzzing in ears, rapid breathing, confusion of mind, unconsciousness

TREATMENT OF PERSONS AFFECTED (oxygen deficiency)

Remove to fresh air, give oxygen - artificial respiration if breathing stopped.

HUMIDITY: High temperatures with high humidity are very enervating and cause considerable discomfort.

TEMPERATURE: High temperatures with low humidity are not dangerous except from the blistering effect of heat.

IMPURE AIR:

1. Air deficient in oxygen is not dangerous unless the oxygen content is below 16 per cent, or unless the oxygen has been displaced by toxic gases.
2. Non-toxic gaseous impurities are not dangerous unless gases have displaced the oxygen content to below 16 per cent.
3. Some toxic gaseous impurities, even in very low concentrations, have deadly effects. Effects may be sudden or gradual according to the concentration of impurity.

OXYGEN - (O_2)

Oxygen, a colourless, odorless, tasteless gas is the most important constituent of air. It is necessary for the support of life and combustion. Men breath most easily and work best when the air contains approximately 21 per cent of oxygen, but they can live and work, though not as well, when there is less oxygen. When the oxygen content is about 17 per cent, men at work will breathe a little faster and more deeply. The effect is about the same as when going from sea level to an altitude of 5,000 feet. Men breathing air containing as little as 15 per cent of oxygen usually become dizzy, notice a buzzing in the ears, have a rapid heartbeat, and often suffer headaches. Very few men are free from these symptoms when the oxygen in the air falls to 10 per cent. Mine air should contain not less than 19.5 per cent oxygen.

The flame of a safety lamp or candle is extinguished when the oxygen falls to about 16.0 per cent. A carbide lamp flame will burn in an atmosphere containing as little as 12.5 per cent of oxygen.

Since oxygen is more soluble in water than nitrogen, air in a confined area, when exposed to water, will probably have a lowered oxygen content. As an example: the oxygen content of the air from a hydraulic compressed air plant is lowered to about 17.7 per cent of oxygen and a consequent rise in nitrogen content occurs.

Oxygen percentage higher than the normal 20 to 21 per cent apparently has no injurious effects on men. This is found to be the case in the use of self-contained oxygen breathing apparatus. There is no noticeable effect after successive periods of wear. Oxygen in high percentages, as used with the oxygen breathing apparatus, helps men to work with less fatigue. However, it is dangerous to breathe pure oxygen at pressure much higher than 15 pounds per square inch for a very long time. Lorrain Smith, the well-known physicist, states that irritating effects of oxygen are only found in human beings after they have been exposed for 48 hours or more in an atmosphere containing 80 per cent oxygen.

The effects of oxygen deficiency near or below sea level are the same as those due to the reduction of oxygen to high altitudes. At approximately 7 per cent of oxygen the face becomes leaden in colour, the mind becomes confused, and the senses dulled. When there is no oxygen in the atmosphere, loss of consciousness occurs in a few seconds without any warning symptoms. J.S. Haldane, the British physicist, says that loss of consciousness in air deprived of oxygen is quicker than in drowning; not only is the supply of oxygen cut off, but oxygen previously in the lungs is rapidly removed and used up; loss of consciousness is quickly followed by convulsions, then by cessation of respiration. Oxygen may be so lacking as to imperial life before one realizes the danger.

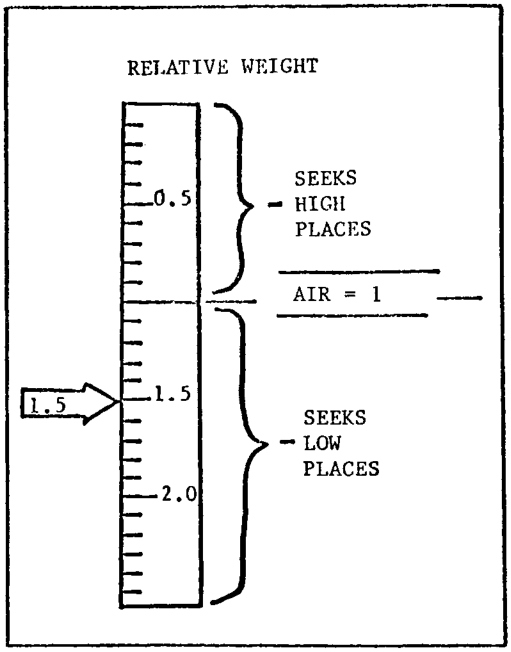
Some of the causes of oxygen deficiency underground are:

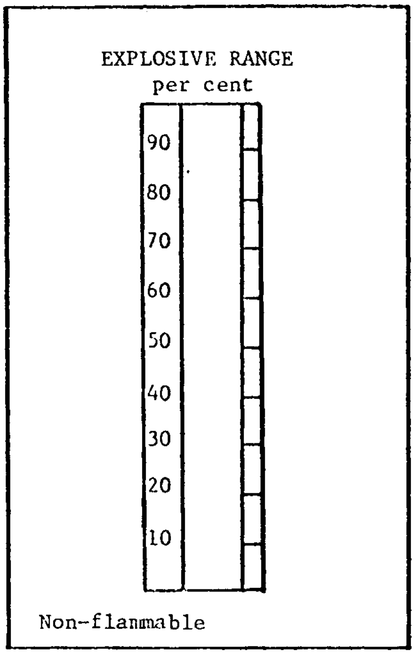
1. absorption by water or certain types of rock, ore, or fill
2. the breathing of men in confined space
3. displacement by carbon dioxide, carbon monoxide, or other gases
4. heating conditions or combustion

OXYGEN DEFICIENCY

Oxygen Present	Effect
21%	Breathing easiest
17%	Breathing faster and deeper
15%	Dizziness, buzzing noise, rapid pulse, headache, blurred vision
9%	May faint or become unconscious
6%	Movement convulsive, breathing stops, shortly after heart stops

GAS CARBON DIOXIDE (CO_2)





OTHER PROPERTIES

COLOUR:	NONE
ODOUR:	NONE
TASTE:	Acid if breathed in large quantities.
OTHER:	

HOW FORMED

Oxidation of organic materials, rotting timber, burning wood, blasting, diesel engines, humans breathing and as a product of complete combustion of organic materials.

THRESHOLD LIMIT VALUE AND EFFECT ON HUMANS

T.L.V. = 5,000 ppm - stimulates breathing; 50,000 ppm - increases respiration 300 per cent; 100,000 ppm - can be endured for only short periods.

TREATMENT OF PERSONS AFFECTED

Remove to fresh air, give oxygen, artificial respiration if breathing stopped.

CARBON DIOXIDE (CO_2)

Carbon dioxide, an inert gas, is a product of the decomposition and/or combustion of organic compounds in the presence of oxygen, and also of the respiration of men and animals. It is a colourless, odorless gas which, when breathed in large quantities, may cause a distinctly acid taste. It will not burn or support combustion. Carbon dioxide, being heavier than air, is often found in low places and abandoned mine workings, and is a normal constituent of mine air. The proportions of carbon dioxide in mine air is increased by the process of breathing, by the burning of flame lamps, by fires, explosions, and blasting, or by escaping with thermal water. Clinical investigations indicate that carbon dioxide influences the respiratory rate. This rate increases rapidly with increasing amounts of carbon dioxide.

The following table shows the effect upon a human being of increasing amounts of CO_2 in the air breathed:

%CO_2 in atmosphere	Increase in respiration
0.05	slight
2.0	50%
3.0	100%
5.0	300% and laborious
10.0	Cannot be endured for more than a few minutes

Carbon dioxide in air has these effects when the oxygen content remains approximately normal and the individual is at rest. Moving around or working increases the symptoms and the danger is greater than when the individual is resting. Concentrations of over 5 per cent of carbon dioxide in the air are usually accompanied by an appreciable lowering of the oxygen content. Carbon dioxide in mine air should be not more than 0.50 per cent.

PHYSIOLOGICAL EFFECTS OF CARBON DIOXIDE

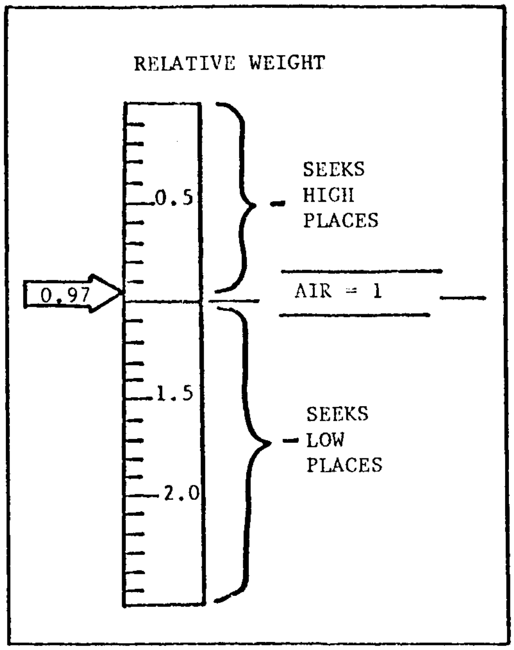
Percentage of Carbon Dioxide in the Atmosphere	Increase in respiration
.5	Maximum allowable for an 8-hr. day
0.05	Slight
2.0	50%
3.0	100%
5.0	300% and laborious
10.0	Cannot be endured for more than a few minutes

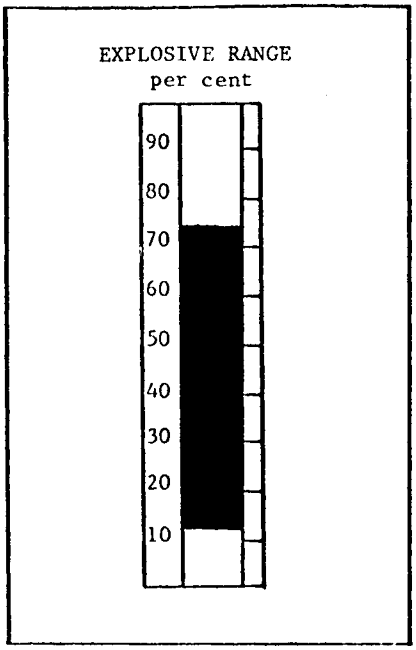
Concentrations of over 5 per cent of carbon dioxide in the air are usually accompanied by an appreciable lowering of the oxygen content.

NITROGEN (N_2)

Nitrogen is a colourless, odorless, inert gas. It is not combustible, nor will it support combustion. It has no physiological effect on men and is only dangerous if it occurs in such concentrations that it dilutes the air sufficiently to cause the oxygen content to fall below a safe limit. This dilution may result from the oxidation of various substances or from the consumption of an active fire, thus robbing the mine atmosphere of a part of its oxygen. The oxygen may be reduced to a very low point and the residual nitrogen mixed with the products of combustion such as carbon dioxide, carbon monoxide, sulphur dioxide, etc.

GAS CARBON MONOXIDE (CO)





OTHER PROPERTIES

COLOUR: NONE
ODOUR: NONE
TASTE: NONE
OTHER:

HOW FORMED

Incomplete combustion of organic materials. Diesel exhaust, blasting, fires.

THRESHOLD LIMIT VALUE AND EFFECT ON HUMANS

T.L.V. = 50 ppm - saturates blood so oxygen cannot be used. Early symptoms include tightness of skin on forehead, dizziness, nausea, confusion of mind, a pink colour of the skin, and unconsciousness. Absorption by blood is cumulative.

TREATMENT OF PERSONS AFFECTED

Remove from further exposure, give oxygen. Medical aid for acute poisoning, keep patient at rest.

CARBON MONOXIDE (CO)

Carbon monoxide gas constitutes one of the greatest hazards to life in underground mining. It is one of the products of combustion in normal blasting operations and in the use of diesel motors underground, and is dangerous unless adequate ventilation is provided. It is also produced by such abnormal occurrences as mine fires or gas explosions. It is a product of incomplete combustion and is formed wherever organic compounds are burned in an atmosphere with insufficient oxygen to carry the process of burning or oxidation to completion. It is a colourless, odorless, tasteless gas which, when breathed in even low concentrations, will produce symptoms of poisoning. Carbon monoxide will burn and air that contains 12.5 to 74 per cent of carbon monoxide will explode if ignited. It is only slightly soluble in water and is not removed from the air to any extent by water sprays. It is slightly lighter than air, having a specific gravity of 0.967.

Carbon monoxide in excess of 0.01 per cent, if breathed indefinitely may eventually produce symptoms of poisoning; 0.02 per cent will produce slight symptoms after several hours exposure. When 4 parts in 10,000 (0.04 per cent) are present and the exposure is for two to three hours, headache and discomfort usually occur. With moderate exercise, when 0.12 per cent is present, slight palpitation of the heart will occur in 30 minutes, tendency to stagger in 11/2 hours, and confusion of mind, headache, and nausea in 2 hours. In concentrations of 0.20 to 0.25 per cent unconsciousness usually occurs in about 30 minutes. The effect of high concentrations may be so sudden that one has little or no warning before collapsing. The carbon monoxide content of the air in which men are employed for a period of 8 hours should not exceed 0.005 per cent or 50 ppm.

HOW CARBON MONOXIDE ACTS

The oxygen absorbed from the air in the lungs is normally taken up by the blood in the form of a loose chemical combination, with the red colouring matter (haemoglobin) of the corpuscles, and in this form it is carried to the tissues where it is used. Haemoglobin forms a much more stable compound with carbon monoxide than with oxygen and when saturated with the former it cannot take up oxygen.

The affinity of haemoglobin for carbon monoxide is about three hundred times its affinity for oxygen; hence when even a small percentage of carbon monoxide is present in the air breathed, the haemoglobin will absorb the carbon monoxide in preference to the oxygen. When carbon monoxide is absorbed by haemoglobin it reduces the capacity of the haemoglobin for carrying oxygen to the tissues to a proportionate extent. It is this interference with the oxygen supply to the tissues that produces the symptoms of poisoning.

The symptoms of poisoning more or less parallel the extent of blood saturation. The first definite symptoms, during rest, make their appearance when 20 or 30 per cent of the haemoglobin is combined with carbon monoxide. Unconsciousness takes place at about 50 per cent saturation and death occurs at about 80 per cent.

According to experiments conducted by the United States Bureau of Mines, the symptoms produced by various percentages of carbon monoxide in the blood are as follows:

PERCENTAGE OF BLOOD SATURATION	SYMPTOMS
0 - 10	None
10 - 20	Tightness across forehead, possible headache
20 - 30	Headache, throbbing in temples
30 - 40	Severe headache, weakness, dizziness, dimness of vision, nausea, vomiting and collapse
40 - 50	Same as 30 - 40, with more possibility of fainting and collapse, increased pulse and respiration
50 - 60	Fainting, increased pulse and respiration, coma with intermittent convulsions
60 - 70	Coma with intermittent convulsions, depressed heart action and respiration, possible death
70 - 80	Weak pulse and slowed respiration, respiratory failure and death

The symptoms decrease in number with the increase in the rate of saturation. If exposed to high concentrations, the victim may experience but few symptoms. The rate at which a man is overcome and the sequence in which the symptoms appear depend on several factors; the concentration of gas, the extent to which he is exerting himself and the state of his health and individual susceptibility and the temperature, humidity and air movement to which he is exposed.

Exercise, high temperature and humidity, with little or no air movement, tend to increase respiration and heart rate and consequently result in more rapid absorption of carbon monoxide.

TREATMENT FOR CARBON MONOXIDE POISONING

The onset of carbon monoxide poisoning may be either sudden or gradual, depending on the concentration and period of exposure. Interest usually centres in the treatment of the acute or sudden form.

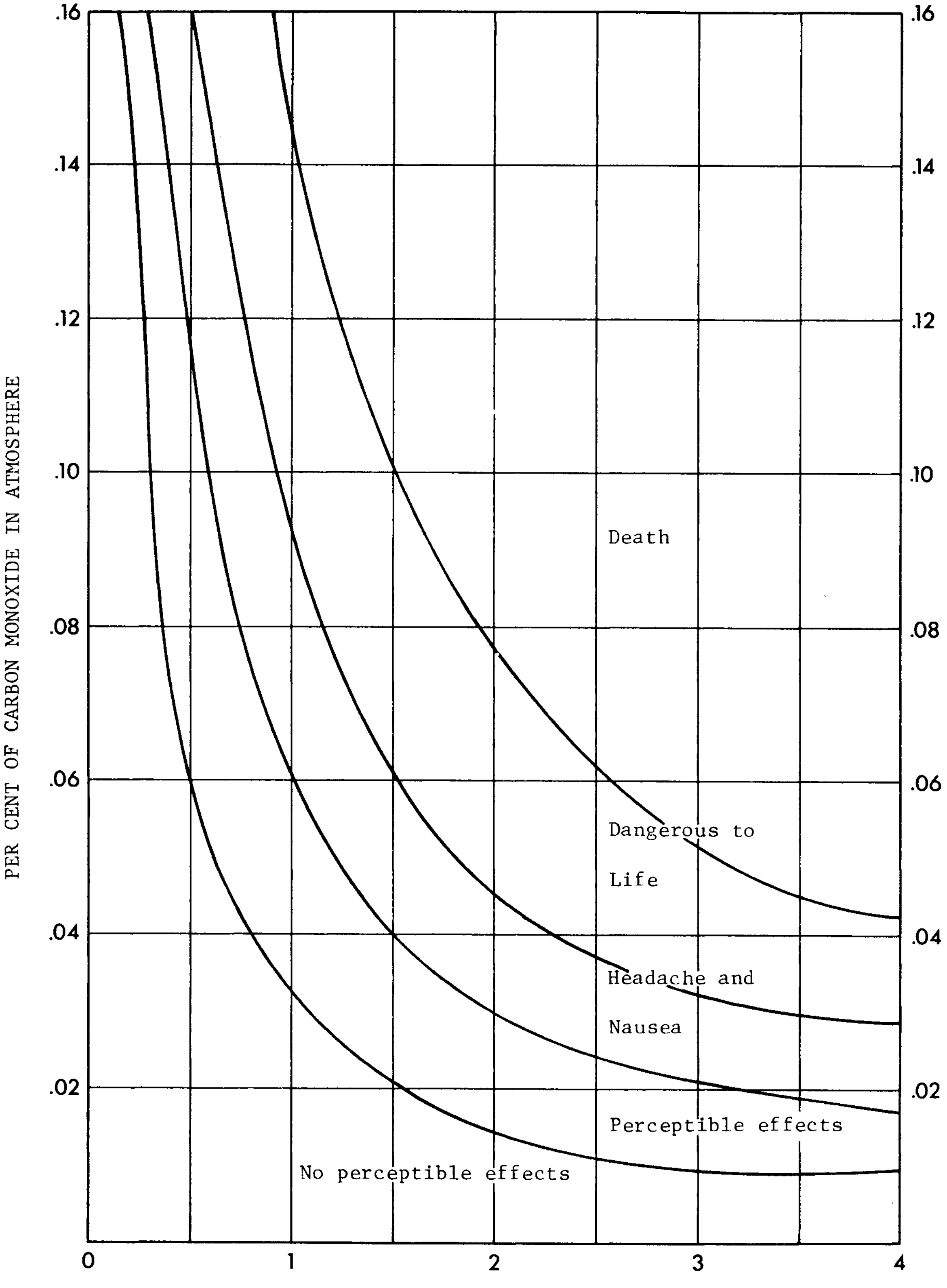
In the treatment of the chronic or gradual form of poisoning the most important factors are avoiding further exposure and taking a thorough rest. In the treatment of acute carbon monoxide poisoning the most important thing is to get the gas out of the blood as rapidly as possible, thus decreasing the possibility of serious after effects or even loss of life through failure of the heart and respiration. As soon as the patient begins to breathe air in which there is no carbon monoxide the process of eliminating the gas from the blood will begin naturally. However, this normal elimination is slow and often has serious effects. It requires possibly 8 to 15 hours to reduce the carbon monoxide haemoglobin to 10 per cent of the total haemoglobin. Inhalation of pure oxygen will remove the carbon monoxide from the blood four or five times faster. The use of oxygen alone in an oxygen therapy unit is common practice because it is usually readily available owing to its general use in industry. Inhalation treatments are preferably given with an inhalator, but the oxygen may be administered by improvised apparatus or sprayed directly over the patient's face from a cylinder when an inhalator is not at hand. Caution should be observed in controlling the flow when using the gas directly from the cylinder. The cylinder should be opened and the flow regulated before the gas is directed toward the patient. No improvised mask or device should be used in which pressure can be built up and injure the patient. Because of its great efficiency an inhalator is preferable to any improvised device.

The steps in the effective treatment of carbon monoxide poisoning are as follows:

1. The patient should be removed to fresh air as soon as possible.

2. If breathing has stopped, is weak and intermittent,or is present only in occasional gasps, artificial respiration should be given

TIME ON HUMAN BEINGS



persistently until normal breathing is resumed, or until it is definitely established that the patient is dead.

3. Pure oxygen should be administered, beginning as soon as possible and continuing as long as necessary - at least 20 minutes in mild cases and as long as one or two hours in severe cases.

4. Circulation should be aided by rubbing the limbs of the patient (towards the heart) and keeping his body warm with blankets, hot water bottles, etc.

5. The patient should be kept at rest, lying down to avoid strain on the heart; later he should be given plenty of time to rest and recuperate. It cannot be emphasized too strongly that immediate inhalation of oxygen, for 20 to 30 minutes, will lessen to a great extent the severity of results of carbon monoxide poisoning and decrease the possible serious after effects.

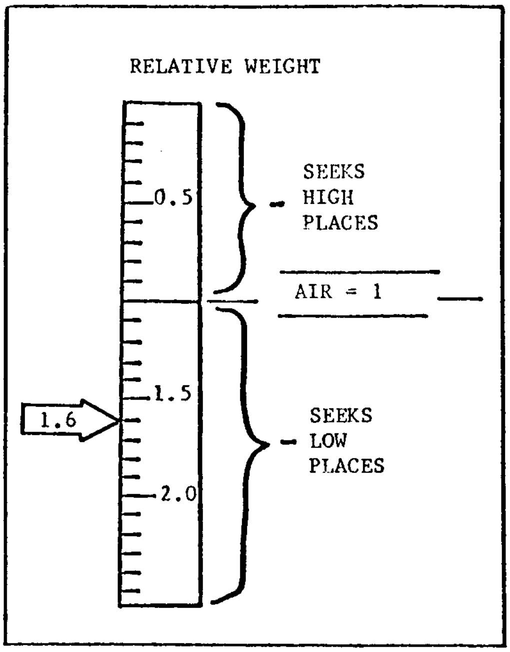
PHYSIOLOGICAL EFFECTS OF CARBON MONOXIDE

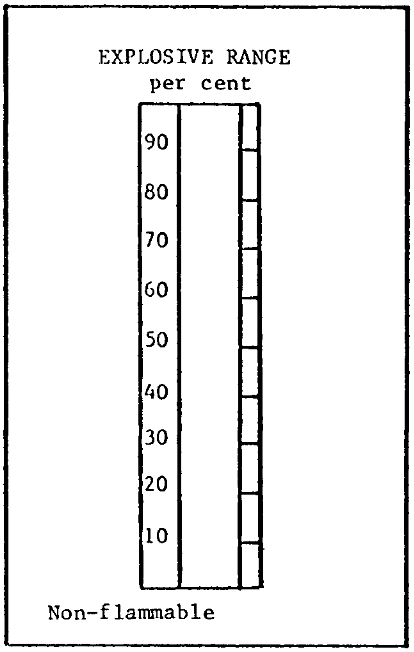
Concentration of CO Per cent	Allowable Length of Exposure
0.005	Allowable for exposure of several hours
0.04 to 0.05	Can be inhaled for 1 hour without appreciable effect
0.06 to 0.07	Just noticeable effects after 1 hour exposure
0.10 to 0.12	Unpleasant, but probably not dangerous after 1 hour exposure
0.15 to 0.20	Dangerous for exposure of 1 hour
0.4 or more	Death in less than 1 hour

OXIDES OF NITROGEN (NO, NO_2, etc.)

Oxides of nitrogen are formed in mines by the burning of explosives and, to a slight extent, by their detonation. They can usually be detected by the "burned powder" odor familiar to blasters and by the reddish colour of nitrogen peroxide (NO_2) fumes, which are formed when the nitric oxide (NO) produced by the explosion comes in contact with the air. Hall and Howell report that gases collected from

GAS OXIDES OF NITROGEN (NO and NO_2)





Non-flammable

OTHER PROPERTIES

COLOUR: NONE in small concentrations; reddish-brown in higher concentrations.

ODOUR: NONE

TASTE: NONE

OTHER:

HOW FORMED

Diesel exhaust, blasting with dynamite and ammonium nitrate blasting agents.

THRESHOLD LIMIT VALUE AND EFFECT ON HUMANS

T.L.V. = 5 ppm - corrosive to tissues of lungs and respiratory trac. Causes oedema of lungs.

TREATMENT OF PERSONS AFFECTED

Remove to fresh air, give oxygen and complete rest. Seek medical aid.

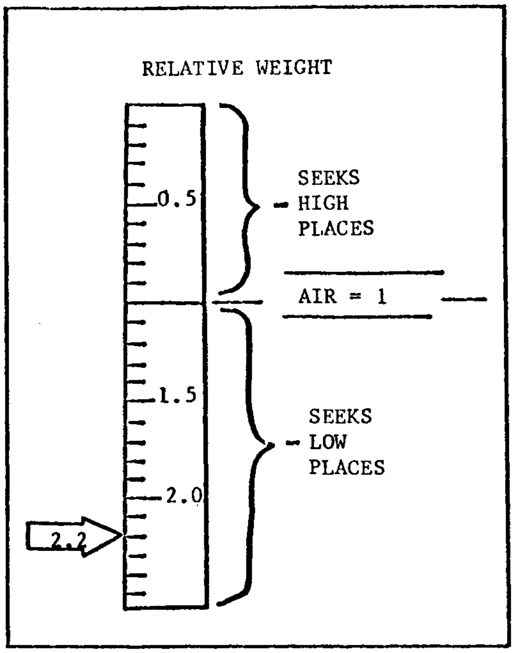
the burning of 40 per cent gelatin dynamite contain 11.9 per cent of oxides of nitrogen. When explosives having properly proportioned components are completely detonated, they usually produce exceedingly small percentages of oxides of nitrogen, which are considered harmless. Explosives from which the wrapper has been removed may produce harmful percentages of oxides of nitrogen, even when detonated. Diesel engines also produce oxides of nitrogen.

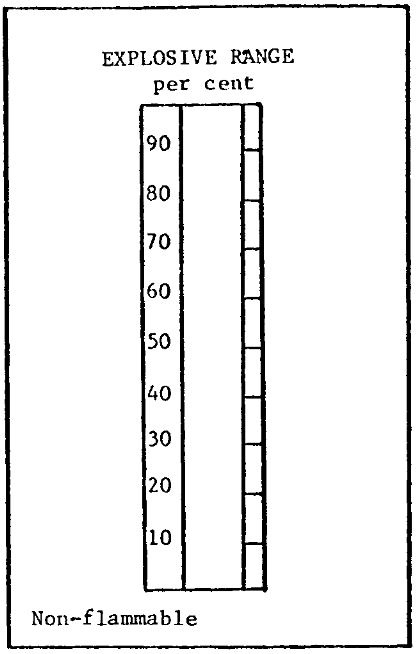
Oxides of nitrogen corrode the respiratory passages and the breathing of relative small quantities may cause death. The effect is unlike that of carbon monoxide in that a person may apparently recover and then suddenly die several days later. Nitrogen peroxide (NO_2) is probably the most irritating of the oxides of nitrogen. Its effect on the respiratory passages usually are not manifest until several hours after exposure when oedema and swelling take place. This irritation may be followed by bronchitis or pneumonia, frequently with fatal results. One-hundredth (0.01) per cent of nitrogen peroxide may cause dangerous illness if breathed for a short time and 0.07 per cent is fatal if breathed for about 30 minutes or less. The Maximum Acceptable Concentration and Threshold Limit Value for this gas are both 5 parts per million. In other words, the concentration for any short period exposure must not be greater than that for an 8-hour exposure.

PHYSIOLOGICAL EFFECTS OF OXIDES OF NITROGEN

Concentration of Oxides of Nitrogen		
Parts per million	Per cent	Effect
5	.0005	Maximum allowable for 8-hr. day
60	.006	Minimum causing immediate throat irritation
100	.01	Minimum causing coughing
100-150	.01-.015	Dangerous for even short exposure
200-700	.02-.07	Rapidly fatal for short exposure

GAS SULPHUR DIOXIDE (SO_2)





OTHER PROPERTIES

COLOUR:	NONE
ODOUR:	Strong pungent sulphur smell.
TASTE:	Acid taste.
OTHER:	Very irritating to breathe - cannot be tolerated in dangerous concentrations.

HOW FORMED

Burning sulphide ores, blasting in sulphide ores, sulphide dust explosions. Some diesel fuels.

THRESHOLD LIMIT VALUE AND EFFECT ON HUMANS

T.L.V. = 5 ppm - irritation of eyes, throat, lungs, intolerable to breathe in dangerous concentrations.

TREATMENT OF PERSONS AFFECTED

Fresh air, oxygen, artificial respiration, if breathing stopped medical aid.

SULPHUR DIOXIDE (SO_2)

Sulphur dioxide is another gas produced by burning sulphide ores or by blasting in sulphide ores or explosions of sulphide ore dust. Some diesel fuels will produce sulphur dioxide when used in a diesel engine.

This gas has a strong sulphur smell which is suffocating and very irritating to breathe. This gas is so irritating to breathe that it cannot be tolerated for any length of time in dangerous concentrations. A person's natural reaction when he encounters this gas is to get out of it and this, of course, should be done.

If forced to breathe this gas for any length of time, coughing and nausea result. The gas will effect the lungs in much the same manner as oxides of nitrogen and hydrogen sulphide. Irritation of the respiratory tract and lungs will cause oedema.

The threshold limit value of sulphur dioxide is a low 5 ppm.

Solubility - Sulphur dioxide is highly soluble in water, in fact it is one of the most soluble gases found in mines.

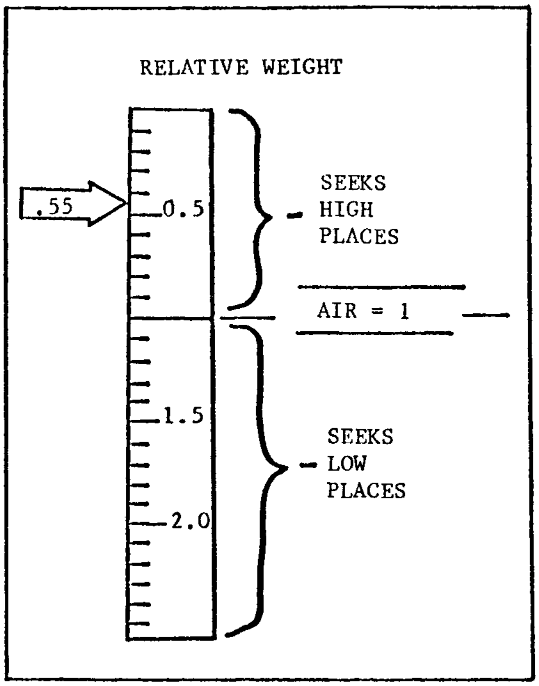
Relative weight - Sulphur dioxide is a very heavy gas and has a relative weight of 2.2. It can, therefore, be expected to accumulate in low places.

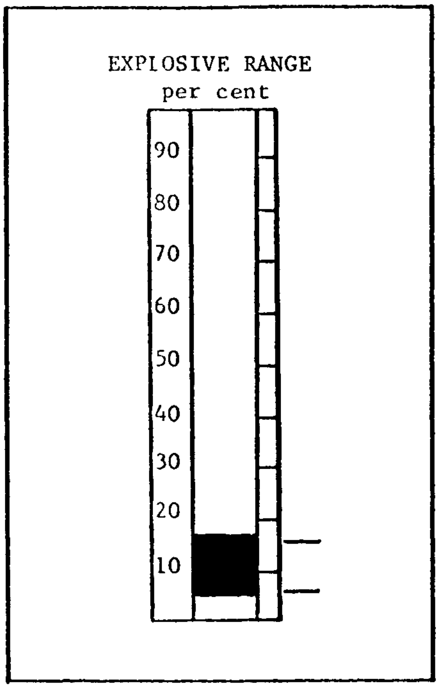
Sulphur dioxide is colourless and has a distinctly acid taste.

EFFECTS OF SULPHUR DIOXIDE

Concentration		
Parts per million	Per cent	Effect
5	.0005	Maximum allowable for an 8 hr. day
20	0.002	Coughing, irritation to eyes, nose and throat
150	.015	May be endured for several minutes
400	.04	Impossible to breathe

GAS METHANE (CH_4)





OTHER PROPERTIES

COLOUR:	NONE
ODOUR:	NONE - often associated with other sulphurous gases.
TASTE:	NONE
OTHER:	

HOW FORMED

Decomposition of vegetable matter. Released from coal seams or some rocks when mining carried out or when diamond drilling.

THRESHOLD LIMIT VALUE AND EFFECT ON HUMANS

Non-poisonous. But due to flammability men must withdraw at 2.5 per cent. Blasting stopped at 1 per cent.

TREATMENT OF PERSONS AFFECTED

Non-toxic. If concentration causes oxygen deficiency treat as such.

METHANE (CH_4)

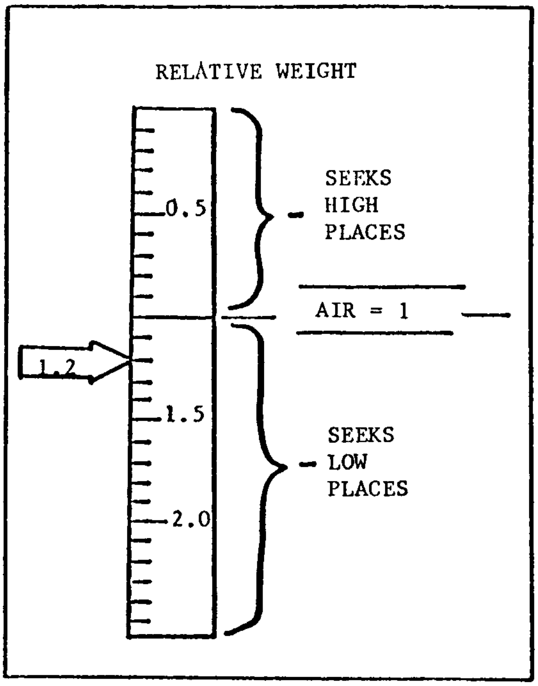
Methane or marsh gas is encountered in some metal mines in the Bridge River and in practically all coal mines in British Columbia. Flow of the gas is variable and is occluded in the pores of the coal. It is formed by the decomposition of organic matter in the presence of water and the absence of air or oxygen. It can be seen in the form of bubbles in stagnant pools, hence the name "Marsh Gas".

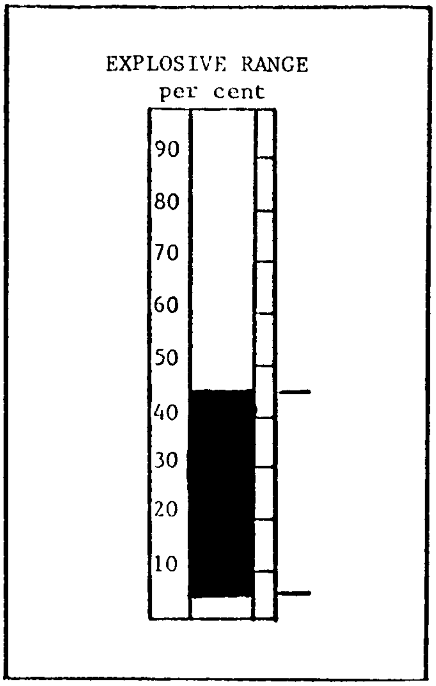
Methane is a colourless, odorless, tasteless gas. An odor caused by the presence of other gases such as hydrogen sulphide, often accompanies it. Methane will burn with a pale blue non-luminous flame and still air that contains 5 to 15 per cent of methane and 12 per cent or more of oxygen will explode and this is its chief danger. However, the inflammable and explosive range of methane is variable and all occurrences of the gas should be considered as dangerous. Where the occurrence of methane is suspected or known adequate ventilation to dilute the gas to a harmless percentage is important.

Methane is considerably lighter than air and when found in mines is usually near the roof or in high places. Accumulations of the gas may be encountered in unused and poorly ventilated mine workings, or when old workings are being dewatered. It may be caused by the decaying of old timbers.

Methane has no direct effect upon men, but it may displace the oxygen content of the air to such an extent as to cause oxygen deficiency. An open-flame lamp or a spark may cause an explosion. The British Columbia Coal Mines Regulation Act requires that all men be withdrawn from any work heading when the methane content of the general body of air in that heading reaches 2.5 per cent. This Act also requires electrical circuits to be isolated in any work area when the methane content in the general body of air in that area reaches 1.25 per cent and that no blasting or shotfiring is done when the methane content exceeds 1 per cent.

GAS HYDROGEN SULPHIDE (H_2S)





OTHER PROPERTIES

COLOUR:	NONE
ODOUR:	Rotten egg smell in low concentrations.
TASTE:	NONE. Irritates nose, throat, eyes, etc.

HOW FORMED

Burning sulphide ores, explosions of dusts from sulphide ores, hydrochloric acid on sulphide concentrate.

THRESHOLD LIMIT VALUE AND EFFECT ON HUMANS

T.L.V. = 10 ppm - paralyzes respiratory centre.
Low concentrations cause oedema of lungs, bronchitis, pneumonia.

TREATMENT OF PERSONS AFFECTED

Remove to fresh air, give oxygen, artificial respiration if breathing stopped, get medical aid and advise of exposure to hydrogen sulphide.

HYDROGEN SULPHIDE (H_2S)

Hydrogen sulphide is one of the most poisonous gases known. Fortunately only traces of it are ordinarily found in mine operations. In some respects it is more dangerous than hydrogen cyanide. In low concentrations its distinctive "rotten egg" odor is noticeable, but in high concentrations the sense of smell is quickly paralyzed by the action of the gas on the respiratory centre and cannot be relied on for warning. The gas has a specific gravity of 1.19 and, being heavier than air, may collect at low points.

Hydrogen sulphide inhaled in a sufficiently high concentration produces immediate asphyxiation; in low concentrations it produces inflammation of the eyes and respiratory tract and sometimes leads to bronchitis, pneumonia, and oedema of the lungs.

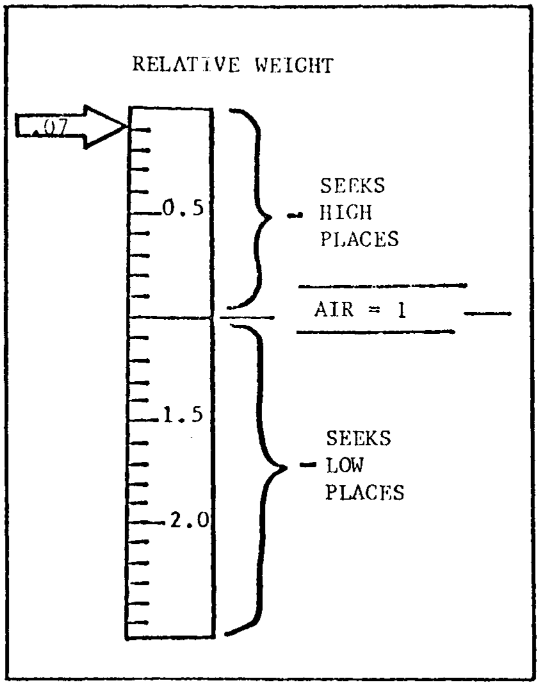
Subacute poisoning may be produced by long exposure to concentrations as low as 0.005 per cent. Immediate collapse usually results from exposure to concentrations of 0.06 to 0.1 per cent, and death quickly ensues. The 8 hour daily exposure should not exceed 0.001 per cent or 10 ppm.

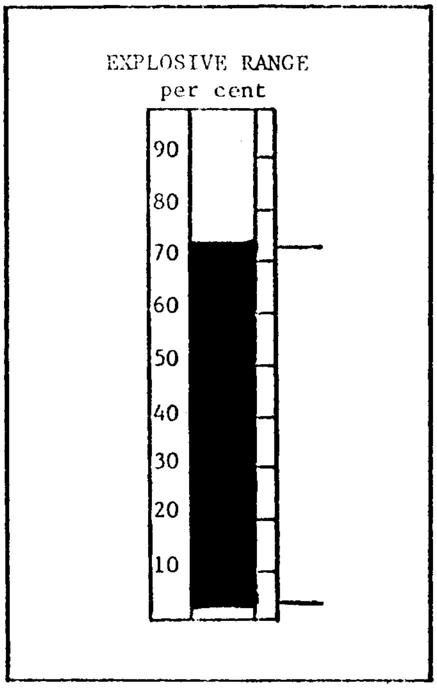
When explosions of dust occur in blasting operations in sulphide orebodies, the resulting gases may contain varying amounts of hydrogen sulphide, along with sulphur dioxide and possibly other sulphur gases.

EFFECTS OF HYDROGEN SULPHIDE

Per Cent		
.001	Maximum allowable for 8 hr. day	
0.005 - 0.010	Subacute poisoning	
	1. Mild eye irritation	1 hour
	2. Mild respiratory irritation	
.02 - .03	Subacute poisoning	
	1. Marked eye irritation	
	2. Marked respiratory irritation	1 hour
.05 - .07	Subacute to acute poisoning	
	1. Unconsciousness	1/2 - 1 hour
.10 - .20	Acute poisoning	
or more	1. Unconsciousness	Minutes
	2. Death	

GAS HYDROGEN (H_2)





OTHER PROPERTIES

COLOUR: NONE
ODOUR: NONE
TASTE: NONE
OTHER: Highly explosive over wide range

HOW FORMED

Electrolysis in battery changing stations. Incomplete combustion and molecular breakdown of water when rock heated to incandescence. Present in coal gas and caused by blasting in coal.

THRESHOLD LIMIT VALUE AND EFFECT ON HUMANS

Non-toxic. Only physiological effect is when oxygen depleted.

TREATMENT OF PERSONS AFFECTED

As for oxygen deficiency.

HYDROGEN (H_2)

Hydrogen is a colourless, odorless, and tasteless gas. It is very much lighter than air with a relative weight of .07 and is highly flammable. Hydrogen is explosive over a broad range of concentrations, i.e. from 4 per cent to 74 per cent. It will explode with as little as 5 per cent oxygen in the air and is most violently explosive at concentrations of 7 per cent to 8 per cent.

Hydrogen is not a toxic gas and as with methane the only danger of breathing it is when the concentration is such that the oxygen content of the air is reduced.

The only real hazard of hydrogen gas then is from its flammable and explosive properties.

Hydrogen gas is normally found in mine air in only very small quantities. It can, however, be produced at the time of mine fires when rock is heated to incandescence and as a result of incomplete combustion.

The most common source of hydrogen gas under normal circumstances in metal mines is in battery locomotive charging stations. The electrolytic action which takes place during battery charging releases hydrogen gas. Charging stations must, therefore, be well ventilated and smoking, electric arcs, etc., must be avoided in them.

In coal mines hydrogen gas occurrences in small quantities are more general.

From a trace to as much as 9 per cent can be found in crevices of a coal face after blasting. It is formed here as a result of incomplete combustion of explosives and by distillation of the coal caused by the explosion.

Hydrogen gas is usually present in amounts up to 2 per cent in gas from gob and ordinary mine fires and is always present after coal dust explosions.

Coal gas can contain as much as 50 per cent hydrogen.

Hydrogen gas can be detected with the multi-gas detector previously described and with vacuum bottles.

A vacuum bottle is simply a sealed bottle from which all air and other gases have been removed. The bottle is taken into the suspected atmosphere and the vacuum is released, allowing the atmosphere to enter the bottle. The bottle is then sealed and sent to a laboratory for analysis of the contents.

Almost the same result as a vacuum bottle can be obtained by filling a clean bottle with water and emptying the bottle in the suspected atmosphere. As the water is dumped from the bottle the surrounding atmosphere enters the bottle. The bottle can then be sealed and sent out for analysis.

The flame safety lamp will indicate the presence of hydrogen or any flammable gas. Concentrations of the gas, however, cannot be determined with the safety lamp.

Hydrogen is not a common gas in mines but when it occurs its explosive nature makes it extremely dangerous. We should be aware that it can be released at the time of mine fires.

MERCURY (QUICKSILVER) (Hg)

A heavy (S.G. 13.6)* silver-white liquid (above -38° F) metal capable of conducting heat and electricity. It sometimes occurs free or in the metallic state in some ore deposits but more commonly occurs as cinnabar (HgS), a carmine-coloured sulphide which is readily converted to the metallic state by heating in an abundant air supply. There are several occurrences of cinnabar in British Columbia and at least on one deposit a mine has been developed. Mercury has a large number of industrial uses including the manufacture of electrical equipment, explosive detonators, insecticides and the recovery of metallic gold and silver in the form of amalgams.

When in the liquid state and while in contact with air, mercury vapor is being released continually, the amount released increasing with increasing temperature. The recommended safe working limit for a daily eight-hour exposure to mercury vapor is not more than 0.1 milligrams of mercury per cubic metre of air. Exposure of an individual to amounts greater than this may, depending on the concentration encountered and time of exposure, develop chronic or acute mercury poisoning. This condition should be prevented from developing by close control of all vapor escape sources which can be determined with regular use of a mercury detector (sniffer) and by regular employment rotation of workmen away from vapor source areas. Regular urinalyses or blood analyses of such workmen makes it possible to ensure their mercury level remains within safe limits. As mercury is readily eliminated in

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*The specific gravity of solids is the ratio of the weight of the solid with respect to the weight of an equal volume of water.

body perspiration and body waste, the regular rotation of workmen as determined by the aforementioned analyses will prevent the development of mercury poisoning.

The symptoms of mercury poisoning are stomatitis, tremors, and physic disturbances. Usually the first complaints are of excessive salivation and pain on chewing, with loosening of teeth in severe cases. The use of a dust respirator is not effective in removing the mercury vapour and type "N" respirator is only partly effective, hence, the only satisfactory protection is an airline respirator or self-contained breathing apparatus.

The possibility of mercury poisoning can be greatly reduced by endeavouring, wherever possible, to:

1. keep metallic mercury covered with a layer of water
2. avoid spillage and clean up any spills immediately
3. spray contaminated areas with lime-sulphur spray
4. observe habits of good personal hygiene, e.e. frequent baths and washing of hands, frequent laundering of clothes, no smoking or eating in contaminated areas.

HAZARDS DUE TO GASES DURING OR AFTER MINE FIRES OR EXPLOSIONS

During and following metal mine fires the two greates hazards to life are poisoning from the breathing of carbon monoxide and suffocation in an atmosphere deficient in oxygen. The conditions which cause contamination in mine atmospheres are listed below in the order of hazard:

CARBON MONOXIDE:	This gas is always present at the time of an underground fire and gives little or no warning.
OXYGEN DEFICIENCY:	This condition occurs because of the consumption of oxygen by combustion or chemical reaction and its replacement by toxic or inert gases. Precautions must always be taken against it.
SMOKE:	The hazard is due to its irritating qualities and obstruction of vision. It may be explosive.
DANGER OR EXPLOSION:	Gases caused or generated by fire (as in smoke) may explode.

METHANE:	This gas is not produced by mine fires or explosions but may cause them. Its presence in a mine during rescue or recovery operations create a considerable hazard.
SULPHUR DIOXIDE:	This gas is present at the time a fire occurs in a sulphide orebody. Because of its irritating qualities, it gives advance warning when in less than toxic concentrations.
OTHER GASES:	Hydrogen sulphide, nitrous oxides, etc. are not likely to be encountered, but the possibility of their occurrence should be kept in mind. Hydrogen sulphide sometimes indicates the presence of methane.

ARSINE GAS

Toxicity

Arsine gas (arsenous hydride or AsH_3 is a powerful hemolytic poison. Only 0.05 parts per million (ppm) can be permitted and 1 - 10 ppm is dangerous after one hour. Over 100 ppm is immediately dangerous to life.

Symptoms of Poisoning

Arsine has an affinity for the haemoglobin of the red corpuscles of the blood. Symptoms of poisoning usually occur three to four hours after exposure and are evinced by tightness of the chest, nausea, vomiting, bronzing of the skin, enlargement and tenderness of the liver and spleen. Symptoms of severe poisoning are red, to black-red urine. Continued exposure to low concentrations may result in chronic poisoning which can lead to anemia and jaundice.

Occurrence

Arsine is a poisonous gas formed by the reaction of hydrogen with arsenic. It is not produced commercially but only accidentally and thus cases of poisoning may escape detection. Arsine is a colourless gas, with an odor somewhat like garlic. It is almost three times as heavy as air, soluble in water, and inflammable.

The presence of acids, alkalis, and metallics are conducive to the formation of arsine but not absolutely necessary. The most probable formation is where a metal, such as zinc, is added to a mill circuit. Hydrogen would be produced here if the solution was acidic and hydrogen would then react with any arsenic present to form AsH_3. Arsenopyrite is the most likely source of arsenic but arsenic can be added to the mill circuit by reagents containing arsenic (e.g., impure copper sulphate.)

Other common sources of arsine are where impure acids are used for scale removal, where impure lead is used in soldering, where zinc coated galvanized pails are used in dipping into impure solutions. Arsine may also be formed by the action of water on metallic arsenides, especially if the solution is heated.

Detection

1. Test papers can be made up by immersing filter paper for two minutes in a cold aqueous solution of 50 grams of mercuric chloride per litre and then hanging up to dry. Such papers will turn brown, dark brown or black in the presence of arsine. For such testing, papers should be hung up at predetermined stations in the plant and changed every shift whether coloured or not. Only a week's supply of test papers should be made up at one time. Storage should be in tight containers.

2. Arsine detectors should be used intermittently to check against test paper method.

Prevention of Poisoning

If the formation of arsine gas is possible the following procedure is required:

1. Pre-employment haemoglobin medical test for all new employees.

2. A haemoglobin test every three months for all workers in the suspected area.

3. Immediate haemoglobin and urine tests for any persons showing symptoms of poisoning.

4. Adequate ventilation in the suspected areas. This ventilation should be from above as well as below the areas.

5. Evacuation of personnel from any area where tests indicate presence of arsine.

QUESTIONS ON GASES

1. What are the main components of air; in what percentages do they occur?

2. Give the properties of oxygen.

3. Will oxygen burn or explode if it is pure?

4. (a) What gases are we most likely to encounter in a fire in a mine?
   (b) Name the most deadly of these gases. Describe it.
   (c) At about what percentage in air does this gas become dangerous to breathe?
   (d) What first aid treatment is recommended for persons affected by this gas?

5. What other gases may be found in a mine fire in sulphide orebodies?

6. What gas or gases are usually associated with blasting?

7. What gases are usually present with smoke?

8. What explosive gases, if any, are we likely to find in mine air?

9. Name some of the causes of deficiency of oxygen in air.

10. What colour is the face when the oxygen content of the air is low?

11. What difference is there in the symptoms of oxygen deficiency between air at sea level that has a low oxygen content and the atmosphere at 5,000 feet?

12. When a person succumbs to oxygen deficiency does respiration or heartbeat stop first?

13. Without the use of special instruments is there any way we can detect the presence of certain gases?

14. (a) With what gas do we associate the smell of rotten eggs?
    (b) In a very small concentration of this gas, what are the first noticeable symptoms?

15. Does breathing pure oxygen at atmospheric pressures have any adverse effect on men?

16. What are considered the two greatest hazards to men during mine fires with regard to mine air?

17. Name the "Damps" and give a brief description of each.

18. What gases displace oxygen in mine air?

CHART OF MINE GASES

	NAME	SYMBOL	RELATIVE WEIGHT (air = 1)	SOLUBILITY GRAMS PER 100 cc. WATER AT 41°F	PROPERTIES	HOW FORMED	WHEN DANGEROUS	THRESHOLD LIMIT VALUE	HOW DETECTED	FLAM-MABLE	EXPLO-SIVE	EFFECT	TREATMENT
1.	Air	Air	S.G.=1	0.00295	Colourless Odorless Tasteless	Constituents O_2 20.93% N_2 79.04% CO_2 0.03%	If O_2 falls below 16% or when poisonous gases enter.	Minimum 19.5% O_2 for 8 hr.	For O_2 with safety lamp & gas detection	No	No	If O_2 below and man working 17% panting- 15% dizziness 9% collapse 7% fatal	Ventilation Fresh Air. If unconscious, give artificial respiration.
2.	Oxygen	O_2	A trifle heavier than air S.G.=1.1	0.005498	Colourless Odorless Tasteless Non-poisonous at ordinary temperatures and pressures	Regenerated by plant life	As above	As above	Safety lamp & candle go out at 16.25% O_2. Carbide light goes out at 12.5% O_2.	No	No	As above	As above
3.	Carbon dioxide	CO_2	Much heavier than air S.G.=1.53	1.237	Colourless Odorless Tasteless in low concentrations. Acid taste in high concentrations induces breathing.	Normal constituent of mine air. From breathing of humans and animals from decay of animal and vegetable matter. Released from thermal water & exuded from some rock strata. Mine fires.	Above 2% causes greatly increased lung ventilation up to collapse.	Maximum 0.5% for 8 hr. exposure	Analysis of vacuum bottle sample Detectors Displaces O_2 and will therefore extinguish lamp at high concentration.	No	No	At 2% increases lung ventilation by 50%. At 3% increases ventilation by 100%. At 5% increases ventilation by 300%. May displace oxygen.	Provide fresh air and oxygen. If unconscious, give artificial respiration.
4.	Nitrogen	N_2	A trifle ligher than air S.G.=0.97	0.002365	Colourless Odorless Tasteless Acts as a diluent of O_2 in air.	Normal constituent of mine air. Highly concentrated N_2 has been reported to issue from rock strata in some mines.	High N_2 concentration, displaces O_2 in air.	Maximum 81% for 8 hr. exposure	Analysis of vacuum bottle sample. Displaces O_2 and will therefore extinguish lamp at high concentrations.	No	No	No effect but O_2 shortage experienced in high concentrations.	Provide fresh air. If unconscious, give artificial respiration.

NAME	SYMBOL	RELATIVE WEIGHT (air = 1)	SOLUBILITY GRAMS PER 100 cc. WATER AT 41°F	PROPERTIES	HOW FORMED	WHEN DANGEROUS	THRESHOLD LIMIT VALUE	HOW DETECTED	FLAM-MABLE	EXPLO-SIVE	EFFECT	TREATMENT
5. Methane	CH_4	Much lighter than air S.G.=0.55	0.00717	Colourless Odorless Tasteless	Decay of certain bacteria or organic matter in coal measures and in some metal mines in contact with carbonaceous rock. Decaying timber.	When displaces O_2 or explosive when 5%-15% present with at least 12% O_2	Withdrawal point for men 2.5% Electric motors stopped at 1.25%. Blasting stopped at 1%.	Flame safety lamp when in excess of 1.25% methane detector.	Yes	Yes, see column 8. Maximum explosive force at 9.0%	No effect physiologically except can displace O_2.	As for O_2 deficiency.
6. Carbon monoxide	CO	lighter than air S.G.=0.97	.003559	Colourless Odorless Tasteless Poisonous	From incomplete combustion. Blasting, diesel exhaust, underground fires.	Depends on concentration and length of time of exposure. 0.4% death in less than 1 hr. 0.15 to 0.20 for 1 hr. 0.04 for 1½ hr. Headache and nausea.	0.005% or 50 ppm-8 hr. exposure maximum.	CO detector** canary vacuum bottle sample assay.	Yes in certain concentrations.	12.5% to 75.0%	Headache, nausea, death. Dangerous after effects. Pink to red skin colour.	Fresh air O_2 if nausea or unconsciousness. Artificial respiration if not breathing. Rest.
7. Hydrogen sulphide	H_2S	A little heavier than air S.G.=1.19	0.5276	Colourless. Smell of rotten eggs Irritates eyes and respiratory tract Poisonous	Decomposition of some sulphur compounds. Blasting in sulphide ores. Hydrochloric acid spilled on sulphide concentrate or ore. Thermal waters. Underwater decomposition of vegetable matter.	+0.01% acute poisoning +0.07% rapid unconsciousness +0.05% dangerous + ½ hr. .002 - .003*	0.001% or 10 ppm for 8 hrs.	Rotten egg odor. Detectors. Eye irritation, Subacute to acute poisoning.	Yes 4.3-45% if enough O_2.	Yes 4.3-45% will explode	Sense of smell deadened. After 1 or 2 inhalations will paralyze the respiratory system.	Fresh air. Artificial respiration if unconscious. Get to doctor.

*subacute poisoning
0.005 - 0.16% irritation of eyes & throat

**Note: A scrubber must be used ahead of detector tube if testing for CO in diesel exhaust.

	NAME	SYMBOL	RELATIVE WEIGHT (air = 1)	SOLUBILITY GRAMS PER 100 cc. WATER AT 41°F	PROPERTIES	HOW FORMED	WHEN DANGEROUS	THRESHOLD LIMIT VALUE	HOW DETECTED	FLAM-MABLE	EXPLO-SIVE	EFFECT	TREATMENT
8.	Oxides of Nitrogen	NO NO_2 N_2O_4 N_2O_2 N_2O N_2O_3 N_2O_5	Heavier than air S.G.=1.59	NO_2 0.007747	Colourless in low concentration. Reddish brown in high concentrations Odorless Tasteless Poisonous	From blasting or burning of dynamite. Diesel exhaust. Burning or decomposition of nitrates or nitrated material.	0.01% may be fatal in ½ hr.	0.0005% or 5 ppm maximum exposure at any time.	Detector	No	No	Toxic will cause oedema of lungs. Delayed effect.	Complete rest. Give O_2. See doctor and advise man's exposure to oxides of nitrogen.
9.	Sulphur dioxide	SO_2	Much heavier than air S.G.=2.20	Highly soluble in water 16.80	Colourless Suffocating Irritating with strong sulphur smell, acid taste, poisonous.	Blasting in or burning of sulphide ores. Some diesel fuels may have appreciable sulphur present and will form SO_2 on burning.	400 ppm dangerous even for short exposure. 50 ppm subacute poisoning, irritation to eyes, throat & lungs. 20 ppm irritating to eyes. Coughing caused.	0.0005% or 5 ppm for 8 hr. exposure	Odor of burning sulphur Irritating to eyes and respiratory tract. Detector.	No	No	Irritating to eyes, throat & lungs. Produces oedema of lungs.	Fresh air Artificial Respiration if not breathing. Get to doctor.
10.	Hydrogen	H_2	Lighter than air S.G.=0.0695	0.0001756	Colourless Odorless Tasteless	Thermal water Battery charging Electrolysis of water. Product of incomplete combustion in explosions and mine fires. Corrosive action of strong acids on metal (iron).	No harmful effects.		Laboratory analysis of gas sample. Would give indication on detectors using Wheatstone bridge resistance measurement.	Yes	Yes 4.1% -74% with as little as 5% O_2. Violently explosive 7-8%.	None except may displace O_2	Treat for low O_2

NAME	SYMBOL	RELATIVE WEIGHT (air = 1)	SOLUBILITY GRAMS PER 100 cc. WATER AT 41°F	PROPERTIES	HOW FORMED	WHEN DANGEROUS	THRESHOLD LIMIT VALUE	HOW DETECTED	FLAMMABLE	EXPLOSIVE	EFFECT	TREATMENT
11. Powder smoke	Consists of small particles of carbon, tarry substances, solid and liquid matter in air.	About the same as air	N.A.	Smokey odor of nitrous fumes. Irritates eyes, has CO and NO_2 mixed in it. Poisonous.	Product of incomplete combustion during blasting.	When CO and NO_2 content above acceptable limit.	Regulated by Mines Act on use of explosives.	Odor, colour of nitrous fumes. CO and NO_2 detectors.	Yes, if flammable gases are present in sufficient quantity	Yes under certain conditions	Headache, dizziness nausea, throat irritation.	Remove to fresh air or give fresh air or O_2. If unconscious artificial respiration Watch for 48 hours
12. Aldehydes	-	Normal same as air	-	Irritates eyes and respiratory tract.	Diesel engine operation. Soluble in water. Removed by a water scrubber on the diesel engine.	1 ppm will irritate the eyes	10 ppm for 8 hr. exposure.	Smell, eye irritation. Analysis of vacuum bottle, sample collected in special solution.	No	No	Small concentrations cause stinging of eyes.	Fresh air
13. Fire damp	CH_4 and air	See methane	See methane	See methane	See methane	5%-15% with +12% O_2. See methane.	See methane. 2½%	See methane	Yes	Yes	See methane	See methane
14. After damp	Mixture of CO, O_2, CO_2, N_2, H_2, H_2O and CH_4	Varies from less than to greater than that of air	-	See CO	Resulting from all underground fires and explosions.	See CO may also have nitrous fumes.	Depends on the amount of CO.	See detection methods for various gases.	Certain mixtures are.	Yes when mixtures are right.	See CO, CH_4, N_2, CO_2 and H_2	Same as for O_2 and CO.
15. White damp	CO		-	See Carbon Monoxide -----------			--See Carbon Monoxide					

	NAME	SYMBOL	RELATIVE WEIGHT (air = 1)	SOLUBILITY GRAMS PER 100 cc. WATER AT 41°F	PROPERTIES	HOW FORMED	WHEN DANGEROUS	THRESHOLD LIMIT VALUE	HOW DETECTED	FLAMMABLE	EXPLOSIVE	EFFECT	TREATMENT
16.	Black damp	Mixture of CO_2 and N_2	If CH_4 present it will be lighter.	-	See CO_2	Absorption of O_2 by water, timbers, oxidation of ore, decay of timbers, men breathing.	Displaces O_2 causing a dangerous condition.	Not over 0.5% CO_2 or less than 19.5% O_2.	If safety lamp goes out, then black damp is assumed. Assay of vacuum bottle sample. CO_2 detector.	No	No	No effect when sufficient O_2 is present.	Same as for O_2 deficiency
17.	Stink damp	H_2S		-	See Hydrogen Sulphide			-- See Hydrogen Sulphide				-	
18.	Arsine (Arsenous hydride)	AsH_3	About three times as heavy as air.		Highly poisonous.	Formed by reaction of hydrogen with arsenic. Hydrogen may have been formed with strong acid on a metal and in the presence of arsenic or arsenic compounds, e.g. mill circuit.	1-10 ppm.	0.05 ppm 1-10 ppm dangerous after one hr. 100 ppm dangerous to life.	Mercury chloride filter paper test. Detectors or by physiological effect.	Yes	Yes	Destroys red blood corpuscles nausea bronzing of skin, black-red urine. Tightness of chest. Slight delayed action. Cumulative effect.	Fresh air, immediately, turn over to doctor. Advise doctor of exposure if known.
19.	Hydrogen cyanide acid. Prussic acid.	HCN			Smell of bitter almonds. Deadly poison.	Hydrochloric acid on sodium or potassium cyanide. May occur in mill areas where cyanide is used. Produced during heat treating of drill steel. May be released from tailings where cyanide has been used for mineral recovery.	10 ppm.	10 ppm	Smell of bitter almonds. Detector.	Gas-yes	Gas-yes	Paralyzes respiratory system developing chemical asphyxia. Absorbed through skin as well as in lungs.	Fresh air. Give cyanide antidote as directed. Get doctor. Type "N" canister not satisfactory. Special cyanide type canister required. Use mask with extreme caution.

NAME	SYMBOL	RELATIVE WEIGHT (air = 1)	SOLUBILITY GRAMS PER 100 cc. WATER AT 41°F	PROPERTIES	HOW FORMED	WHEN DANGEROUS	THRESHOLD LIMIT VALUE	HOW DETECTED	FLAM-MABLE	EXPLO-SIVE	EFFECT	TREATMENT
20. Mercury	Hg			Vapourizes when in liquid state	May occur as free metal in some mercury ores, is produced by heating of mercury ore. Used industrially as in production of mercury-gold amalgam.	As mercury adheres to one's clothing and skin unless careful control is maintained contamination might be continuous.*	0.1 mg/m^3 self-contained equipment only. Safe respiratory protection in areas of high concentration.	Physiological reaction. Detector. Analysis of vacuum bottle sample.	No	No	Excess flow of saliva, loosening of teeth. Diarrhea. Nervous and psychic changes in persons.	Careful personal hygiene-body and clothing. No smoking or eating in areas where mercury is present. Clean plant and spray with lime-sulphur spray.
21. Propane	C_3H_8	1.56	0.1 approx.	Gas inflammable tasteless colourless odorless scented commercially.	Petroleum distillate.	Explosive range 2.4%-9.5%	1000 ppm	Safety lamp methanometer	Yes	Yes	Displaces oxygen.	As for oxygen deficiency.
22. Acetylene	C_2H_2	0.91	0.05	Gas inflammable colourless distinct odor	Water on calcium carbide	Explosive range 2.8%-81%. Tank may explode on shock, i.e. by dropping pressure sensitive above 15 p.s.i.		odor	Yes	Yes	Displaces oxygen	As for O_2 deficiency
23. Chlorine	Cl_2	2.49	1.08	Greenish yellow gas	Various ways chemically but principally from electrolysis of of common salt.	Above 1 ppm	1 ppm	odor	No	No	Corrosive irritant eyes, skin, lungs, etc. Use. Type "N" mask up to 2% concentration.	As for oxides of nitrogen
24. Ammonia	NH_3	0.6	Highly soluble in water	Colourless Strong odor Caustic action	Combination of hydrogen nitrogen with catalytic action	When exposed to oxidizing substances & heat becomes explosive.	50 ppm	odor detector	Yes	Yes	Corrosive irritant to eyes, nose, throat & lungs	Fresh air rest

*Keep plant clean.

GAS CONTROL

Ventilation is not a serious problem around surface or open pit operations, but nevertheless every year workers are killed or injured because of dangerous amounts of gases or vapors, or because of not enough oxygen in places where they work. Such places, which are called Confined Spaces, include buildings, manholes, tunnels, vaults, chemical tanks, oil tanks, storage bins, silos, and pumps, etc.

There are several types of hazards that may be found in confined spaces:

1. Toxic gases or vapors - gases that poison

2. Flammable gases or vapors - gases or vapors that ignite easily

3. Asphyxiant gases - gases that cause suffocation

4. Lack of oxygen

Most people who expose themselves to a dangerous atmosphere are not aware the danger could exist or of the need to protect themselves. In an area where a dangerous atmosphere exists the hazards can best be taken care of by proper and adequate ventilation. (The exception to this rule is when a fire is involved.)

If a surface rescue team cannot ventilate an area, and lives or property are involved, proper respiratory equipment must be worn. This is why we feel a rescue team should be trained in the use of the following types of apparatus - filter type, chemical oxygen and pressure type self-contained equipment.

To control gases on a property, supervisors and rescue teams should be made aware of any special gas-producing chemicals used on their property and should be able to test an area to see if it contains a dangerous atmosphere.

There are various methods and devices in use for detecting the presence and quantity of toxic, noxious and explosive gases. The presence of carbon monoxide and deficiency of oxygen are the greatest hazards in rescue or recovery work, but the chance of encountering other gases make it necessary to train in the use of at least two detectors.

1. The Colorimetric Carbon Monoxide Tester.

2. The multi Gas Detector (Draeger or M.S.A.)
3. Flame Safety Lamp
4. Oxygen Detector
5. Methane Detectors

INSTRUMENTS USED IN MINE RESCUE TRAINING COURSE

The following instruments are used to determine the condition of mine air and the state of the ventilation:

FLAME SAFETY LAMP

The flame safety lamp is a device used for determining if the mine atmosphere will or will not support combustion or life; for detecting the percentage of methane gas and for detecting the presence of excess nitrogen or black damp in mine air.

The lamp has three gauzes, burns naptha, and is magnetically or key locked. Magnetically locked safety lamps are the only permissible flame safety lamps to be used when flammable gases are present. The magnet to open such lamps must not be used in the presence of a flammable gas.

The air feeding the lamp enters through a single gauze below the wick and the gases of combustion from the lamp exit above the wick through double gauzes. These gauzes are constructed of steel wire mesh having 28 wires to the inch or 784 openings to the square inch. The hot gases of combustion in passing through the double gauzes are cooled or quenched by the mesh absorbing the heat from the gases. It is this cooling effect that forms the safety principle and allows the lamp to be used where combustible gases may be encountered. The combustible gases such as methane may burn within the lamp but the resulting flame will be cooled below the ignition point of the gas surrounding the lamp as it passes through the double gauze. However, the safety lamp is only safe when it is assembled correctly and used carefully by a competent person. The flame of the lamp must be kept fairly low at all times and the lamp removed when a large percentage of methane is encountered so that the gauzes do not overheat. The flame from burning gases within the lamp will pass through the gauzes when they become red hot thus being unable to absorb heat from the flame.

Flame safety lamps will not burn in a methane-free atmosphere having an oxygen content below 16.25 per cent; however, they will burn in atmospheres of lower oxygen content if methane is present. The lamp flame will be extinguished when the oxygen content falls below 13 per cent regardless of the percentage of methane present. Usually as the percentage of oxygen in the air approaches 16 per cent the flame will gradually lower, grow dim and will flutter, then go out.

When black damp is present, usually found near the floor, the flame will lower, become dim and will actually leave the wick, showing a space between the wick and the base of the flame.

Excess nitrogen may be detected by observing the action of the flame when the lamp is held near the roof or back of working places. The action of the flame is similar to that when encountering black damp. Carbon dioxide has a similar effect on the lamp. This gas, being heavier than air, will be found near the floor.

Methane gas being flammable will burn within the lamp and has the effect of increasing the length of the lamp flame. The elongation of the flame caused by the gas is a pale-blue flame (cap) that appears to ride on or over the lamp flame. The height or length of the cap is indicative of the percentage of methane present. However, when testing for methane the flame in the lamp should be lowered until there is just a small yellow flame visible. This method will allow the blue cap of the burning methane to be more visible.

Approximate size of blue caps in relation to percentage of methane:

1/3 inch cap represents 1.0 per cent methane
3/8 inch cap represents 2.0 per cent methane
1/2 inch cap represents 2.5 per cent methane
7/8 inch cap represents 3.0 per cent methane
1 1/3 inch cap represents 4.0 per cent methane

ANEMOMETER AND VELOMETER

These instruments are used in the determination of air flow for ventilation purposes.

An anemometer consists of a steel ring within which is posed a rotating vane; the blades of the vane are inclined to the plane of rotation. The air current striking the blades rotate the vane; the number of revolutions being recorded on the face of a dial by means of a series of gears. The instrument is so calibrated that each revolution of the vane corresponds to one lineal foot of air travel. It is employed to measure the velocity of the air current as expressed in feet per minute.

The design of a velometer is based on the pitot tube principle. Pressure exerted on a vane travelling in a circular tunnel causes a pointer to indicate the measured valves on a scale, either in English units or metric units.

THERMOMETER

Moderate temperature is measured by thermometers, on either the Fahrenheit or centigrade scales. Thermometers consist of a thick glass tube with a small uniform bore, sealed at one end and terminating in a small bulb at the other end. This bulb contains mercury or alchol; when the temperature rises the liquid expands and rises, when the temperature drops the liquid level drops.

Fixed points on the Fahrenheit thermometer are 32° and 212° F, 32° F is freezing temperature and 212° F is boiling point.

Fixed points on the centigrade are 0° C, freezing temperature and 100° C boiling point.

To convert centigrade to Fahrenheit $9/5 \times C + 32 = F$
To convert Fahrenheit to centigrade $(F-32) \times 5/9 = C$

Example

Convert 60° centigrade to Fahrenheit
$60 \times 9/5 = 108 + 32 = 140^\circ$ F

Convert 140° Fahrenheit to centigrade
$(140 - 32) \times 5/9 = 108 \times 5/9 = 60^\circ$ C

The safety cap on a McCaa oxygen apparatus bottle contains Rose Metal, which melts at 94° C

94° C $= 9/5 \times C + 32 = 201^\circ$ F.

In the gram-metric measurement system being adopted in Canada by 1978, centigrade and Celcius temperature readings are the same.

Two thermometers are used in the construction of an hygrometer, a device for determining the humidity of air. The thermometers are mounted side by side on a frame and the bulb of one is covered with muslin kept moistened with water. Evaporation from the moistened bulb produces a depression of temperature so that this thermometer reads lower than the dry bulb. The thermometers should be mounted so as to permit the free circulation of air around the bulbs. Usually the device is constructed so that it can be freely swung in the air being monitored in order that the thermometers will reach constant readings. The two readings are recorded and by reference to a chart or special slide rule the relative humidity of the air can be determined.

MINE WATER GAUGE

A mine water gauge is a U-shaped glass tube having a 1/4 inch bore and mounted on a suitable base to which an adjustable scale is affixed.

Water is placed in the bend of the tube to indicate by difference of water level in the two arms of the gauge, what is the difference of pressure exerted on them. Both ends of the tube are open, and one arm is extended and bent at right angles to enable it to be inserted in a hole in the wall separating the intake and the return airway. The pressure on the intake is always greater than that on the return side of the mine. This causes the water level to sink in the arm of the tube exposed to the intake and rise a corresponding amount in that open to the return. The difference in the two levels is read on the scale in inches, each inch of water gauge reading corresponds to 5.2 pounds per square foot.

Example

A water gauge reading of 2.5 inches would show a ventilating pressure of 13 pounds per square foot (2.5 x 5.2 = 13).

A cube, 12 inches on each side filled with water, weighs 62.5 pounds. It is evident that an inch in depth of this water will have a weight of 62.5 ÷ 12 = 5.2 pounds. This weight of water, being distributed over a square foot of area, corresponds to a pressure of 5.2 pounds per square foot due to 1 inch of water level.

BAROMETER

A barometer is an instrument used to measure the pressure of the atmosphere. The most reliable instrument for the purpose is a mercurial barometer. This consists of a glass tube closed at one end and open at the other. This tube, being first filled with mercury, is inverted and its open end immersed in a basin or vessel of mercury. The surface of the liquid in the basin being exposed to the pressure of the atmosphere, the column of the mercury in the tube now sinks to a level such that the weight of the mercury column is supported by the atmospheric pressure acting on the surface of the mercury in the basin, there being a vacuum or no pressure at the top of the tube. Since each cubic inch of mercury weighs 0.49 pound, and the height of the mercury column supported by the atmospheric pressure at sea level is 30 x 0.49 = 14.7 pounds per square inch.

A rapid fall in the barometer indicates a decrease in the atmospheric pressure which in turn decreases the mine ventilating pressure. This would allow the gases in gobs and abandoned workings to expand and flow into the active workings, thus creating a dangerous condition.

The barometer gives an indication of different elevation, it varies approximately 1 inch for each 900 feet of ascent.

The barometer reading with an elevation of 3,315 feet would be 3,315 divided by 900, which would be 3.68 of a drop in barometer. Therefore, 30 minus 3.68 is 26.32, which is the barometer reading at this elevation.

ELECTRIC CAP LAMP

The electric cap lamp is the safety lamp which is most commonly used by miners. It is a lamp in which the energy necessary to provide electricity for the light is stored in a chemical form in the cells during charge, and is released by chemical action during discharge.

The principal safety feature of the electric cap lamp in a methane concentration is the spring supporting the light bulb. In the event the light bulb is broken, the spring automatically breaks the electrical circuit.

OXYGEN DETECTOR

In 1966 a new type of polarographic electrode was developed by the Safety in Mines Research Establishment in Great Britain. This instrument is capable of determining the amount of oxygen present in a sample of gas being tested. The apparatus is an electrolytic cell having a lead anode and a cathode made of a membrane of either teflon or silicone rubber metallized on one face with a layer of gold overlain with a layer of silver. The oxygen in the sample diffuses through the membrane to the cathode and an electric current is produced the magnitude of which depends on the amount of oxygen present. Instruments based on this electrode are insensitive to shock, orientation, air velocity, and to other gases generally found underground. The instrument should not be used in atmospheres containing oxides of nitrogen or where it is possible to coat the membrane with oil or similar material. This equipment has several models available but most notably with the following ranges of oxygen:

1. 0 per cent - 25 per cent
2. 0 per cent - 40 per cent
3. 0 per cent - 100 per cent
4. 0 per cent - 50 per cent and 0 per cent - 100 per cent monitor

The time required to make a test is between 20 and 30 seconds with an accuracy of ± per cent if the instrument is at ambient temperature.

METHANE DETECTORS

Several electrically operated methane testers are available some of which pump either mechanically or manually the gas sample being tested while others rely on infusion of the gas sample through a porous fitting. All operate with a Wheatstone bridge circuit which has one of the four balanced resistance paths of the bridged circuit passing through the burning chamber. The burning gas causes an increase in the amount of heat in the wire and this causes a change in resistance which varies with the heat generated or the amount of combustible gas present. The circuit imbalance is represented by a meter reading calibrated to indicate the percentage of methane in the atmosphere. Departmental experience indicates that the porous head detectors can give low readings where there is an appreciable ventilating current. This is caused by the cooling effect of the circulating air.

COLORIMETRIC CARBON MONOXIDE TESTER

This instrument consists of an aspirator bulb with an adjustable control valve, a replaceable indicating tube, and a standard colour scale. The operator must have good eyesight to make a comparison between the colour scale and the indicating tube.

Inspecting the Detector Before Use

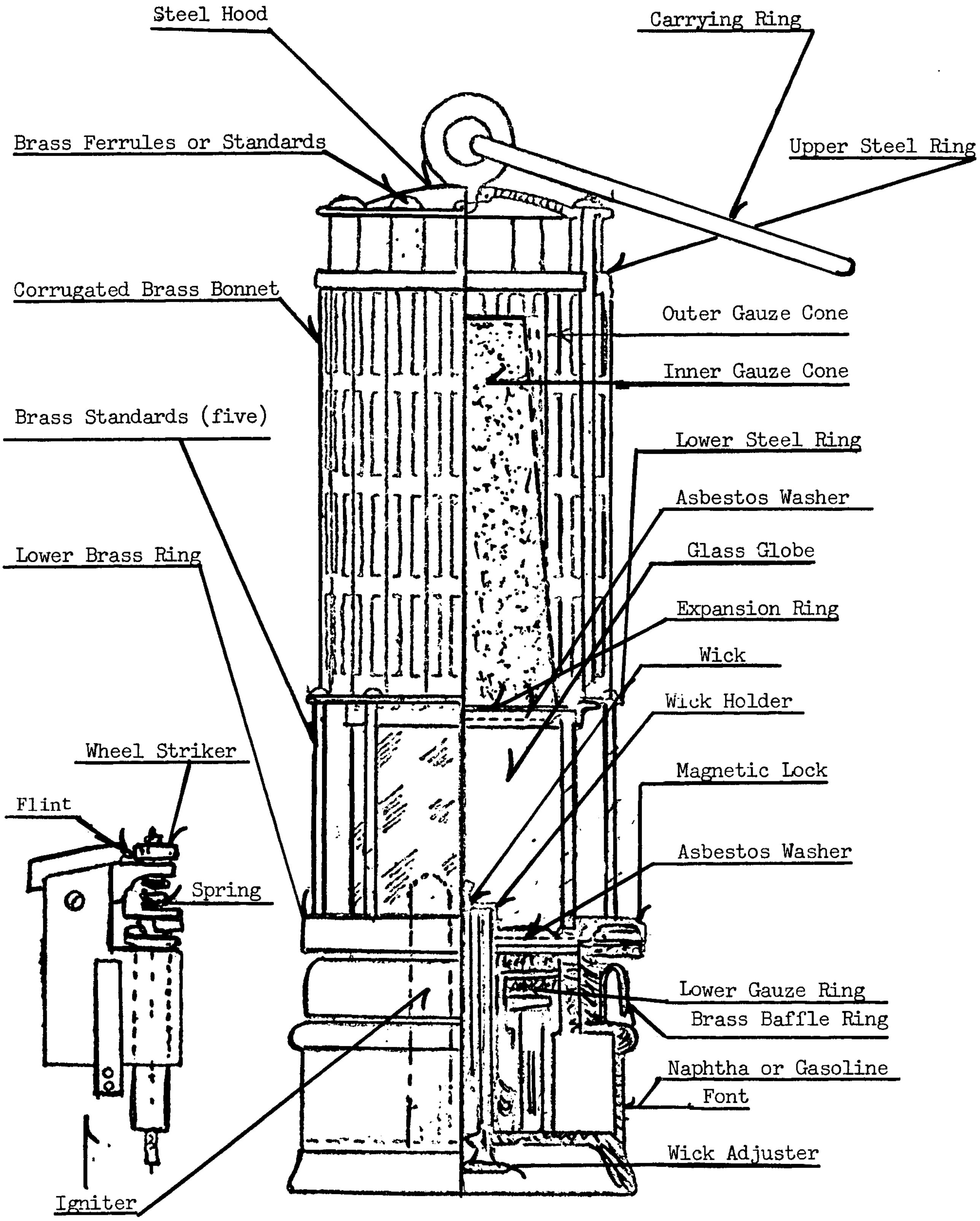
To test the instrument for air tightness, deflate the bulb fully place a finger firmly over the inlet opening and observe the bulb. If the bulb tends to inflate, the rubber band over the outlet opening, or the bulb itself may be leaking.

Thirty seconds (+ or - 3) are required to inflate the aspirator bulb when all air is exhausted from it with no tube in place. Adjust flow control valve screw, if necessary, using a small screwdriver to obtain this rate. If proper flow cannot be made by adjustment remove valve screw and clean orifice with a fine wire. Replace screw and adjust to obtain correct flow.

Use of Tester

In use, the sealed ends of the indicating tube are broken and the tube is inserted in the tube holder of the tester with the empty end of the tube towards the aspirator bulb. A measured sample of air, controlled by a specially designed metering orifice, is then aspirated through the tube. When the air sample contains carbon monoxide, the yellow silica gel in the detector tube turns green, the shade and intensity being directly proportional to the concentration of carbon monoxide in the air sample. The varying shades of green shown on the colour scale are easily distinguished and the comparable carbon monoxide concentrations which they indicate are clearly marked in percentages. The bulb should be completely deflated before sampling begins.

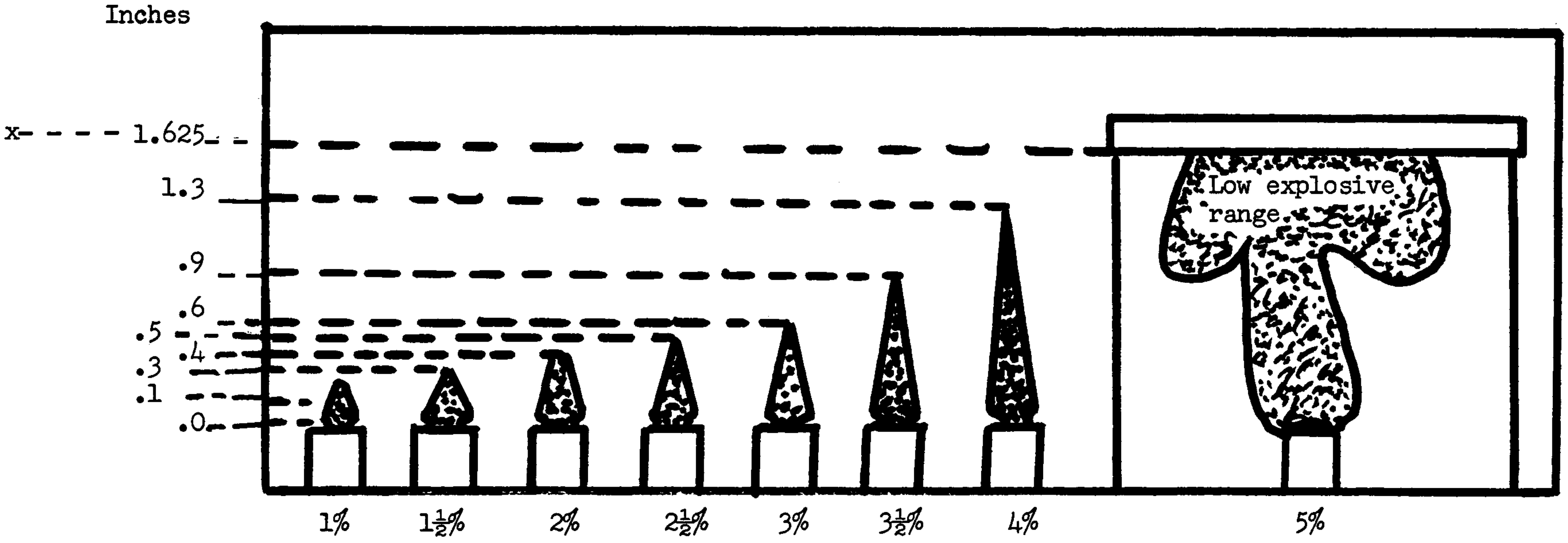
The tester is capable of indicating the presence of carbon monoxide in air from 0.001 to 0.10 per cent by volume. A special chemical is placed on either side of the silica gel to act as a guard. The guard chemical removes water vapor, gasoline vapor, and other interfering substances ordinarily encountered with carbon monoxide. One squeeze of the suction bulb is recommended to obtain an accurate indication of carbon monoxide concentration in the range of 0.005 to 0.10 per cent. In the range from .001 to .005 more accurate colour determinations may be obtained by giving the bulb from two to five squeezes. The tube will retain any colour change indicating carbon monoxide for a period of at least eight hours providing the broken ends are sealed immediately after testing. New tubes may be kept indefinitely, providing the ends are not broken. The tube may be used only once if any colour appears, but several tests may be made if no colour change takes place.



Wolf Safety Lamp

Scale - Two Thirds Full Size

Colour of Methane Gas Cap on lamp—LIGHT BLUE



Percentage of Methane Gas with Wolf round wick lamp
Testing flame 1/10 th.inch high
x—— Upper limit of visible gas cap
1% visible to naked eye —— 2½% withdrawal point.
5% lowest—10% most violent—15% highest Explosive range.

Testing Diesel Exhaust with the Colorimetric

Where diesel motors are used in mining operations, it is necessary that frequent tests be made to check the amount of carbon monoxide in the exhaust gases. A scrubber, filled with gasorbent is available, and should be attached to the inlet of the instrument. The gasorbent prevents the passage of all gases except carbon monoxide, which would have an effect on the silica gel. Readings may then be taken in the regular manner. Samples should not be taken directly from the exhaust manifold, as hot gases will cause errors in the result.

DRAEGER GAS DETECTOR

This instrument, consists of a spring- loaded rubber bellows with a capacity of 100 cubic centimetres of air, and a replaceable indecating tube. Air to be tested is drawn directly into the indicating tube before passing into the bellows, and thus the instrument requires no purging before inserting the tube. The outlet valve of the bellows provides so little resistance that the air will not return through the testing tube.

The Draeger gas detector is designed for the testing of a number of gases, using various indicating tubes. We are concerned here primarily with the testing of carbon monoxide.

Two different types of indicating tubes are available for testing of low and high quantities of carbon monoxide. The low-range tubes are used in testing CO from 10 to 3, 000 parts per million, (0.001 per cent to 0.3 per cent.) The high-range tube, identified by the yellow band, is used for testing CO from 0.3 per cent to 4 per cent. All tubes contain filtering chemicals to remove hydrocarbons and other gases that could affect the reading on the instrument.

Inspecting the Detector Before Use

The bellows should be squeezed once or twice to be sure the outlet valve is operating. Then place a finger over the inlet and collapse the bellows. The bellows should remain collapsed unless the outlet valve is leaking. It is not necessary to check the time taken for the bellows to inflate, as that action is controlled by the resistance built into each indicating tube. If the outlet valve is leaking, the valve cover plate may be removed and the valve seat inspected or cleaned.

Use of the Detector

To use the detector, select the proper CO indicating tube,

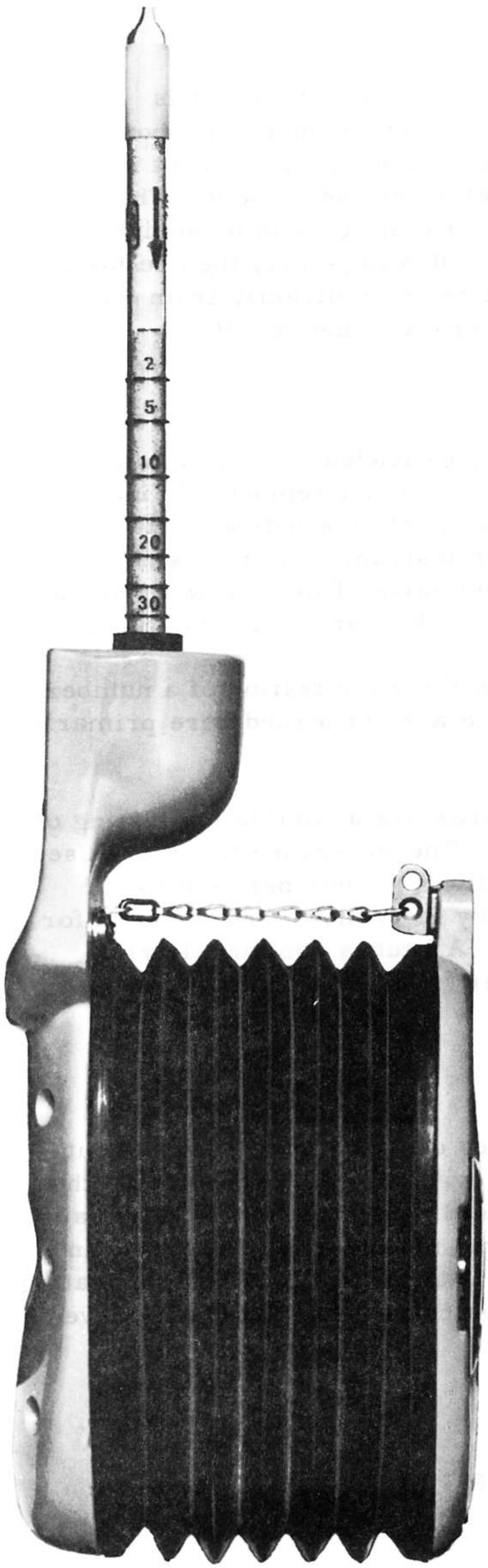


Fig. 1 Multi Gas Detector ready for use

25652

The DRÄGER Multi Gas Detector, ready for use, consists of two parts:

THE GAS DETECTOR PUMP

and the

DRÄGER TUBE

chosen as a function of the measuring problem involved.

Pump and tube together form one unit in the measurement. The DRÄGER tube is the indicating instrument of the Multi Gas Detector.

The unit is supplied in a metal carrying case. A protective bag for the pump and spare parts are also supplied with the unit.

Accessories for the DRÄGER Multi Gas Detector:

1. **Pump stroke counter**
2. **Extension tube (3 m long), with bag, for sampling at inaccessible points**
3. **Hot air probe for the investigation of furnace waste gases**
4. **Supplementary part for the respiratory CO test**
5. **Motor vehicle exhaust probe for the investigation of exhaust gases**
6. **Mixing device**
7. **Dust sampler.**

The advantages of the DRÄGER Multi Gas Detector are:

- **Operation with one hand**
- **Low weight and simple operation**
- **Always ready for use**
- **DRÄGER tubes for about 100 different gases and vapours**
- **Printed measuring scale on the DRÄGER tubes**
- **Immediate reading of the result on the DRÄGER tube.**
- **Optimum accuracy of measurement**
- **Maintenance-free bellows pump**

depending on the concentration of CO that may be expected due to conditions that are known. Break the sealed ends of the indicating tube by inserting them in the "breaker" attached to one end of the drag chain on the bellows. Insert the tube firmly into the detector inlet so the passage of air will be according to the arrow on the tube, squeeze the bellows fully to expell the residual air, and then allow the bellows to re-fill completely. If the air sampled contains carbon monoxide, a dark stain will be noticed extending downwards through the white crystals. The percentage is measured according to the distance the stain extends into the crystals.

The figures 1, 5, 10, 20, and 30 painted on each of the low-range tubes are interpreted when a 1-squeeze test has been made, as 100, 500, 1000, 2000, and 3000 parts per million (01; .05; .1; .2 and .3 per cent) respectively. If the colour change is too slight to be readily observed after 1 squeeze, or does not extend as far as the first marking, nine more squeezes should be given. The above figures would then indicate 10, 50, 100, 200, and 300 parts per million (.001; .005; .01; .02; and .03 per cent).

The high range tube has the figures 0.5; 1.0; 2.0; 3.0 and 4.0 painted on it, and a 1-squeeze test, is interpreted directly "in percentage". A 10-squeeze test is interpreted as .05; .1; .2; .3; or .4 per cent respectively.

In either tube, the reading is taken at the lowest level of the general discoloration, and NOT at the deepest point of colour penetration.

All tubes have a band on the upper end on which can be written data concerning the test. Tubes, once coloured will not change colour for several hours, and so may be read later under better lighting conditions than found in testing areas underground. Tubes that have been used and no colour reaction obtained, may be re-used up to 10 times or until colour is found, in one day. Once coloured, they must not be re-used.

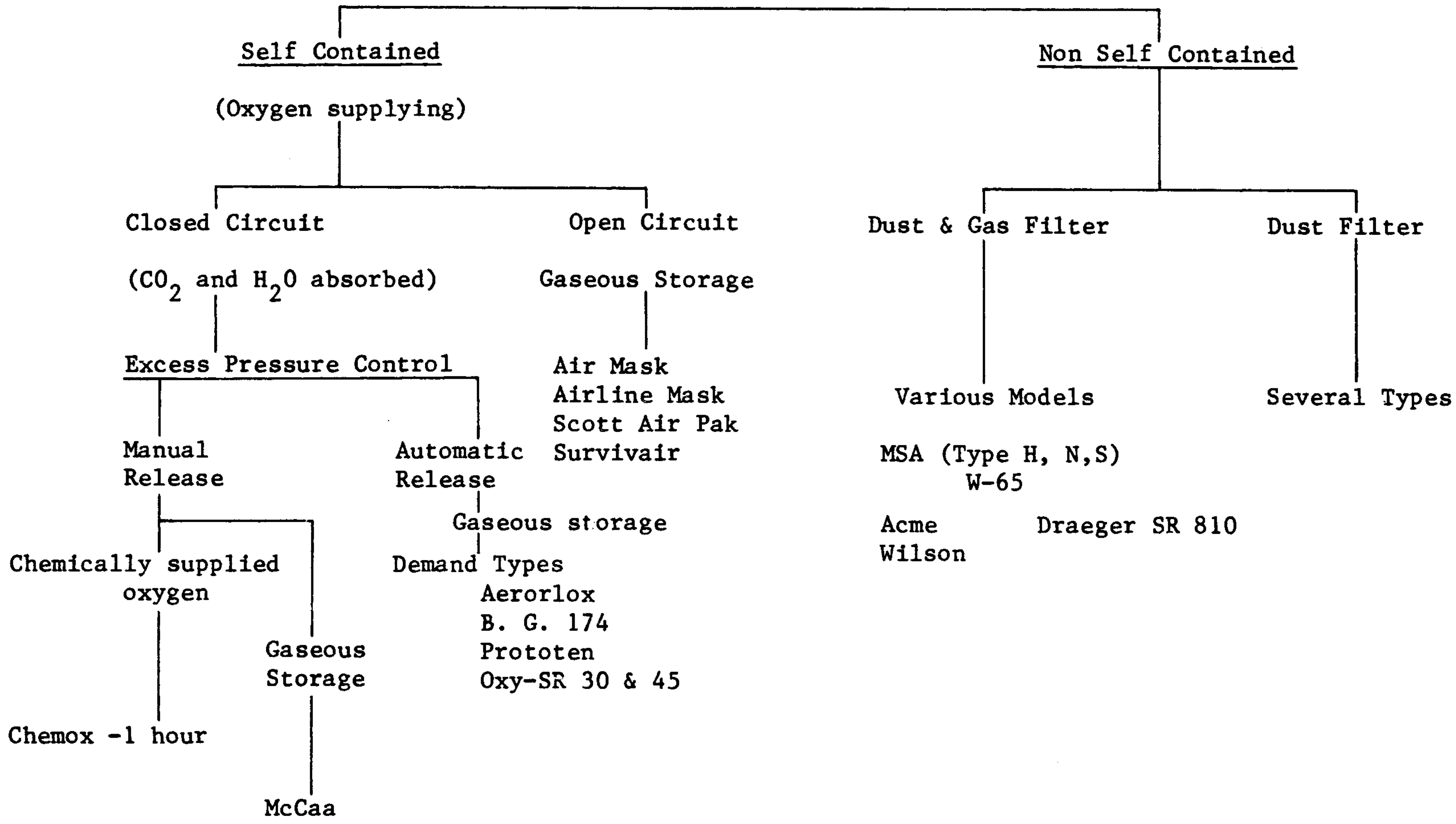
When testing diesel exhaust or other high mixtures of hydrocarbons for carbon monoxide, a carbon pre-tube, filled with activated charcoal should be used as an additional filter to prevent the hydrocarbons from reaching the testing crystals. Exhaust gas should not be sampled directly from the manifold, but should be passed through some form of cooler to bring the temperature into the range of 50° to 112° Fahrenheit.

The example described above is based on testing for carbon monoxide. Since this apparatus is a Multi-Gas Detector a wide range of detector tubes are available for different contaminants. Each gas and its indicating tube has its own characteristic and method for use, making it impossible to have a working knowledge of how to use them all. This is not a problem, for in each new box of tubes is a Data Sheet which contains all the information needed to make a test with the type of tube to be used; therefore, it is important that anyone using a multi-gas detector should know how to read the Data Sheet.

Common Applications of the Draeger Multi-Gas Detector

1. For controlling the threshold limit values of contaminated air in work areas.
2. Testing tanks, sewers, and manholes before entry.
3. For tracing leaks in gas pipes and reservoirs.
4. In detecting gas losses in certain types of processes such as recovery plants, etc.
5. Identifying unknown gaseous contaminants by using different detector tubes.
6. Measuring the hydrogen sulphide in refinery gases and sewage disposal plants.
7. Controlling CO_2 concentrations in greenhouses, fermenting rooms, grain silos, fruit storage rooms, and testing for leaks in CO_2 extinguisher systems.
8. Measuring the CO_2 content in flue gas or fork-lift and vehicle exhaust gases.
9. Adjustment of the fuel injection pump for diesel engines.
10. To rapidly diagnose the per cent CO in alveolar air or in samples of blood.

RESPIRATORY PROTECTIVE EQUIPMENT



FILTER-TYPE SELF-RESCUERS

The filter-type "self-rescuer" is a small gas respirator designed to provide protection to the wearer against carbon monoxide gas which is usually present in the air following a mine fire or explosion.

Owing to its small size, the filter-type self-rescuer may be easily carried on the underground worker's belt as is the case with coal miners, or they can be carried on the machine the worker is operating. It can therefore be readily available in the case of emergency.

Filter-type self-rescuers are also commonly stored in "caches" in strategic locations in mines so as to be readily available in case of emergencies.

There are two models, the Draeger Model 810 and the MSA Model W65. Both the model 810 and the model W65 self-rescuers are sealed at the factory and these seals should not be broken unless the self-rescuer is to be used. Once the seal is broken the chemicals in the apparatus can deteriorate and render the apparatus useless to the wearer.

The model 810 is sealed in a vacuum while the model W65 is sealed under pressure in the inert gas nitrogen.

Miners should always examine their self-rescuers for dents or other external damage before being used. If the seal is broken or the container damaged, do not use it.

Although there are slight variations in design, both the W65 and the model 810 operate on the same principle.

When the wearer inhales through the mouthpiece, air is drawn in through the bottom of the self-rescuer and passes through the coarse dust filter bag which enclosed the lower part of the apparatus. Coarse dust is removed by this bag. The air then passes through a fine dust filter in the bottom of the canister and through a drying agent. This drying agent removes excess moisture from the air which could reduce the effectiveness of the apparatus.

After passing through the drying agent, the air flows through a chemical called "Hopcalite" which changes the deadly carbon monoxide gas to relatively harmless carbon dioxide. The air containing the harmless amounts of carbon dioxide is then breathed by the wearer after having its temperature reduced by a heat exchanger.

When exhaled, the air again passes through the heat exchanger and out through a check valve to the outside air. The check valve allows air to pass outwards through it but will not allow air to come in from the outside. All inhaled air must pass through the canister and is treated before it reaches the wearer's lungs.

The filter-type self-rescuer is a very simple apparatus.

Protection Provided by the Filter-Type Self-Rescuer

The filter-type self-rescuer will protect the wearer against a 1 per cent carbon monoxide concentration (10,000 ppm) for up to one hour providing there is enough oxygen present to support life.

Protection is provided against higher concentrations of carbon monoxide for shorter periods of time. However, the heat build-up in the apparatus is quite rapid for higher concentrations. There is always a certain amount of heat build-up of the air and this is an indication that carbon monoxide is actually present, and the more carbon monoxide that is present the hotter will be the air breathed.

In spite of heat build-up, the self-rescuer must be kept in the mouth until fresh air is reached. Death from carbon monoxide poisoning can be swift and is more permanent than the discomfort caused by breathing hot air.

It is important to remember that a heat build-up in the air can be expected when using a self-rescuer in an atmosphere containing carbon monoxide. The hotter the air the more carbon monoxide is present and the more important it is to continue using the apparatus.

When mounted on moving equipment or carried by workmen, the self-rescuer has a service life of five years provided the seal is not broken.

When placed in properly constructed caches, the shelf life is indefinite. A properly constructed cache should be moisture proof, as moisture will seriously affect the life of a self-rescuer.

When the Self-Rescuer is Used

The self-rescuer should be used immediately at the first indication of a fire or explosion even though no smoke is visible.

Waiting until smoke is visible could well prove fatal because the area could be filled in advance of the smoke by lethal concentration of carbon monoxide. Smoke may not appear at all.

Use the self-rescuer at the first indication of a fire or explosion and keep it on until fresh air is reached.

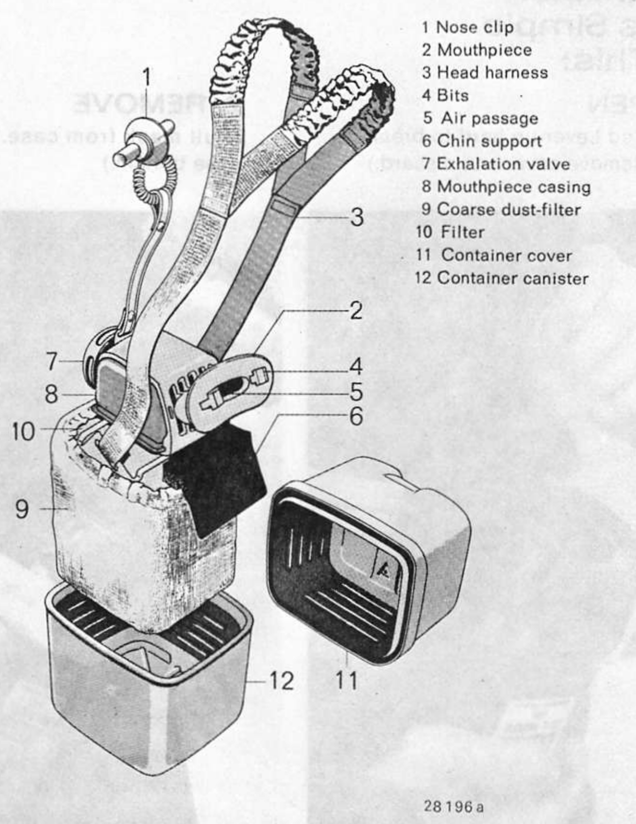
Use of the Self-Rescuer

The first step in using a self-rescuer is to break the seal by raising the lever on top of the case. The cover is then removed and the self-rescuer is removed from the container. The mouthpiece is inserted in the mouth with the grip held between the teeth and the flange placed firmly between the teeth and lips to form a good seal. The nosepiece is then placed firmly over the nose so that the wearer is forced to breathe through his mouth. The head strap is placed over the head to support the weight of the self-rescuer. When wearing the self-rescuer, there must be sufficient oxygen to sustain life (16 per cent by volume).

(illustr. 3) is now available for the first time in plastics with a new type of vacuum closure. The can part and the lid part are pressed together firmly and tightly by the action of a strong internal vacuum. The closure force holding the two parts together is approximately 70 kp (154 lbs.). The protection afforded to the filter and its mouthpiece by the container is exceptionally good. To open the plastics container in an emergency, the tear-open tab is pulled up (illustr. 4): air can then flow into the container, so that it can be immediately opened. The filter can then be taken out.

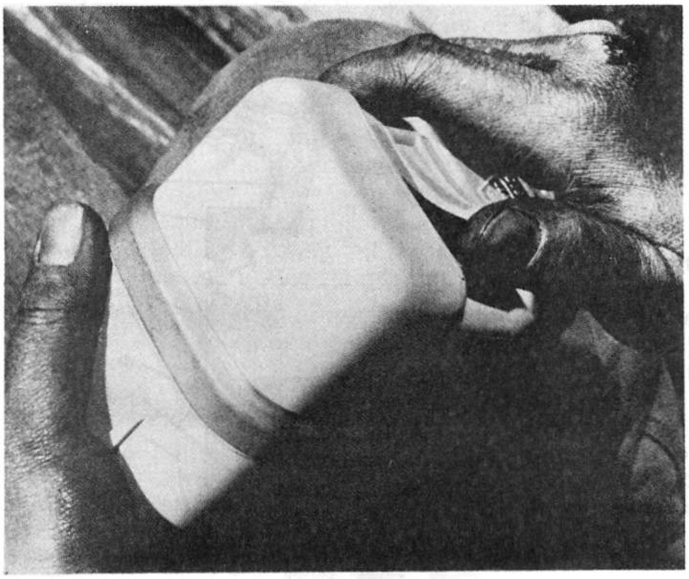
Component (c):

In case of emergency it must be possible to take hold of the filter self-rescuer without delay and to put it on quickly. It should therefore always be carried and not laid down, not even at the working place. This purpose is served by the carrying pouch (illustr. 5) which can be fastened to the lamp strap or to the belt. The carrying pouch is of soft, rubber-like plastics. It enables the filter self-rescuer to be carried in comfort and ensures that it is always readily available in every situation.



3 Principal components of the FSR 810 filter self-rescuer

4 Tear-open tab of the plastics container



Carrying pouch **5**

Using the Self Rescuer Respirator Is As Simple As This:

1. OPEN

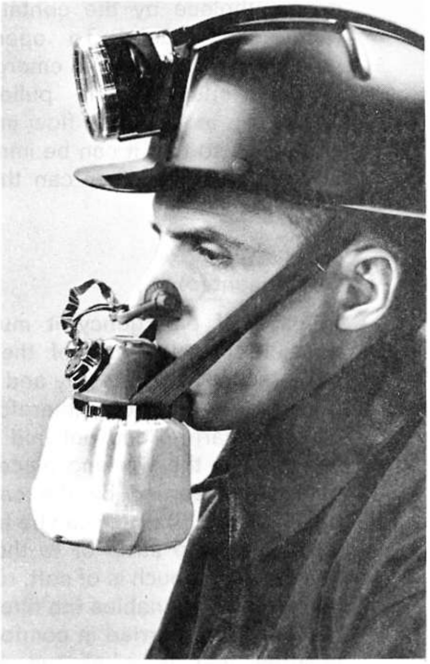
(Pull Red Lever up hard to break seal. Remove cover and discard.)

2. REMOVE

(Pull mask from case. Discard case bottom.)

3. USE

(Insert mouthpiece between lips and teeth, bite on lugs, place nose clip over nostrils. Pull support strap over head. Breathe thru Self-Rescuer.)

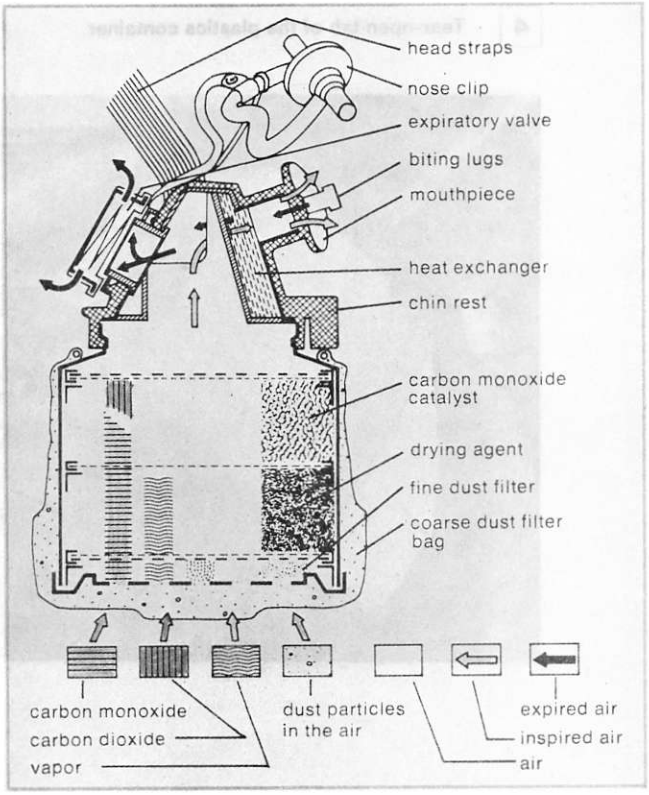


The M-S-A Self Rescuer W65... unique construction... simple operation

The filter unit consists of an outer coarse dust filter and an inner fine dust filter to remove dust particles, a drying agent to protect the hopcalite from moisture and the hopcalite catalyst to oxidize carbon monoxide. Separator screens and baffles are spot welded securely in position.

Breathable air is cooled by the heat exchanger before inhalation. Expired air passes back through the heat exchanger and out through the spring-loaded mica disc expiratory valve. The rubber mouthpiece utilizes a saliva drainer to protect the filter bed from moisture.

The Self Rescuer is secured to the wearer's head with a self-adjusting, cradled headstrap. The cushioned spring steel nose clip, attached by cord and "reminder" metal strip, prevents nasal breathing. Prior to use, a hermetically sealed stainless steel case protects the respirator.



TYPE "N" CANISTERS AND MASKS

The Type "N" mask is a gas mask consisting of a full facepiece covering the eyes, nose, and mouth, a flexible elastomeric, nonkinking breathing hose attached to an air purifying canister. The canister is carried in a chest harness having a neck strap and waist strap to hold the canister tightly to the body.

The facepiece is designed to give a comfortable gas tight fit to a wide variety of facial sizes and shapes. Because of the many variables in facial dimensions and sizes of faces a single facepiece size will not fit all faces. A face-fitting program should be used to determine those persons who cannot be fitted.

The facepiece, hose, and canister assembly must include check valves to allow air flow in one direction only. An inhalation valve is located at the top of the canister and an exhalation valve is a part of the facepiece. The incoming air into the facepiece is directed over the lens to reduce moisture condensation and where this is a significant problem a nose cup can be installed in the facepiece to direct the exhaled air to the exhalation valve without contacting the lens.

The lens of the facepiece is shaped and positioned to give wide visual limits. They are usually made of plastic with some twin lens facepieces having laminated safety glass for a better scratch resistant service.

An adjustable molded rubber head harness holds the facepiece to the face. Some have provision for supporting prescription lens within the facepiece when these are needed. Any support for prescription lens passing through the area where the facepiece contacts the face will result in a leak. Facial hair in the facepiece contact area will also result in a leak and must be avoided.

The Type "N" canister is an air purifying type of device that contains several types of chemicals for removing different groups of gases including carbon monoxide. It also contains a highly efficient particulate filter for removing toxic particulates including smokes, dusts, mists, and fumes. A window indicator is a part of the canister to visually tell the wearer when the canister is no longer able to convert carbon monoxide to carbon dioxide. A positive closing external check valve is attached to the outlet of the canister and connects to the breathing hose.

The granular chemical contents are placed in several layers within the canister and a compression spring at the top of the canister keeps them from shifting their position thereby assuring that all the incoming air contacts the chemical to remove toxic contaminants. The top of the canister also contains layers of filter material which are placed so that any dust from the chemicals cannot come into the facepiece when the mask is worn. Canisters have corrugated bodies or internal baffles to more effectively use their contents. When a granular chemical is placed against a smooth surface such as the side wall of the canister body, it does not pack as tightly to the smooth surface. This then becomes the path of least resistance for the air flowing through the canister. Corrugations or baffles cause this easy flowing air to take a longer path of travel and thereby bring it in contact with as much of the canister chemicals as possible. This prolongs the life of the canisters and prevents channelling and short canister life.

Because the chemicals are affected by moisture, a top seal and bottom seal close the canister inlet and outlet, and should always be kept in place while the canister is stored. Type "N" canisters should be stored in a clean, dry location away from widely varying temperatures and high humidity. When stored in the recommended location their shelf life is three years from the date of manufacture or no longer than one year after the seals have been broken to attach the canister to a mask assembly. Canisters are code dated or otherwise identified regarding their date of manufacture. (Check with the manufacturer to learn their particular date coding.)

The function of the canister is to remove all toxic contaminants from the air drawn into the canister. This is accomplished as follows as the air flows through the several layers of materials:

1 A high efficiency filter removes particulate contaminants by mechanical filtration. The openings in the filter media are small enough to remove particles of smoke that are sub-micron in size.

2. Acid gases such as chlorine, sulphur dioxide, hydrogen sulphide, phosgene are absorbed chemically on materials that are caustic.

3. Ammonia and other basic types of gases are absorbed on chemicals that have an acid reaction.

4. Organic vapors or materials that generally contain carbon and hydrogen plus many other elements are absorbed on the surface of activated carbon. Organic vapors include gasoline, paint solvents, chloroform, and many others.

5. The catalyst Hopcalite oxidizes carbon monoxide to harmless carbon

dioxide. It is placed above all the other canister chemicals which act as dryers to help keep moisture from the Hopcalite. Excess moisture will destroy the Hopcalite. When fighting fires with water, fog, foam, etc., and the canister is openly exposed, the Hopcalite could be destroyed in a few minutes.

6. A layer of calcium chloride is placed at the top of the chemical bed to remove any moisture which may enter from the top of the canister. This is a protection for the Hopcalite when the canister is stored attached to the complete mask assembly.

The indicating window in the Type "N" canister contains panels of two shades of a light blue colour. The darker shade section changes colour with a change in the moisture content of the chemical directly behind it (Hopcalite). The light section is a reference colour. When the canister is used or stored and it picks up moisture, the darker section will gradually become lighter in colour until it matches or becomes lighter than the reference section. When this change takes place the canister is no longer capable of catalytically oxidizing the carbon monoxide to carbon dioxide. The indicating window is designed to tell the condition of the Hopcalite layer only and does not in any way relate to the other chemicals or the canisters ability to remove other classes of gases.

Because the canister contains a variety of chemicals it is able to give protection against a variety of gases and vapors, as well as toxic particulates. The label affixed to the canister describes its protection capabilities. The maximum concentrations in which the canister can be used are 2 per cent acid gases, 2 per cent organic vapors, 2 per cent carbon monoxide, and 3 per cent ammonia. These limits were established by the United States Bureau of Mines a good many years ago and are at the present time undergoing consideration for revision. The Type "N" canister is painted red for identification. Other types of canisters giving protection against single gases, single classes of gases, or combination of gases and vapors are identified by other colours. Only the Type "N" canister with the exception of the mine rescue escape respirator can give protection against carbon monoxide.

The most important precaution when using a Type "N" is that it should never be used where the oxygen content of the contaminated air is not sufficient to sustain life (16 per cent by volume).

Because Type "N" masks have been used for fire fighting in atmosphere containing a high concentration of toxic gases and vapors, and in areas having a low oxygen content, they are no longer recommended for use in fire fighting. A label stating "not to be used for fire fighting" is attached to each canister. Where there is adequate oxygen and some knowledge of the contaminant in the atmosphere this type mask can, however, give very good protection.

When the Type "N" mask is used to enter a toxic atmosphere after it has been donned according to the instructions furnished with each mask, the wearer should cautiously enter the atmosphere and if any odor or irritation is noted, he should leave the area. The mask should be rechecked, tested for tightness, and again entered cautiously. Continued odor or irritation is an indication of a serious problem and the mask and canister should be completely checked. The wearer may also have facial characteristics that precludes his wearing a mask.

Type "N" canisters are designed and laboratory tested to meet performance requirements using test gases that are representative of the classes of gases the canister will protect against. The high concentration tests are made using 2 per cent of the gas by volume in an air flow of 64 litres per minute, low concentration in an air flow of 32 litres per minute. Canisters and complete mask assemblies also must meet pressure drop or resistance to breathing requirements test that are made at an air flow of 85 liters per minute. The flow rates used are based on the minute-volume requirements of people doing moderate to heavy work. The high flow resistant test assures a reasonable resistance to breathing during high inspiratory flows when doing heavy work. A complete mask will have a resistance on inhalation at 85 litres per minute flow 3.75 - 4.00 inches water gauge and .6 - .75 inch water gauge on exhalation.

When the canister is used in an atmosphere containing several toxic gases and vapors, they are removed by the chemical layers as the air moves up through the canister. At the same time the gases are removed water vapor is also taken from the air. Clean, dry air that may contain only carbon monoxide then passes through the Hopcalite layer. This layer requires clean dry air containing only carbon monoxide to preserve its activity as long as possible. As the canister is used and approaches the end of its life it will begin to pass low concentrations of the toxic gases. These can be detected by smell or irritation. The change in odor takes place gradually and will give the wearer adequate time to return to fresh air to replace his canister with a new one. Because carbon monoxide has no odor, the window indicator should be carefully watched when the canister is used in the gas. As long as the indicator section of the window shows a darker colour than the reference section, the canister will give protection against carbon monoxide.

It is extremely difficult to estimate the life of a canister when variable exposure conditions, including concentration of contaminants in the air, breathing rate of the wearer, temperature, and humidity adversely affect service life Since the exposure conditions are subject to wide variation, it is most difficult to estimate the service life of a gas mask canister. However, for guidance purposes, actual man tests performed under Bureau of Mines Schedule 14F stipulate the following minimum service requirements at an average breathing rate of 25 litres per minute in concentrations of 2 per cent for most gases and vapors or 3 per cent ammonia can predictably and reliably give acid gases 15 minutes, organic vapors 25 minutes, ammonia 15 minutes, and carbon monoxide 30 minutes. This time will be correspondingly higher at lower concentrations. Against carbon monoxide the canister life may range between 1 1/2 - 2 hours, depending upon the amount of moisture in the atmosphere. This time, however, should not be considered definite. The window indicator should be relied upon to tell when the canister will no longer protect against carbon monoxide. The canister also can only give protection where the total concentration of toxic gases does not exceed 2 per cent by volume. Where the combined total concentration of toxic gases may possibly exceed this concentration other types of breathing equipment should be used.

During use it is possible the canister may become warm or even hot. This is an indication that it is being exposed to relatively high concentrations of gases and vapors. Each of the reactions involved in the removal of gases and vapors produce heat. This is most particularly true for the carbon monoxide reaction. When the incoming air into the facepiece becomes intolerable the wearer should retreat to a less contaminated area. It is also possible under conditions of very high humidity that an increase in breathing resistance will be noted. If this occurs the canister should be replaced even though an odor or irritation has not been observed.

The Type "N" gas mask features the Window-Cator Canister which contains a moisture indicator. A small, round window in the front of the canister has two half circles--one shows a light blue reference colour, the other a darker blue indicating colour. In use, as the absorbent is penetrated and absorbs moisture, the indicator colour grows gradually lighter....closer to the reference colour. When the colours match, the canister is beginning to lose its effectiveness against carbon monoxide and should be replaced.

Gas mask canisters used for emergency purposes should be replaced after each use. Specific indications for canister replacement and/or return to fresh air are:

1. If the window indicators of the Type "N" canisters show the specified colour changes.

2. If any leakage is detected by smell, taste, or eyes, nose or throat irritation.

3. If high breathing resistance develops.

4. If the canister shelf life is exceeded.

The Type "N" mask can give good protection when it is used wisely and in recognition of its limitations. Steps to consider when using the mask are:

1. Don the mask carefully following the manufacturer's instructions.

2. Test for tightness and comfortable fitting of the facepiece. If leakage is noted repeat donning procedure.

3. Enter the contaminated area cautiously. If an odor or irritation is noted, return to fresh air and determine cause.

4. When odor or irritation is noted after mask has been used, return to fresh air and replace canister.

Type N Cannister and Mask

5. If canister and incoming air becomes hot, retreat from contaminated area. Canister is being exposed to very high concentrations of toxic gases or vapors.

6. Frequently observe the indicator window when exposed to carbon monoxide.

7. Never use a Type "N" mask where the oxygen content of the atmosphere is less than 16 per cent.

8. Do not use the Type "N" mask for fire fighting or where the total toxic gas, vapor or particular concentration exceeds 2 per cent by volume.

9. Use suitable instruments to determine concentration of oxygen and air contaminants.

10. When fighting fires with water, fog, foam, etc., endeavour to protect canister from being unduly exposed to these agents.

DRÄGER Oxygen Self Rescuer OXY-SR® 30

The oxygen self rescuer Oxy-SR® 30 is a newly designed escape apparatus for use in work places where toxic atmospheres and oxygen deficiency may be expected.

The **Oxy-SR® 30** is a compact, easily carried apparatus which makes the wearer completely independent of the surrounding air for approximately 30 minutes. The unit is of the closed circuit type, i. e. the expired air is regenerated and enriched with oxygen for re-breathing.

The Oxy-SR® 30 is fitted with an oxygen cylinder with lever valve enabling its use to be interrupted. The apparatus is therefore suitable for inspections and similar short operations.

Special features are

- **Instant readiness for use**
- **Adaptable to all breathing air requirements through a lung demand valve**
- **Compact and very light (2.3 kg)**
- **Minimal breathing resistance**
- **Low temperature of the breathing air**
- **Charging control by pressure indicator**
- **Low business costs**

Procedure for use:

1. **Open cover and put on the unit**
2. **Place the mouthpiece in the mouth and put on the nose clip**
3. **Open the cylinder valve**
4. **lay on gas-protection glasses**

The impact-resistant plastic casing with cover contains:

The oxygen cylinder — working pressure 300 atmospheres, re-chargeable soda lime container, folded

29 054

Fig. 1 How the Oxy-SR® 30 is carried

29 052

Fig. 2a Oxy-SR® 30

29 053

Fig. 2b Oxy-SR® 30 M

Fig. 3 Oxy-SR® 30 29055

Fig. 4 Oxy-SR® 30 M 27600

breathing bag with pressure relief valve, high pressure control valve with a constant dosage of 1.5 litres/minute and lung demand regulator, corrugated breathing tube with mouthpiece set i.e. breathing-protection mask.

With the cover open, breathing connection fitted, and cylinder valve open, the lung demand valve supplies oxygen over and above the constant dosage to flow into the breathing bag to meet the wearer's requirements, which is particularly important in the first few seconds.

The expired air passes through the breathing tube into the soda lime container, where the carbon dioxide is absorbed. The respirable air then flows into the breathing bag where oxygen from the constant dosage unit is added. On inhalation, the air flows via two non-return valves and the breathing tube to the mouthpiece. The self rescuer Oxy SR® 30 is thus a self-contained breathing apparatus.

With low body work, excess breathing air is discharged into the atmosphere through the pressure relief valve.

When the apparatus is put into operation it functions entirely automatically.

After use, the oxygen cylinder must be re-charged and the soda lime canister refilled.

The Oxy SR® 30 will be delivered in two different types.

- Oxy SR® 30 with mouthpiece-set and gas-protection glasses fitted into cover of casing.
- Oxy SR® 30 with breathing-protection mask. The cover of this apparatus was made higher, so that it can take a small elastic full-mask.

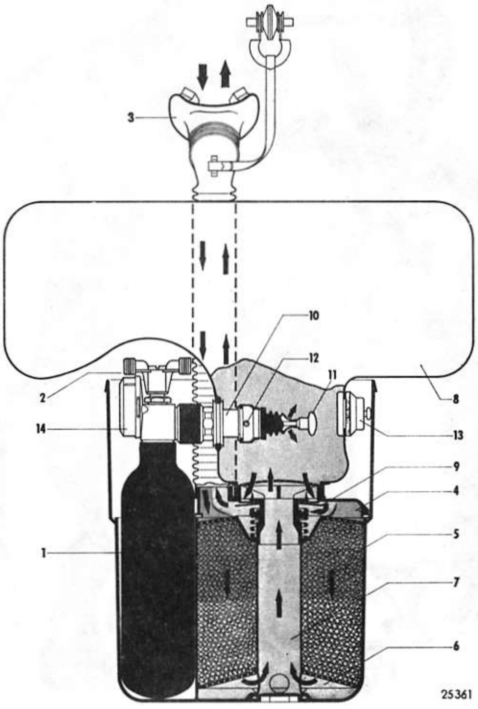


Fig. 5 Circuit diagram of the Oxy SR® 30

1	Oxygen cylinder	8	Breathing bag
2	Lever valve	9	Non-return valve
3	Breathing tube with mouthpiece and nose clip	10	Control valve
		11	Control lever for lung demand regulator
4	Valve chamber	12	Constant dosage unit
5	Soda lime	13	Pressure relief valve
6	Collecting chamber	14	Valve with pressure gauge
7	Central pipe		

ONE-HOUR CHEMOX OXYGEN BREATHING APPARATUS

Portable self-contained equipment generates its own oxygen, providing complete respiratory protection in any area of oxygen deficiency or concentration of toxic gases.

Bureau of Mines Approved M-S-A One-Hour CHEMOX Oxygen Breathing Apparatus utilizes a replaceable chemical canister which removes the carbon dioxide from the wearer's exhaled breath and evolves an ample supply of oxygen which automatically continues in accordance with the wearer's breathing requirements. Entire unit is well balanced and comfortable to wear.

APPLICATIONS

Fire departments, steel plants, chemical plants and laboratories, petroleum industry, food processing, marine transportation.

Oxygen deficient atmospheres or in hazardous concentrations of toxic gases.

FEATURES

Complete respiratory protection for one hour.
Automatic timer rings a bell at end of pre-set time to warn wearer to return to fresh air.
No cylinders, valves, and other mechanical components.
Easily replaceable canisters.
Canisters last indefinitely in storage.
Speaking diaphragm allows easy conversation.
Quick Start Canister enables starting at temperatures as low as — 20°F.

SPECIFICATIONS

Carrying case: 23⅛ in. x 17¼ in. x 9⅜ in.

Weight, complete, with canister: approximately 13½ pounds.

Should more detailed information be desired, ask for Bulletin No. 0103-5.

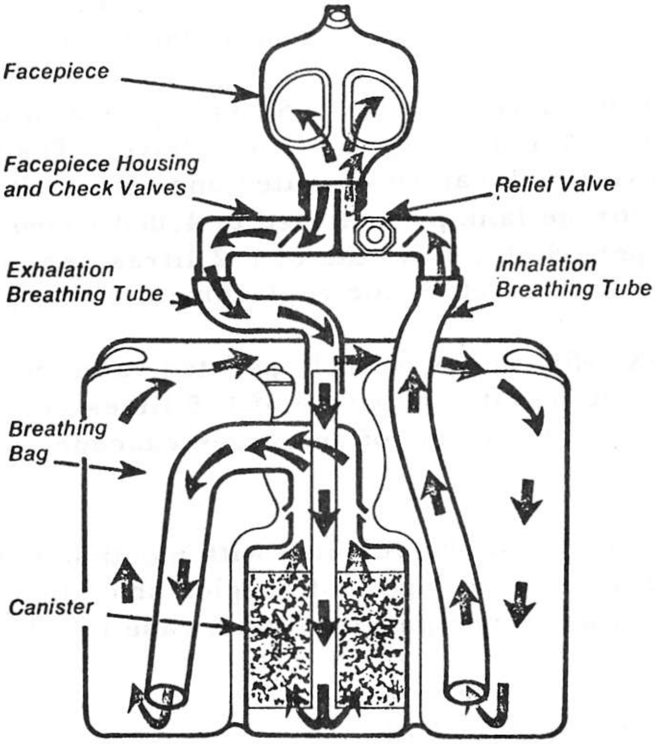
Complete parts list 994219 available at no charge on request.

CATALOG NUMBERS

01-87500	One-Hour CHEMOX Oxygen Breathing Apparatus with Clear-tone Speaking Diaphragm and one canister, complete in case.
01-45151	CHEMOX Canister, only.
01-92900	Quick Start CHEMOX Canister.

Note: ¾ hour Chemox Oxygen Breathing Apparatus can be upgraded to 1 hour type at a nominal cost.

portable self-contained equipment generates its own oxygen, providing complete respiratory protection in any area of oxygen deficiency or concentration of toxic gases



This flow diagram traces the passage of exhaled breath from the facepiece through the exhalation valve and tube to the canister. There the carbon dioxide in the breath is removed, and the moisture content reacts with the chemicals to evolve pure oxygen. This oxygen flows up through the canister into the breathing bag reservoir through the tube to the wearer's facepiece.

SELF - CONTAINED SELF - RESCUERS

At least two self-contained self-rescue units have been manufactured for rescue purposes in mines. Among these are the units produced by the Auer and by the Draeger companies in West Germany.

The Auer self-rescuer is a miniature chemical oxygen producing unit with a quick start canister It provides a 45 minute supply of oxygen The oxygen is quite hot inasmuch as the compactness of the unit does not allow for cooling as is done in the Chemox.

The Draeger rescuer OXY-SR is supplied in two units which are the same except for the oxygen release valve. The OXY-SR 45 has a push button valve which can be operated onoe only. It supplies oxygen from the small storage tank pressurized to 4,000 pounds per square inch for a 45-minute period at a flow rate of 1.2 litres per minute. This unit must be returned to the factory for replacement of the push button valve.

The OXY-SR 30 has a hand operated valve control and can supply oxygen for 30 minutes at a rate of 1.5 litres per minute. This unit can be recharged by means of an oxygen cascade system and high pressure pump.

Both models may be supplied with mouthpieces or face masks. When mouth pieces are used a pair of goggles should be packed within the carrying case lid. A complete unit with case weighs approximately 5 pounds.

DESCRIPTION AND FUNCTION

The impact resistant plastic casing and cover contains:

The oxygen cylinder - working pressure 300 atmospheres, refillable soda-lime canister, folded up breathing bag with pressure relief valve, high pressure control valve with 1.5 litres per minute constant flow and lung demand regulator, corrugated breathing tube with mouthpiece and nose clip, or optional full facepiece.

With cover open, mouthpiece and nose clip fitted, and cylinder valve open, the required oxygen supply is maintained by the constant flow unit and the lung demand regulator. The operation of the latter is most essential as it fills the breathing bag in the first seconds of use.

The expired air passes through the breathing tube into the soda-lime canister where the carbon dioxide is absorbed. The respirable air flows on into the breathing bag where oxygen from the constant dosage unit is added. On inhalation, the air flows via the double non-return valve and the breathing tube to the mouthpiece. The OXY-SR self-rescuers are thus self-contained breathing apparatus.

At low respiratory rates, excess gas is eliminated by the pressure relief valve.

When the apparatus is put into operation it functions entirely automatically.

After use, the oxygen cylinder must be recharged and the soda-lime canister refilled.

Duration of OXY-SR 45

Charging Pressure:

300 atm (4410) psi	45 minutes
200 atm (2940) psi	30 minutes
135 atm (1985) psi	20 minutes

Procedure for use

1. Open cover and don unit.

2. Insert the mouth piece and adjust the nose clip or, if the unit has a full facepiece, this is put on in the regular manner and face straps adjusted.

3. Open cylinder valve and breathe.

CHEMOX OXYGEN BREATHING APPARATUS

The Chemox oxygen breathing apparatus is a self-contained, closed-circuit machine employing a replaceable canister containing a chemical which, when in contact with the moisture in the exhaled breath, evolves a supply of oxygen for breathing requirements and absorbs the exhaled carbon dioxide and moisture. This apparatus has been approved for one hour by the United States Bureau of Mines. It affords the wearer complete respiratory protection in atmospheres which are gaseous or deficient in oxygen.

PARTS OF THE APPARATUS

The apparatus has six main parts: the facepiece and breathing tubes, the frame and harness, the manifold, the breathing bag, the canister, and the time-limit warning bell.

Facepiece

The facepiece is full-vision with a speaking-diaphragm. It has corrugated-rubber inhalation and exhalation tubes, fastened respectively to the left and right hand sides of a metal housing which holds the inhalation, exhalation, and pressure relief valves and is connected to the lower part of the facepiece. The breathing tubes are connected to the manifold by their respective couplings.

Frame and Harness

The frame consists of an aluminum breast plate and canister-holder. These are covered on the outside with a padded, rubberized fabric to protect the wearer from the heat of the canister when in use. The frame is carried by webbing shoulder and waist straps. The canister is supported by a swinging bail, or stirrup, attached to the metal holder and is tightened into place against the manifold by means of a jack screw and hand-wheel on the bail. A rubber gasket forms the seal between the canister and the manifold.

Manifold

The manifold is a metal distribution chamber or box attached to the top of the framework over the canister holder. A metal tube passes down through the centre of the manifold chamber and a cone-shaped socket-casting at the bottom of the manifold into which the neck of the canister fits. The lower end of the tube has a puncturing nose for breaking the copper-foil seal of the canister and fits into a tube in the centre of the canister. The upper end of the tube has a coupling for attaching it to the exhalation tube. Outside the tube in the base of the manifold there is an annular opening leading to the chamber of the manifold. This opening connects with the outer circuit of the canister. On the side of the manifold there is a connection leading from this chamber to the right hand section of the breathing bag A bracket on the side of the manifold carries an elbow which connects the left-hand section of the breathing bag and the inhalation tube.

Breathing bag

The breathing bag is made of rubberized fabric. It is divided into two sections, one on each side of the canister holder, connected together at the top. The bag is held in position to the frame by the connections with the manifold at the top and by a bolt to the frame at the lower end of each section.

Quick Start Canister

The quick start canister is a metal container filled with an oxygen-producing chemical (potassium superoxide.) It is held in the holder between two sections of the breathing bag, and weighs four pounds before use.

An oxygen candle, fired by pulling on a cord lanyard, is attached to the bottom of the canister.

Warning Bell

The apparatus is fitted with a warning bell which is pre-set and warns the wearer when it is time to leave the working place. It is attached to the upper part of the manifold.

OXYGEN FLOW THROUGH APPARATUS

During exhalation the flow is from the facepiece through the right-hand breathing tube, the metal tube through the manifold chamber and the seal-puncturing nose, and down the centre tube of the canister to the bottom. The oxygen then flows up through the chemical, which absorbs the carbon dioxide and the moisture and liberates oxygen, to the top of the canister. From here the flow continues to the bottom of the right hand side of the breathing bag, then to the bottom of the left hand side of the breathing bag, from which it flows into the facepiece through the left hand breathing tube.

INSTALLING QUICK STARTING TYPE CANISTER

A. Lift up on lip of plastic cap until seal is broken. Completely remove the remainder of the cap, exposing the air tight copper foil canister seal. This Copper Foil Seal Must Be Fully Exposed Before Inserting Canister.

B. With the handwheel screwed down far enough for the bail to be swung outward, swing the bail outward and insert canister fully into canister holder with the smooth side to the front. The canister should be inserted sufficiently so that the copper foil seal is punctured and the rubber gasket fits snugly against the V-shaped recess in the plunger casting. Screw the handwheel clockwise until it is tight against the canister.

C. Remove candle cover by rotating swivel plate 180°. Pull swivel plate down, push cover toward centre of canister, and let cover dangle. WARNING. DO NOT PULL LANYARD UNTIL READY FOR USE.

NOTE: The Canister Must be Inserted with the Smooth Side to the Front.

DONNING OF APPARATUS

The following are the consecutive steps in putting on the apparatus before entering a toxic atmosphere. The Apparatus Must Always Be Put On In Fresh Air.

1. Unfasten and straighten all harness straps.

2. With one hand, grasp the apparatus by the plunger casting, dropping the facepiece over the hand holding the apparatus. With the other hand grasp the D-ring assembly where the two large web straps join, placing the breast plate of the canister holder on the chest and slipping the head through the V-shaped opening formed by the two web straps.

3. Continue to hold the apparatus on the chest with one hand and with the other reach around the body at one side and grasp the free end of the web strap on that side. Bring the end of the strap under the arm and snap into the D-ring located on the top side of the breast plate. Repeat this procedure for the other strap.

4. Adjust the position of the apparatus on the body by means of metal slides located on the web harness straps. The position of the apparatus on the body should be such that when the facepiece is put on, the breathing tubes will permit free head movement.

5. Attach the waist strap to the small D-ring located on the lower corner of the breast plate and pull up to a snug fit, tucking in the loose ends.

6. Pull out the facepiece headband straps so that the ends are at the buckles and grip facepiece between thumbs and fingers. Insert chin well into the lower part of the facepiece and pull the headbands back over the head. To obtain a firm and comfortable fit against the facepiece at all points, adjust headbands as follows:

   (a) See that straps lie flat against head.
   (b) Tighten lower or "neck" straps.
   (c) Tighten the "side" straps. (Do not touch forehead or "Front" strap.)
   (d) Place both hands on headband pad and push in toward the neck.
   (e) Repeat operations (b) and (c).
   (f) Tighten forehead or "Front" straps a few notches if necessary.

   Test the facepiece for tightness by squeezing the corrugated breathing tubes tightly. Inhale gently so that the facepiece collapses slightly and hold breath for 10 seconds. The facepiece will remain collapsed while the breath is held, providing the assembly is gas tight. If any leakage is detected around the facial seal, readjust head harness straps. If other than facial seal leakage is detected, investigate the condition and correct. The facepiece must be subjected to a tightness test before each use.

7. With the facepiece adjusted and checked for tightness, start the canister by the following method:

   STARTING QUICK STARTING TYPE CANISTER
   This must be done in Fresh Air

   (a) Pull lanyard straight out away from body. Removal of cotter pin fires candle, inflating breathing bag with oxygen within 15 seconds. NOTE: If Candle Fails to Fire, Insert New Canister.

   (b) Starting of the candle may be accompanied by a slight amount of harmless smoke. The breathing bag will be inflated with oxygen.

   After initial start and use of canister, do not attempt to restart and reuse either type of canister.

The CHEMOX Apparatus Should Be Stored And Started At Temperatures Above 32°F. When a Quick Start Canister is used, the apparatus can be started at temperatures as low as -20°F.

8. To check the complete apparatus for tightness:

   (a) Grasp the lower end of the inhalation (left hand) breathing tube and squeeze it tightly. Inhale gently and if the facepiece collapses the facepiece seal is sufficiently tight and the exhalation valve is functioning properly. This will also test the upper part of the inhalation breathing tube for leaks.

   (b) Continue to squeeze the lower end of the inhalation (left hand) breathing tube. Depress the pressure relief valve button. It should then be possible to exhale through the valve. While still holding the button down, inhale and if the facepiece collapses as above, the relief valve is functioning properly.

   (c) Release the inhalation (left hand) tube and squeeze the lower end of the exhalation (right hand) breathing tube. Inhale and then exhale forcibly. The exhaled air should be forced out between the face and the facepiece only, this will indicate that the inhalation valve is functioning properly and the upper end of the exhalation tube is free of leaks.

   (d) With the bag well inflated, grasp the upper ends of both breathing tubes and squeeze tightly, and depress both sides of the breathing bag with the elbows. If The Breathing Bag Does Not Deflate, The Complete Apparatus is Tight.

   If a Leak or Defect Is Indicated In Any Part Of The Apparatus, It Should Be Checked And The Condition Corrected Before Use.

9. Breathe normally as the apparatus furnishes enough oxygen to meet any breathing requirement.

Use of the Timer

Since the apparatus has a nominal one hour service life as indicated below, it is necessary to determine the length of time required to return to fresh air from the working place and set the timer accordingly. The timer dial is calibrated in minutes, and by turning the pointer clockwise to the number of minutes left after deducting the time for exit, the timer will be properly set. For example, if it takes 10 minutes to return to fresh air, deduct 10 minutes from 60 and set the timer at 50. The bell on the timer will ring for approximately 7 seconds when the pointer returns to 0, at which time the wearer must return immediately to fresh air.

GENERAL INFORMATION FOR USE

The canister will produce more oxygen than will be used so the breathing bags will become over inflated, causing exhalation resistance. The excess volume can be eliminated (vented) by depressing the valve button on the facepiece. Do not over vent.

There are two indications in addition to the timer that the canister is becoming expended--fogging of the lens(es) on inhalation and increased resistance of exhalation. These two indications will not normally appear until after one hour of use but may become noticeable under conditions of extreme hard work. The lens(es) will clear on inhalation until the canister is almost expended, then they will begin to fog. Do not confuse excess breathing bag pressure with canister resistance. If excess breathing pressure is relieved by use of the pressure relief valve and the exhalation resistance is still present, the canister is about expended.

If Either Of These Two Indications Appear, Return To Fresh Air.

CAUTION

NEVER ALLOW ANY SUBSTANCE TO ENTER THE NECK OF THE CANISTER, ESPECIALLY OIL, WATER AND OIL, GASOLINE, GREASE, ETC., AS THE CHEMICAL CONTAINS OXYGEN, WHICH WILL CAUSE COMBUSTION OF ANY INFLAMMABLE MATERIALS WITH WHICH IT IS BROUGHT INTO DIRECT CONTACT, ESPECIALLY IF SUCH MATERIALS ARE MOIST.

AFTER USE

1. To remove the canister turn the handwheel down, swing bail outward and remove the canister with the hand suitably protected by a glove or other covering since the canister may be hot. Do Not Reuse The Canister.

2. Always use the following procedure before discarding the canister:

To dispose of canister, remove to surface, punch a small hole in front, back and bottom, and place in bucket of clean water sufficiently deep to cover the canister at least 3 inches. When bubbling stops, any residual oxygen will be dissipated and the canister will be expended. Pour the residual water which is caustic, down a drain or dispose of in any other suitable manner and then discard the canister. Do Not Puncture Canister Underground.

DEMAND APPARATUS

Scott Air Pak	MSA Oxygen Mask*	MSA Air Mask*
Model No. 6000A2M	Model No. 401	Model No. 401

The Air or Oxygen Pak may be used safely in any atmosphere containing any gas except one which irritates or poisons through the skin, such as hydrogen cyanide or highly concentrated ammonia. It may be used under any conditions of temperature, pressure,or moisture in which a man can work.

Model No. 6000A2M is approved by the United States Bureau of Mines for a half hour of continuous use with a fully charged air cylinder having a capacity of 40.3 cubic feet at 1,980 psi. Its total weight is 29 1/2 pounds.

The purity of the air used to recharge Air Pak bottles is of prime importance as the compressed air must contain not less than 20.5 oxygen and more than 0.005 carbon monoxide. Oxygen Pak bottles are of approximately 100 per cent oxygen. Many companies use the same equipment for compressing air as they use for filling oxygen cylinders thus assuring themselves of the purity of the air. This type of compressor uses water, or soap and water lubrication and the cylinders of the compressor are usually water cooled to eliminate the formation of carbon monoxide which could be caused through the heat generated.

Air compressors using oil lubrication may be used as a source of compressed breathing air only when carbon monoxide indicating devices are used in the circuit continuously to check the purity of the air and the air is properly filtered. Oil or grease, etc., must NOT be used in or around an oxygen pump or Cascade system.

PARTS OF THE APPARATUS

The Air or Oxygen Pak has five main parts: an alloy metal cylinder or bottle, containing pure breathing air or oxygen; a reducing valve and demand regulator with a shut off valve and by pass valve; a facepiece and corrugated breathing tube with "quick connect" coupling; a metal back-plate to which is fastened the web-type carrying harness; an auxiliary charging hose and the female half of a high pressure self sealing coupling.

Air-cylinder or Bottle

For purposes of clarity the term "bottle" will be used throughout

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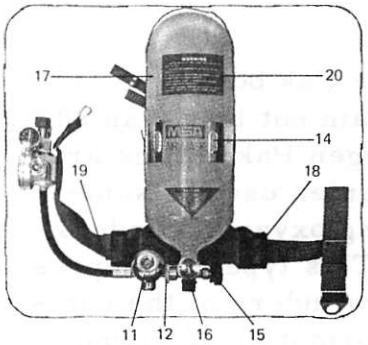
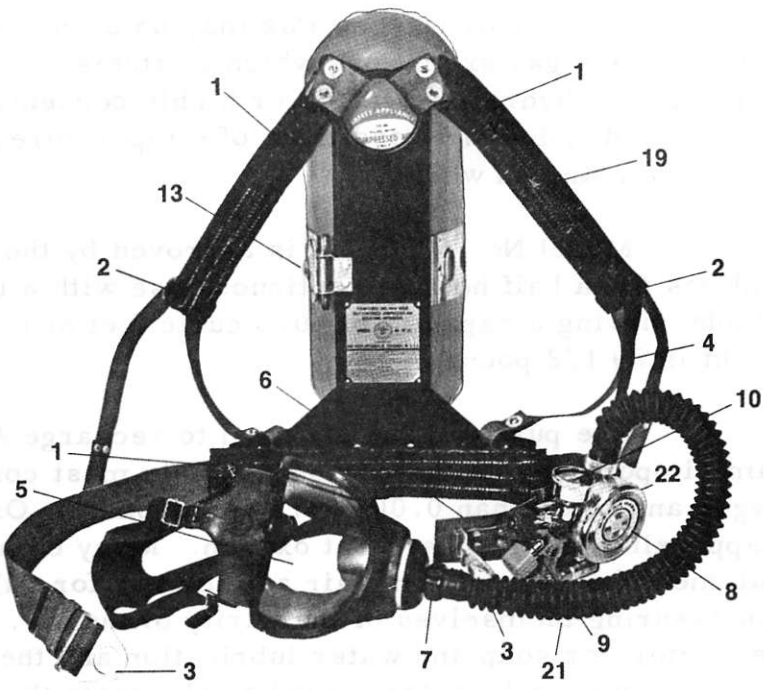
*See final paragraph on page 113

At twenty checkpoints, the new Model 401 MSA Air Mask has the features you need:





1. 3-zone comfort . . Cushionaire harness with wide, foam-padded straps at the shoulders and lower back. Harness is strong, latex-treated, mildewproof nylon.

2. Shoulder straps have quick-adjust buckle.

3. Waist strap has snap fastener and quick-adjust buckle.

4. Retaining strap for chest is also quick-adjust.

5. The Ultravue Facepiece is easily interchangeable with other principal MSA respiratory equipment. A speaking diaphragm assists communication when the facepiece is worn. This facepiece has picture-window visibility and means for mounting prescription glasses. The Ultravue Facepiece has a baffle to inhibit direct breathing against the lens. An optional antifogging "nosecup" is available.

6. A snap-on neck strap holds mask when mask is removed from the face.

7. Facepiece coupling provides easy disassembly for cleaning.

8. With the new Model 401, breathing is easy even under hard work conditions because the demand regulator requires minimal inhalation effort. This low resistance to breathing builds the wearer's confidence because the MSA regulator delivers all the air he needs.

9. Should the automatic functioning of the regulator be impaired, the bypass valve can be opened for direct, controlled flow from the cylinder to the mask. Identified by its bright red color and indented finger grip, this valve is separate from the yellow, round, main-line valve.

10. Pressure gauge can be read easily.

11. The MSA Audi-Larm provides a loud, clear, continuous ringing to indicate when the breathing supply is low. There is no lever to move or adjustment to make, because the Audi-Larm cocks automatically when cylinder valve is opened. The Audi-Larm is separate from the demand regulator to facilitate replacement, should it ever be necessary.

12. The high-pressure hose connection to the cylinder is made with a hand-tightened fitting which eliminates using a wrench. The connection fits any standard air cylinder.

13. For fast cylinder change, simply turn this positive cam-type latch, slip out the empty cylinder, slide in the recharged cylinder, and twist the latch to lock.

14. With the same MSA Air Mask, several different sizes of cylinders can be used because the stainless steel holder fits all 45-, 43-, 40-, 26-, or 22-cubic-foot-size cylinders.

15. Right-angle position makes MSA's cylinder valve handwheel easy to open and eliminates the need for a guard assembly which could interfere with its turning.

16. Pressure gauge on valve is flush mounted for increased safety, and a unique rubber guard protects it from damage if cylinder is accidentally dropped.

17. MSA cylinders have a bright, hard, lasting finish.

18. Sturdy MSA back plate, made of tough, anodized and painted aluminum, can withstand severe usage.

19. Harness straps are replaceable. Fastened to the frame with snaps, they can be easily replaced in the field.

20. Cylinder has 45-cubic-foot air capacity (10 percent more than in older models).

21. A pressure relief valve to release pressure in excess of the normal operating pressure of the reducing valve. Mounted external to the regulator to vent to the air.

22. A pressure relief valve to release any excessive pressure which may develop on the low pressure side of the regulator because of blockage on the regulator outlet.

Catalog numbers

457153	MSA Air Mask complete in case
457152	Same, less case
94007	Cylinder, Air Mask, complete with valve.

this description. The bottle is made of metal alloy and is much lighter than steel bottle of comparative size would be. It is approved by the United States Interstate Commerce Commission and tested to a pressure of 3,000 psi. When charged to its present permitted pressure of 1,980 psi, it contains 40.3 cubic feet of air or oxygen.

There is a main bottle valve which should be opened at least one full turn when the Pak is being worn. There is a safety cap designed to fail under excess pressure.

The compressed air bottle is distinctively coloured and marked to identify its contents; it is painted a "canary yellow" and has stencilled in black paint the words "Pure Breathing Air Only" marked on the body of the bottle in large letters. The oxygen bottles are green and marked "Oxygen."

Fitted to the valve body is a pressure gauge known as the bottle-gauge which shows the bottle pressure at all times even when the main bottle valve is shut off.

Attached to the bottle opening by means of a coupling nut is a "T" fitting, to this is attached a neoprene covered high pressure flexible hose about 18 inches long leading to the reducing valve and regulator. This is on the Air Pak only. The other branch of the "T" has a pressure operated check valve to which is connected a neoprene covered high pressure flexible hose about 24 inches long ending in the female half of a high pressure self sealing coupling. This latter hose is used when re-charging the apparatus while wearing it, from one or more large cylinders. This type of hose is available for the Oxygen Pak if requested. The threads on the cylinders and hoses are made so that the air thread will not fit on the oxygen thread coupling, thus preventing dangers of interchanging same.

Low Pressure Alarm

An alarm bell is available for Demand Apparatus, to sound when the bottle pressure is reduced to approximately 400 psi. This bell cannot be shut off and will continue to ring for four to five minutes, by which time the wearer will have emptied the bottle.

Reducing Valve and Regulator

The regulator delivers air to the user in accordance with his requirements. When the user inhales, the regulator delivers air or oxygen from the bottle, reduced to a pressure approximately three and a half psi. above atmospheric pressure during the inhalation period and in a volume dependent upon the depth of inhalation. The maximum volume which may be supplied is 165 litres per minute. When the user exhales, the regulator shuts off the air or oxygen from the bottle, thus conserving the air or oxygen supply.

The regulator assembly consists of (1) the regulator body and mechanism (2) the high pressure gauge, (3) the by pass valve, (4) the regulator shut off valve, (5) the shut off regulator lock.

The high pressure gauge is mounted on the regulator-housing in view of the wearer at all times. This gauge indicates the bottle pressure when the main bottle-valve is opened and provides a positive indication of the amount of air left in the bottle. The figures on the dial are luminous for maximum visibility.

The assembly is connected to the flexible hose from the bottle and fastened to the chest strap of the harness. The regulator is connected to the breathing tube from the facepiece by a "quick-connect" coupling at the top of the regulator. The regulator shut off valve (yellow knob) is provided to shut off the air to the regulator if and when the by-pass valve (red knob) is in use.

A by pass valve is provided for use in the event of damage to the demand regulator.

OPERATION OF THE REGULATOR

Air or oxygen at bottle pressure enters the regulator and passes through the shut off valve orifice, and continues through the passage, screen, and orifice. After being reduced by the first stage valve to a lower pressure, the air or oxygen continues past it to the inside of the bellows assembly which is spring loaded to maintain a constant pressure of 35 psi in this chamber. If this pressure increases, the bellows expands, actuating the lever, which in turn closes the first stage valve, reducing the pressure. If the pressure in the bellows drops, the reverse takes place, building the pressure up to 35 psi, and maintaining the pressure in the bellows chamber at 35 psi, passes through the passage to the demand valve.

When the user inhales he creates a decrease of pressure or a suction in the mask and breathing tube assembly which is connected through "quick-connect" coupling to the chamber. When the pressure in the chamber is reduced, the outside atmospheric pressure depresses the diaphragm inward, moving the demand valve stem toward its open position. The demand valve then opens, permitting the air or oxygen to flow from the passage and under the diaphragm. Since the area of the diaphragm is large and the spring rate of the demand valve is low, the negative pressure, or suction required for full opening of the demand valve is small. The variation in effort in breathing is not noticeable, regardless of whether the user is at rest or performing violent physical exertion.

The orifice is protected by the inlet screen which has a total area of openings of over 15 times that of the normal orifice opening. This provides adequate protection against any clogging of the orifice which would restrict the flow to less than maximum requirements.

If the first-stage valve sticks in the open position permitting the pressure in the passage to build up beyond 50 psi, the safety valve opens, discharging air or oxygen in a continuous flow, at reduced pressure, directly into the chamber. Under such circumstances the user would be warned that the initial reduction stage had failed. He would receive a continuous flow of air or oxygen to the mask at an increased pressure. He should return to fresh air at once. It is almost impossible for the valve to stick in the closed position because the high pressure is applied to the underside of the valve. This would force the valve open under any conceivable condition.

Should the demand valve stick in the open position the flow of air or oxygen through the restricting orifice would so limit the volume that there would only be a tendency to inflate the mask, and the pressure in the mask would be held at less than three inches of water by the operation of the exhalation valve.

FACEPIECE AND BREATHING TUBE

Two models of facepieces are available for the Scott Air-Pak. Both are full-face, full-vision type. On air or oxygen masks a rubber diaphragm exhalation valve in front of the wearer's mouth permits talking or telephoning. Air or oxygen is inhaled through a corrugated rubber tube connected to a Y-shaped fitting at the bottom of the facepiece. Each branch of the Y leads to the bottom of the eyepiece lenses. The inhaled air or oxygen strikes the lens and clears off any fogging that may occur. The facepiece is held tight to the face by a six-strap headpiece.

The bottom end of the breathing-tube has a quick-connect female coupling which enables the user to connect or disconnect the breathing tube easily and quickly, using his fingers only. When connecting, a sleeve approximately one inch long slides into the regulator orifice and the coupling nut is tightened. It is not necessary to use any tools to tighten the nut as the sleeve prevents the threads being cross-threaded.

HARNESS

The harness is made of a specially treated webbing. The metallic snaps and buckles are treated to reduce sparking.

The harness consists of a back plate under the bottle, two shoulder straps, a chest strap, and a waist strap. At the top of the back plate is a "D" ring for attaching a life-line.

CHARGING ASSEMBLY

The superiority of these types of apparatus over other types of breathing devices is the ability to recharge the bottle when wearing the machine in an irrespirable atmosphere.

At the bottle opening a pressure operated check valve is connected to the "T" fitting; this valve prevents air or oxygen escaping from the bottle when the charging hose assembly is not in use. Connected to this check valve is a neoprene covered high pressure hose about 24 inches long, the free end having the female half of a high pressure self-sealing coupling (the male portion of this coupling has the self-sealing valve in it). This apparatus charging hose assembly is fastened when not in use, to the chest strap on the right side by means of a snap buckle or small strap.

DIRECTIONS FOR OPERATING THE SCOTT AIR-PAK

During normal operation of the apparatus the shut off valve (yellow knob) should be fully opened and locked in position. It is provided to shut off the operation of the demand regulator in the event of damage or failure and should be closed only after the by pass valve has been opened. The emergency by pass valve (red knob) should be fully closed. It is provided for use in case the automatic demand regulator becomes inoperative. When opened it provides a continuous flow of air or oxygen to the facepiece, by-passing the regulator mechanism. If required, the by pass valve should be opened first, by turning counter-clockwise, then the regulator shut off valve should be closed and the flow of air through the by pass valve adjusted to suit the user's requirements. WHEN OPERATING THE VALVES, TURN GENTLY WITH THE FINGERS. DO NOT USE FORCE.

TESTS FOR THE SCOTT AIR-PAK

Similar to all other breathing devices the oxygen or Air-Pak should be frequently tested between periods of actual use (at least once a month) to determine its condition and should always be carefully tested for airtightness and proper working order before it is worn. Any leaks and/or defective parts found during these tests should be adjusted, repaired,or replaced. There is absolutely no excuse for wearing a breathing device that is known to be not working properly or is leaking.

When soapsuds have been used for detection of leaks at connections the parts should be thoroughly cleansed after the test has been completed.

With the exception of the demand regulator, repairs, adjustments or replacement of parts should only be done by a competent person. Any repairs or adjustments necessary to the regulator must only be done by the manufacturer, his agent or by a person authorized to make such repairs.

STATION TESTS

Check the equipment to see if it is complete, paying particular attention to the harness, that no undue weakening has taken place through wear or chafing especially where the webbing passes through the backplate and where the regulator loop fastens over the chest strap.

TESTING BOTTLE

Test for moisture in bottle--After the bottle has been charged, hold it in a vertical position with the valves down. Open the main bottle valve and close it quickly. If water is blown from the valve, it shows that moisture has gathered in the bottle. Accumulations of moisture, sediment, rust, or scale should be removed by taking the valve out of the bottle and cleaning the bottle. This is to be done by experienced persons only.

Test for tightness of bottle valve--To test the main bottle-valve firmly attach a metal cap with the gasket provided for this purpose to the outlet end of the valve under test, making sure that the bottle is fully charged, and open the valve to its fullest extent. Immerse the valve and neck of the bottle in water. Escaping bubbles around the valve stem indicate a leak in the packing gland. Close the main bottle valve, remove the metal cap and again immerse the outlet of the valve in water. Bubbles indicate that the valve is not closed tightly or that it has a defective seat. Any leaks or defective parts found during either test should be repaired or replaced before the bottle is used.

All air bottles, like oxygen bottles, must be re-tested every five years to comply with Board of Transport Commissioners' regulations.

Test for Regulator and Regulator Hose Assembly

With the equipment connected (except facepiece and breathing tube) open the bottle valve and observe the bottle gauge pressure. Observe the pressure of the gauge mounted on the regulator housing. The two gauges should check. Close the main bottle valve. The regulator and regulator hose assembly should hold the trapped pressure. Should a drop in the pressure be shown by the needle of the regulator gauge moving back toward zero, a leak is indicated.

Regulator Shut ·off Valve--Yellow Knob

With the regulator shut-off valve and by-pass valve closed and the main bottle valve open, draw air or oxygen in from the "quick-connect" orifice by inhaling until the regulator gauge is at zero. Then watch the gauge to see if the pressure builds up. If the pressure rises, the regulator shut off valve is leaking.

With the regulator shut off valve and by-pass valve closed and the main bottle valve open, place a soap-bubble across the "quick-connect" fitting on the regulator. If the by pass valve is leaking, the bubble will expand and break.

Charging Hose Assembly

With the main bottle valve in the full opened position remove the safety cap from the end of the charging coupling, immerse the end of the coupling in water. Any bubbles will indicate a leak in the pressure operated self sealing valve. Check the connection by means of a soap and water solution. A leak in the hose may be found by immersing the hose in water when bubbles will indicate a leak.

Facepiece Test

Put on the facepiece and tighten the straps on the head-harness; seal the bottom of the breathing tube with the hand, inhale, and hold the breath as long as possible. Do this several times. If the facepiece or the breathing tube appears to leak, check the fitting on the face and, if the leak is still indicated, locate it or replace the facepiece and the breathing tube with one you know to be in good order.

General Test

Connect the facepiece and plug in the "quick-connect" coupling and tighten the nut with the fingers and thumb; check the regulator performance. Inhale deeply and quickly. The regulator should supply a full flow to give the user, on demand, all the air or oxygen he requires.

If, during slow light inhalation a "honking" or "chattering" sound is heard in the regulator, it can usually be stopped by breathing faster. If the bellows vibrate under any breathing condition, the regulator should be changed and sent to the manufacturer for overhauling.

If the demand valve sticks in the open position, air will continue to flow when the user is not inhaling. This condition can usually be corrected by blowing back into the regulator "quick-connect" opening. Check and re-check the regulator several times before discarding it.

FIELD TESTS

The Field Tests are to be carried out by the user each time the apparatus is worn, before leaving the fresh air base. Check the general condition of the apparatus paying particular attention to the harness.

High Pressure Test

1. Open the main bottle valve and check the bottle gauge and the regulator gauge. The pressure registered on these gauges should correspond.

2. Close the main bottle valve. Watch the needle of the regulator pressure gauge; should the needle move steadily towards zero, a leak is indicated, and should be corrected. (Note--a drop in pressure here of less than 100 pounds in one minute may be ignored.) When satisfied there are no leaks, open the main bottle valve one full turn only.

3. Put the apparatus on your back and adjust it comfortably.

Facepiece Test

Before connecting the breathing tube to the demand regulator, put on the facepiece, adjust it, and inhale and exhale several times. Place the hand on the bottom of the breathing tube and try to inhale. If the user can inhale, the facepiece may not be adjusted properly. Re-check the adjustment and try again. If a leak is still indicated, locate and correct it, or replace the facepiece and breathing tube.

Regulator Test

With the facepiece still on the face, connect the breathing tube to the regulator. Inhale and exhale several times to check the operation of the regulator; open and close the by pass valve to ensure it is working properly.

Remove the facepiece until you are ready to enter the irrespirable atmosphere.

USE OF APPARATUS WITH AIR LINE OR EXTENSION HOSE

The equipment consists of a standard apparatus equipped with an auxiliary connection in the air supply line between the apparatus bottle and the regulator, and cylinders of compressed air equipped with special supply hoses, connections and gauges.

A person may travel in an irrespirable atmosphere, using air or oxygen from the apparatus bottle he is carrying to a place where there is an auxiliary supply of compressed air or oxygen at the fresh air base. Here he may recharge his apparatus bottle from a large cylinder by equalization, or obtain air directly from the large cylinder. A 244-cubic-foot cylinder, at 2 200 psi, will supply the user under normal conditions for a minimum of six hours. A "jumbo" size cylinder, with a capacity of 300 cubic feet at 2,400 psi, will supply the user for a minimum of eight hours.

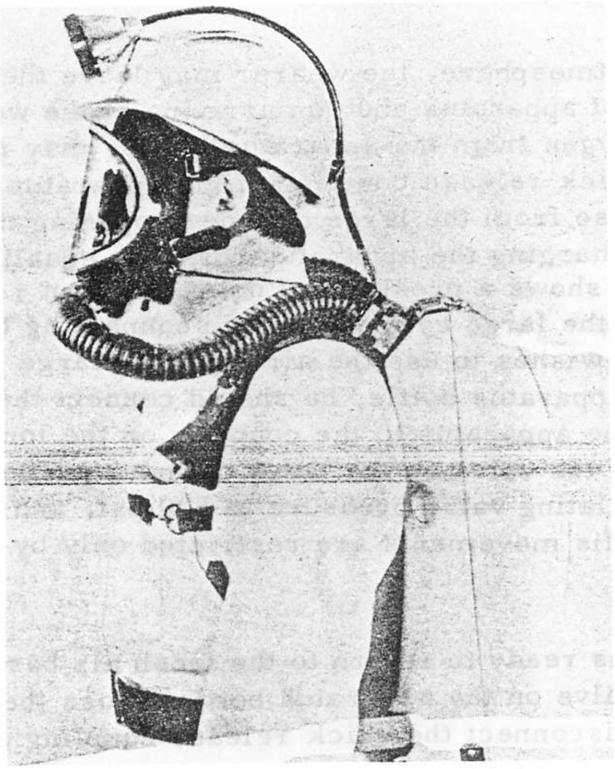
The complete apparatus with extension-hose assembly consists of one or more large cylinders of air or oxygen at the desired location, with suitable manifolds if necessary; a main large cylinder valve with a "T" connection; an 18-inch high pressure hose connected to one branch of the "T", equipped with a check valve and a quick release coupling; a pressure-reducing regulator equipped with gauges, one showing the cylinder pressure and one showing the reduced or regulated pressure; a high pressure hose of the desired length connected to the low pressure outlet of the regulator, equipped with a check valve and a quick release coupling; a "T" connection and an 18-inch high pressure hose equipped with a check valve and a quick release coupling for insertion into the apparatus air supply tube. Care must be maintained in preventing large cylinders from upsetting.

USES

In non-flammable atmosphere, the wearer may leave the fresh air base with this type of apparatus and, on arriving at the working-place still using the air or oxygen from the apparatus bottle, may re-charge it by connecting the quick release coupling of his apparatus to the coupling on the 18-inch hose from the large cylinder, opening the large-cylinder valve and re-charging the apparatus bottle by equalization until the apparatus gauge shows a pressure of not more than 1,980 psi, then closing the valve of the large cylinder and disconnecting the quick release coupling. If he wishes to use the air from the large cylinder instead of from the apparatus bottle, he should connect the "quick release coupling" on the apparatus to the coupling on the long extension hose, and then open the valve on the large cylinder. The next step is to adjust the regulating valve pressure to 500 psi, and then close the bottle valve. His movements are restricted only by the length of the extension hose.

When the operator is ready to return to the fresh air base he should open the main bottle valve on the apparatus bottle, close the main valve on the large cylinder, disconnect the quick release coupling of the extension hose, and proceed to fresh air.

The MSA Air Mask and MSA Oxygen Mask Model No. 401 which are used on some properties are basically the same, except that the cylinder capacities are 45 cubic feet at approximately 2,000 psi and they weigh about 33 pounds.



Aerorlox

by

SIEBE GORMAN

N.C.B. Mouthbit Type

by

SIEBE GORMAN

Aerorlox liquid oxygen breathing apparatus

1.0 Introduction

Aerorlox is a 3 hour, closed circuit, liquid oxygen breathing apparatus which provides cool, dry air even when being used in a hot environment. Breathing resistance is so low that it is hardly noticeable under heavy work conditions. The rated duration of Aerorlox is 3 hours with a 25% safety factor at hard work rate and a 6.5 lb charge of liquid oxygen. As the work rate decreases so the duration increases.

2.0 Technical data

Weight with liquid oxygen		32 lb falling to 26 lb	(13.4 kg) (11.8 kg)
Dimensions	– length	19.5 in	(49.5 cm)
	– width	15 in	(38.1 cm)
	– depth	6.25 in	(15.9 cm)
Liquid oxygen charge		6.5 lb	(3 kg)
Absorbent charge		3.5 lb of 6-10/mesh Protosorb (soda lime)	(1.6 kg)
Oxygen flow		6–12 litres/minute	

3.1 The exhaled warm saturated air passes from the mouthpiece through the exhalation valve housed in it, along the exhale breathing tube into the purifying canister.

3.2 When the air in the circuit reaches a pressure of 0.8 in (2.0 mbar) water gauge, any further exhaled air is discharged to atmosphere via the automatic relief valve.

3.3 The exhaled air passes through the radial flow purifying canister where carbon dioxide is absorbed.

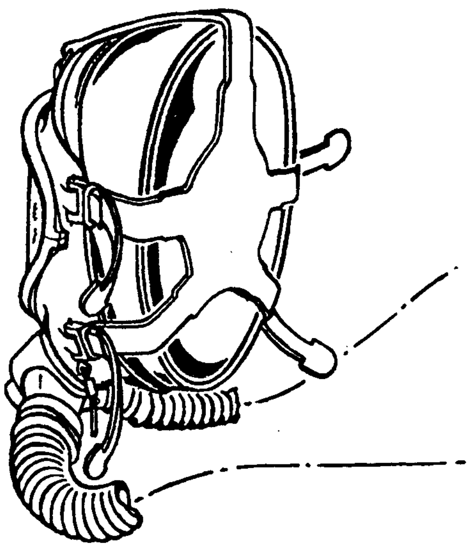
3.4 The purified air passes over one end of the liquid oxygen pack into the breathing bag.

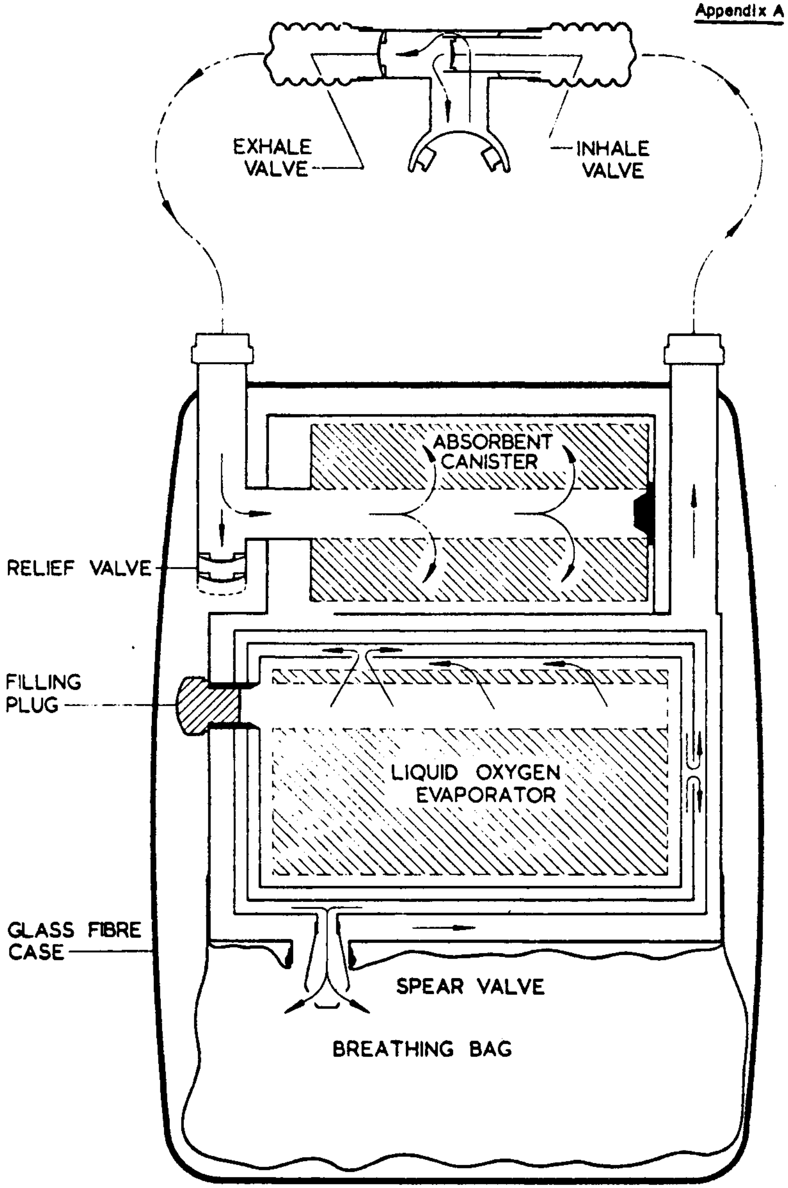
3.5 This cools the air and condenses the moisture which collects in the breathing bag.

3.6 The heat from the purified air surrounding the liquid oxygen pack stimulates the evaporation of oxygen. The oxygen gas passes from the innermost container to and fro through the outer cases, and, by so doing, slows down heat input to liquid oxygen. As the cool gaseous oxygen flows out of the evaporating tube, it mixes with the purified air in the breathing bag, further reducing the air temperature and condensing more of the moisture. The condensate falls into the breathing bag where it remains trapped.

3.7 Oxygen enriched air from the breathing bag passes over the liquid oxygen pack between baffles to increase its path, and, in the process, is further cooled.

3.8 The now cool, fresh, dry air passes along the inhale breathing tube and through the inspiratory valve into the mouthpiece.




EXHALE VALVE
INHALE VALVE
ABSORBENT CANISTER
RELIEF VALVE
FILLING PLUG
LIQUID OXYGEN EVAPORATOR
GLASS FIBRE CASE
SPEAR VALVE
BREATHING BAG

AERORLOX

The "Aerorlox" set is a three-hour, closed circuit, liquid oxygen breathing apparatus, developed from the earlier "SIMBAL" apparatus. It provides cool dry air even when working in hot environments. The resistance to breathing is low and is unlikely to be noticed even under heavy work conditions.

The set is housed in a fibre glass case which protects breathing bag, liquid oxygen pack, and absorbent canister and carried by a rucksack-type harness which ensures comfort in wear and quick-release action when adjusting or removing.

The fully charged weight of the apparatus is 33 pounds and without liquid oxygen, 27 1/2 pounds.

Approval: The Aerorlox Breathing Apparatus meets the requirements set by the Bureau of Mines and National Institute for Occupational Safety and Health, Approval No. TC13F32 for approved three hour units.

THE BREATHING CIRCUIT

(a) The warm saturated air that is breathed out passes from the mouthpiece through the exhalation valve housed in it towards the absorbent canister along the corrugated tube.

(b) Any excess air present in the breathing circuit over 2 centimetres water gauge passes through the relief valve and escapes from the apparatus.

(c) The bulk of the exhaled air passes through the radial flow soda-lime (Protosorb)* canister which absorbs carbon dioxide.

(d) The purified air passes over one end of the liquid oxygen pack into the breathing bag.

(e) This cools the air and condenses the moisture which collects in the breathing bag.

(f) The heat from the purified air surrounding the liquid oxygen pack stimulates the evaporation of oxygen. The oxygen gas passes from the innermost container to and fro through the outer cases and by doing so slows down heat input to the liquid oxygen. As the cool gaseous oxygen flows out of the evaporating

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* 'Protosorb' - Trade Name for soda-lime.

tube it mixes with the purified air in the breathing bag, reducing further the air temperature and condensing more of the moisture.

(g) Oxygen enriched air from the breathing bag passes over the liquid oxygen pack between the baffles to increase its path and in the process is further cooled.

(h) The now cool, fresh, dry air passes along the breathing tube and through the inspiratory valve into the mouthpiece as the next breath is taken.

PREPARING THE APPARATUS FOR USE

The "Aerorlox" apparatus must be charged with soda-lime and IMMEDIATELY BEFORE IT IS REQUIRED TO BE USED with liquid oxygen. Once charged with liquid oxygen it will begin to evaporate and should the apparatus not be used the oxygen will be exhausted in approximately four hours.

REMOVING SET FROM THE FIBRE GLASS CASE

To charge the soda lime canister or to do the "wet test", remove the set from its fibre glass case.

(a) Stand the set up on its base.

(b) Release the bottom catch by pulling "D" ring with the finger of the right hand to disengage from the stud and with the left hand placed on top of the case tilting it forward to help this action.

(c) Rest the case on its base and take the lid off by lifting it by the "D" ring and sliding off the top hinges.

(d) Turn two turn-buckles as positioned in the back of the bottom fibre-glass case to horizontal position (in line with their slots).

(e) Place hands on the metal case sides above breathing bag.

(f) Pull the unit out above one inch to disengage turn-buckles from the slots.

(g) Holding it firmly in two hands lift it up to slide out tube connections from the slots.

(h) Place the set on the bench.

REPLACING SODA LIME CANISTER

(a) Place the set (without the fibre glass case) on its side on the bench with end cap facing upwards.

(b) Using thumb of the left hand, pull off bayonet spring to unlock it.

(c) Place right hand on top of the end cap and relief valve assembly.

(d) Depressing the end cap assembly, turn it clockwise to disengage bayonet pins. (Steady the set with left hand holding spring in the withdrawn position).

(e) Place end cap assembly on the bench.

(f) Take canister assembly out of the case.

(g) Take clamp-plate out of the canister by lining up three cut-outs with canister lugs.

(h) Take sponge pad out.

(i) With charged canister after use empty its contents into the waste bin.

(j) Inspect canister generally and wipe outside with damp rag. Canister is ready for charging.

FILLING THE SODA LIME CARTRIDGES

Fill the removable canisters with six to ten mesh soda lime by means of the "Harris Filler". This ensures a closely packed canister of high efficiency.

(a) The filling hopper ("Harris Filler") should be placed on a large shallow tray to collect spilt 'Protosorb'. Set the hopper vertically by means of the set screws on the base board. When vertical, the plumb line will be above the pointer on the lower flange.

(b) Slide the empty canister between the guides on the base of the hopper until the canister reaches the rear top.

(c) Pour slowly into the top hopper approximately three and a half pounds of six to ten mesh 'Protosorb'. The granules should fall freely into the canister. If there is any tendency for the hopper to become blocked, give it a firm tap on the side.

(d) When the canister is filled to at least a quarter inch from the top, carefully remove it from the filler, taking care not to disturb the 'Protosorb'.

(e) Place the plough on top of the 'Protosorb' and rotate it until it bottoms on the centre spindle.

(f) Remove the plough, insert the sponge pad and on top of it clamp plate with spring. Depressing slightly, turn it round to engage three webs under the lugs of the canister. (The spring holds the charge firm and takes up any settlement during use.)

The canisters once charged may be inserted in the apparatus or held ready for immediate use in the special storage cans.

(g) Before inserting the end cap which holds the relief valve in the case, wipe the "U" seal, the rim of the outer case (inside) and the "0" ring seal inside the tube with a damp rag to remove any particles of soda lime.

(h) Also check that the rubber washer at the far end of the case is in place and in good condition.

(i) Withdraw the spring on the rim of the outer case (using thumb of the left hand) and place the end cap in position engaging on three bayonet pins. Holding the right hand on top of the cap assembly, depress it and turn clockwise to engage fully bayonet pins.

(j) Release hand pressure and spring to lock in position.

Before charging the set with liquid oxygen do the leak test, generally known as "wet test".

"WET TEST" PROCEDURE

The purpose of this test is to make sure that there are no leaks from the set when pressurized to twelve-inch water gauge.

(1) After charging and replacing soda lime canister in position, check all connections for tightness and correct positioning:

(a) Exhale tube connection (between corrugated exhale tube and soda lime canister end cap tube) - by tightening the round knurled nut.

(b) Inhale tube connection (between corrugated inhale tube and outer case liner) - by checking its correct engagement and tightening the round nut.

(c) Breathing bag connection (between breathing bag neck and outer case liner) - by checking its correct engagement and tightening the round nut.

(d) Correct locking and bayonet pins engagement.

(e) Relief valve seal - by turning its case clockwise.

(f) Filler plug by tightening it.

(2) Unscrew perforated relief valve cap and replace with solid one with "0" ring inside (specially provided for it).

(3) Plug the mouthpiece with the rubber bung with metal liner in it (specially provided for it).

(4) Connect liner to L. P. air line with water gauge column in line (0 - 30 in.).

(5) Inflate the circuit to twelve-inch water gauge.

(6) Watching water column to maintain twelve-inch water gauge, immerse the set in a tank of water and check if there are any leaks.

(7) Take the set out and dry it with clean rag.

(8) Replace perforated relief valve cover.

(9) Take rubber bung out of the mouthpiece.

(10) Place the set back in the fibre glass case remembering to lock turn buckles.

Set is now ready to be charged with liquid oxygen.

CHARGING SET WITH LIQUID OXYGEN

As soon as the liquid oxygen has been poured into the evaporator, the apparatus automatically begins to supply oxygen to the breathing circuit. The period for which the "Aerorlox" set may be used should be reckoned from this moment. This period is normally two hours.

(a) Open the lid of the apparatus by undoing bottom catch.

(b) Place apparatus on its side on the flat weighing scale and support it by balancing the lid on top hinges. (If spring balance is used, suspend the set on the bar provided for it.)

(c) Remove the plug from the liquid oxygen pack.

(d) Insert the filling funnel into the filling hole.

(e) NOTE THE WEIGHT ON THE BALANCE AND CAREFULLY POUR IN LIQUID OXYGEN UNTIL THE SCALE SHOWS SIX AND A HALF POUNDS. MORE THAN THE INITIAL READING. IF ONLY TO BE USED FOR A TWO-HOUR PERIOD, THEN IT IS ONLY NECESSARY TO FILL WITH FIVE AND A HALF POUNDS OF LIQUID OXYGEN.

(f) Remove the funnel and replace the filling plug. Screw it down tightly. Do this at once or else ice will form on the threads and make closure difficult.

(g) Stand the set up and close the lid by securing bottom catch.

The set is now ready for use.

(a) Put the set on and adjust harness to fit comfortably.

(b) Insert mouthpiece and put on nose clip whilst breathing through mouth only.

(c) REMEMBER TO CHECK TIME, NOT TO OVER-RUN WORKING PERIOD OF THE SET. THIS IS THREE HOURS.

MAINTENANCE - CLEANING

Each time the set has been used all parts of the breathing circuit should be washed in water to which disinfectant has been added.

(a) Take the set out of the fibre glass case.

(b) Uncouple breathing tubes and mouthpiece assembly, by unscrewing the round knurled nuts.

(c) Remove end cap with relief valve assembly by undoing bayonet connection.

(d) Empty soda lime canister.

(e) Unscrew breathing bag connection.

(f) Pour out water from the breathing bag, wash it out and leave it to dry.

(g) Wash out liquid pack assembly.

REMEMBER to plug oxygen outlet (3/8 in. Whit. hole located inside the bag connection) with brass plug and length of rubber tubing especially provided for it and keep the free end out of the water.

REMOVE it after washing.

(h) Dry all parts of the apparatus.

Note: Do not use strong detergent or soap solution to clean the mica relief valve disc. Use only clean water and a camel-hair brush.

ADJUSTING THE RELIEF VALVE

A medium length 4 B.A. box spanner and an electrical type screwdriver are required.

(a) Insert rubber bung with liner for 1/4 in. rubber tubing into the exhale tube (threaded end) and connect it to air or oxygen line with flow meter and water column.

(b) Insert rubber bung into the tube retaining "0" ring.

(c) Undo the lock nut inside the exhale tube on the end cap and relief valve assembly using box spanner. (Take the rubber bung out to do that.)

(d) Insert screwdriver through the box spanner into the slot in the screw adjusting the spring.

(e) Open air line and adjust flow to 10 l.p.m. constant.

(f) Adjust spring to water column reading 2.5 cm ± .2 cm. when the direction of flow is vertically downwards. (Water column should be between flow meter and relief valve). Take the rubber bung out to do that.)

(g) After turning the adjustment screw and before measuring the pressure, give the valve a sharp tap with the hand.

(h) Steady the adjusting screw and lock in position by means of the lock nut tightened with the box spanner.

(i) Recheck that the correct setting has been maintained.

GENERAL NOTES ON THE APPARATUS

(1) The oxygen flow from the apparatus is normally in the range of 8 to 12 litres per minute when in use. For 15 minutes after filling, the flow is in excess of these figures.

(2) The breathing bag has a capacity of about six litres when measured from + one-in. water gauge to -one-in. water gauge.

(3) The relief valve operates on almost every breath as the flow of oxygen is well in excess of the body's requirements and the breathing bag is completely full.

(4) The inspired air is coldest approximately five to seven minutes after charging, as it takes this time to cool the set.

(5) The temperature of the inspired air as it enters the mouthpiece does never exceed 30° C (86° F) during the rated service time of the apparatus under the laboratory or practical tests in all ambient conditions up to 30° C (86° F).

For 30° C (86° F) ambient the inspired air temperature reaches about 23° C (73° F) after 30 minutes from about 0° C (32° F) after five minutes and gradually increases to about 28° C (82° F) after two hours. For lower ambient temperatures they are slightly lower, but not in the same proportion as the ambient since it has very little effect on it.

(6) Excessive exertion tends to reduce the temperature of the inspired air. Because of this relationship, the wearer loses body heat to the apparatus and so is able to endure hot environments for a longer period.

(7) The liquid oxygen pack is filled with asbestos wool which absorbs the liquid so that it is unable to be spilt into the outer chamber of the pack or the breathing bag.

(8) Under operating conditions no part of the apparatus is pressurized in excess of 2 1/2-in. water gauge.

TECHNICAL DATA

Weight:

Fully charged approximately 34 pounds falling to about 27 1/2 pounds after two hours' use.

Size:

19 1/2 inches by 15 inches by 6 1/4 inches.

Liquid Oxygen Charge:

6 1/2 pounds.

$C0_2$ Absorbent Charge:

Three one quarter pounds of soda lime ('Protosorb')

Oxygen Flow:

12 to six lpm.

Breathing Bag Capacity:

6 litres.

Breathing Resistance:

1.5-in. water gauge at 200 lpm flow.
.5-in. water gauge at 85 lpm flow.

Relief Valve Setting:

1-in. water gauge.

Appendix 'A'

Circuit diagram.

AERORLOX BENCH DRILL

It is presumed that the Aerorlox machines have been charged with liquid oxygen and with CO_2 absorbent, the details concerning this procedure having been noted on the tag which shall be attached to each machine. During competitions it is suggested that the team coach and a co-ordinator, mine rescue perform these duties. Depending on the location of the filling point it may be necessary for the teams to pick up the charged Aerorlox machines and take them to the bench.

Bench Drill Detail

1. Stand to bench and number.
2. Test horns and any personal rescue equipment.
3. Check the charge tag and enter the details on the bench clip.
4. Check facepiece complete with hoses, valves, etc.
5. Check relief valve and cardoxide (if possible).
6. Couple up breathing tubes.
7. Check harness.
8. Put on and seal up.
9. Step back from bench to permit captain to check team.
10. Vice-captain checks captain.
11. Captain reports to bench judge for further instruction.

Self-Contained Oxygen Breathing Apparatus For Mines Model BG 174

DRÄGER

Special features of the BG 174

- Simple design and fully automatic operation
- Weight only 12.8 kg with a normal duration of use of 4 hours
- Free respiration through wide air passages and unrestricted breathing bag movement
- Air-cooled regenerating cartridge giving a low temperature of the inspired air
- Automatic oxygen pre-flushing, no need to evacuate the apparatus by breathing from it before use.
- Warning signal in the valve assembly indicates oxygen deficiency in the case of an empty or closed oxygen cylinder
- All the working parts and the breathing bag are protected by a strong protective casing.
- Rapid-release harness for easy fitting and removal of the apparatus, no tools needed to change cylinders or cartridges.
- An inspired air cooling device can be fitted.
- A soda-lime artridge can be used.

The model BG 174 oxygen breathing apparatus for mines is a fully-automatic, particularly light breathing apparatus which makes the wearer entirely independent of the ambient atmosphere. It has a compressed oxygen supply with regeneration of the expired air. Controlled by respiratory valves, the breathing air flows through the apparatus in a closed circuit.

The wearer's oxygen requirement is covered by a constant flow of 1.5 litres/minute and a lung demand valve which operates automatically in the case of higher oxygen requirement. In addition, a manually operated by-pass valve is provided by which oxygen can be added to the circuit, by-passing the pressure reducer.

Any excess pressure arising in the circuit in the case of low oxygen consumption is eliminated through an automatic pressure relief valve.

When the cylinder valve is opened, the breathing bag is automatically flushed with an inrush of about 7 litres of oxygen. Thus it is not necessary to evacuate any nitrogen from the apparatus by breathing from it.

Should the wearer forget to open the cylinder valve or accidentally fit an empty cylinder, a warning signal sounds indicating the danger of lack of oxygen and consequent accumulation of nitrogen.

During use, extremely low breathing resistances enable the wearer to breathe almost as freely as in the open air.

▲ Fig. 3 BG 174, closed

◄ Fig. 2 BG 174, open

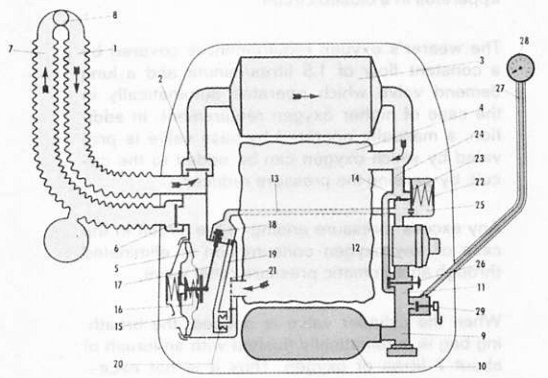


Fig. 4 Circuit of the BG 174

1	Exhalation tube
2	Exhalation valve
3	Regenerating cartridge
4	Breathing bag
5	Valve assembly
6	Inhalation valve
7	Inhalation tube
8	Connection socket for breathing connection
9	Cylinder valve
10	Oxygen cylinder
11	Oxygen valve group
12	Pressure reducer
13	Oxygen line
14	Dosage nozzle
15	Control diaphragm
16	Thrust pin with gasket
17	Lever for lung demand valve
18	Lung demand valve
19	Control line
20	Control bellows of the warning signal
21	Warning signal flap
22	Pre-flushing device
23	Pre-flushing valve
24	Pre-flushing line
25	Control chamber
26	Manual by-pass valve
27	High pressure line
28	Pressure gauge
29	Pressure gauge shut-off valve

The fully-automatic mode of operation and the complete protection of the working parts enable the wearer to concentrate fully on his rescue work, which is usually difficult. After opening the cylinder valve the BG 174 functions quite automatically.

The long duration of use offered by the apparatus ensures the necessary safety for prolonged underground reconnoitring and for difficult rescue work, the full scope of which cannot always be envisaged.

Before use, performance and leak tests can be carried out rapidly and simply with a suitable test set (DRÄGER Universal Test Set Models Rz 22 and Rz 25).

The BG 174 consists of the following main components:

Light metal protective casing

Carrying frame with carrying harness

Oxygen valve group with pressure reducer, preflushing device, manually operated by-pass valve, pressure gauge shut-off valve

Valve assembly with lung demand valve, pressure relief valve, warning signal, inhalation valve, exhalation valve

Breathing bag

Corrugated breathing tubes with saliva trap, with cooling device if required

Pressure gauge line with pressure gauge

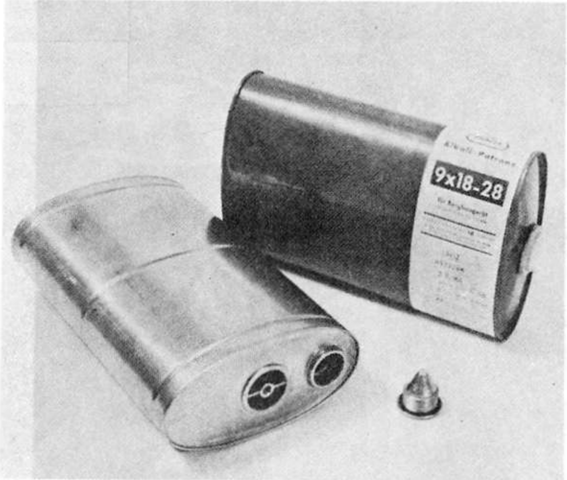
Oxygen cylinder with cylinder valve

Regenerating cartridge

Accessories: mask or mouthpiece

Canisters

Two types of canisters may be used with the apparatus. A refillable soda lime canister may be used with the apparatus for training purposes, but is not approved or recommended for actual rescue work. A disposable regenerative canister must be used in the apparatus during rescue or recovery work. This disposable alkaline canister is factory packed and provides drier and cooler air than the refillable type.



The **protective casing** is made of precipitation-hardened light metal, approved for many years, and provides complete protection for the entire apparatus even under the most arduous conditions of use. It is designed such that it can easily be removed.

All components of the apparatus are simply mounted on a strong **carrying frame.** It is designed such that the apparatus can be worn comfortably on the back, the breathing bag is protected on all sides, the regenerating cartridge is cooled by air circulation, and heat from the regenerating cartridge is not transmitted to the wearer's body.

The **carrying harness** attached to the carrying frame is made of Trevira. The straps are adjusted to the correct length when the apparatus is put on, they are easily re-adjusted and designed for rapid fitting and removal of the apparatus.

The brass **oxygen valve group** combines in one unit all the parts working with high-pressure oxygen:

The **pressure reducer** reduces the cylinder pressure to a working pressure of approx. 4 bar.

The **pre-flushing device** opposite the pressure reducer is dimensioned such that the breathing bag is filled or flushed with approx. 7 litres oxygen, when the cylinder valve is opened.

The **by-pass valve** is designed as a self-closing push button valve. It is opened with only very slight pressure using a finger.

The **pressure gauge shut-off valve** is a diaphragm valve which is lead-sealed in the open position. It enables the pressure gauge line to be shut off in the case of a leak.

The by-pass valve and the pressure gauge shut-off valve are provided for the wearer's safety and should be operated only in cases of emergency.

The **valve assembly** houses the control valves of the breathing circuit, the lung demand valve and the pressure relief valve.

The **lung demand valve** is a simple rocker-arm valve which is operated by a diaphragm responding to slight differences in pressure. The same diaphragm also actuates the **pressure relief valve,** downstream of which a rubber non-return valve is incorporated for safety reasons. The **warning signal** is controlled by the pressure in the oxygen line which leads from the pressure reducer to the lung demand valve. With the line depressurized the outlet of the breathing bag is sealed off by a flap equipped with acoustic reeds.

On the models with the R 3/4" connecting thread, the dosage nozzle for the constant flow of 1.5 litres/minute is located in the oxygen valve group (German approval), on the models with the W 21,8 x 1/14" thread, in the rocker arm of the lung demand valve. (foreign approvals)

30 730

Fig. 6 Rubber mouthpiece and Panorama Nova mask Z

The **breathing bag** is made of tear-resistant fabric rubberized on both sides. It contains only the connections for the breathing air inlet and outlet and can easily be removed and cleaned.

The **breathing tubes** are strong, very flexible deeply corrugated tubes of age-resistant rubber. They are fitted with a central connection for connection to a mask or mouthpiece as desired. The unit can also easily be connected to a test set. A special design of the tubes is available, in which the saliva trap is replaced by a dry-ice container reducing the temperature of the inhaled air by approx. 20 °C.

The **pressure gauge line** is a close-wound spiral high pressure line, relieved of tension by a bronze stranded core and protected by a rubber tube. The pressure gauge, enclosed in a solid brass casing, has a considerable scale length through the concentric arrangement of the pointer thus ensuring clear indication of the pressure.

The alloy steel **oxygen cylinder** has a volume of 2 litres. The test pressure is 300 bar. The charging pressure of 200 bar gives a total oxygen supply of approx. 400 litres. Oxygen cylinders which comply with the regulations in force outside Germany are available upon request.

A standard alkali cartridge 9 x 18-28 should be used as regenerating cartridge when working in earnest, a rechargeable soda-lime cartridge can be used for training purposes.

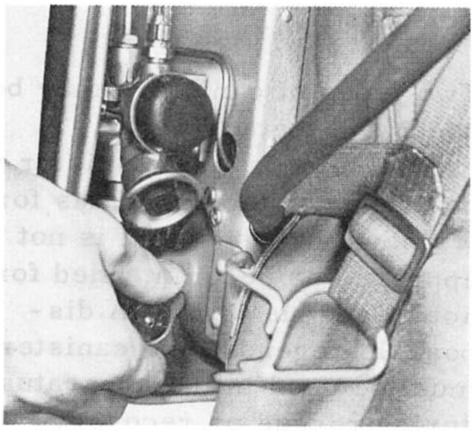


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Fig. 7 Opening the oxygen cylinder valve

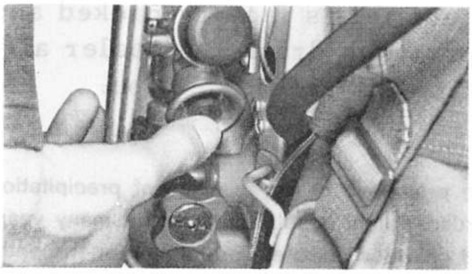

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Fig. 8 Operating the manual booster

25 425

Fig. 9 Closing the shut-off valve

TECHNICAL DATA

Weight: approx. 12.8 kg
Dimensions: approx. 485 mm length
435 mm width
160 mm height

Capacity of the breathing bag:
approx. 6 litres
Capacity of the oxygen cylinder: 2 litres

Oxygen supply:

at a charging pressure of 200 bar,
approx. 400 litres
Duration of use with heavy work
at a charging pressure of 200 bar,
approx. 4 hours

THE DRAEGER SELF-CONTAINED, OXYGEN-BREATHING APPARATUS

TYPE BG174

GENERAL DESCRIPTION

1. The Draeger self-contained oxygen-breathing apparatus, carried on the back enables the mine rescue worker to enter underground areas filled with irrespirable and toxic gases. The apparatus permits the wearer to breathe completely independent of the atmosphere and enables him to effect rescue and recovery in extremely arduous conditions.

2. This closed-circuit apparatus is light in weight (28 pounds), but its construction is rugged and highly resistant to mechanical shock. The exhaled air is freed of its carbon dioxide content in a regenerative canister and passed into a breathing bag. The air purified in this way is then withdrawn from the breathing bag during inhalation.

3. The oxygen consumed during respiration is replaced from a compressed oxygen supply through constant flow metering at the rate of 1.5 litres per minute and, if this is not sufficient to supply the wearer, additional oxygen is provided by a lung-governed demand valve.

4. When the apparatus is initially turned on, the circuit is automatically flushed with approximately six litres of oxygen. Apart from the occasional checking of a pressure gauge, the apparatus requires no further attention during its use. Its operating functions are entirely automatic.

DESCRIPTION OF PARTS

The apparatus consists of six main, and a number of auxiliary parts: oxygen bottle, oxygen control assembly, valve assembly, breathing tubes and facepiece, regenerative canister, breathing bag.

Auxiliary parts include frame, harness, cover, gauge tube, and gauge.

1. The Oxygen Bottle is a high-grade alloy steel cylinder with an atmospheric volume of 2 litres. When charged to a pressure of 2,000 pounds, it contains approximately 270 litres, and at its maximum pressure of 3,000 pounds, it will contain approximately

400 litres of oxygen. The bottle must be hydrostatically tested every five years to comply with the regulations of the Ministry of Transport, Canada. The testing pressure is 4,400 pounds per square inch.

The bottle valve is equipped with a safety cap designed to permit the escape of oxygen without rupturing the bottle under excessive pressure (4,000 pounds).

2. The Oxygen Control Assembly is made of brass and is attached to the right hand wall of the carrying frame. It contains the reducing valve, the preflushing unit, the manual by pass valve for an emergency oxygen supply, and the valve for the pressure gauge line. This assembly is directly coupled to the oxygen bottle by a hand-tight connection.

3. The Valve Assembly attached to the left-hand wall of the frame, controls the delivery of oxygen to the wearer, and consists of a metering orifice designed to allow a constant flow of 1.5 litres per minute. Also included in the assembly are a demand valve to provide additional oxygen if required, inhalation and exhalation valves, a warning device, pressure relief valve, check valve and connections for the breathing tubes.

4. The Breathing Tubes and Facepiece. The tubes are of corrugated rubber with a central connection to attach the facepiece, and with individual couplings connecting to the valve assembly. A moisture trap is attached to the inhalation tube.

   The facepiece has a curved full-view lens with a manually-operated wiper. The neoprene mask body has an inner face-seal and is held in place by a five-strap quick-adjusting head harness.

5. The Regenerative Canister in which carbon dioxide is removed from the exhaled breath may be one of two types: a disposable alkaline cartridge which may be used for a continuous period of up to four hours: a refillable canister which may be used for a maximum period of two hours.

   The use of the alkaline cartridge provides drier breathing air. The wearer is therefore under less physical stress than when using the refillable canister.

6. The Breathing Bag is made of three-ply rubberized fabric. It is so arranged within the carrying frame that it is protected on

all sides, but is able to function without obstruction. It contains a coupling for the valve assembly connection and an elbow connection to the regenerative canister. The minimum capacity of the breathing bag is six litres.

Auxiliary Parts

1. The Carrying Frame and Harness. The frame is made of corrosion-resistant light alloy. The flat side walls, together with the curved plates of the regenerative canister support at the top, and the cylinder support at the bottom constitute a torsion-resistant frame. The back plate acts as a protective cover for the breathing bag space. All fittings of the apparatus are attached to the strong side walls. The regenerative canister support is so arranged that the canister itself is properly cooled, and the transfer of heat to the back of the wearer by conduction and radiation is minimized.

   The rear of the frame is provided with a resilient pad of rubberized fabric with a steel insert, ensuring a comfortable fit, and proper spacing of the apparatus from the body of the wearer.

   The harness is made of nylon-cotton fabric, is comfortable to wear, and is easily adjusted.

2. The Cover protects the components of the apparatus when in use, and is easily removable.

3. The Gauge Tube and Gauge. The tube is a rubber-covered, high pressure, flexible, close-wound spiral hose. The clear, easily-read pressure gauge is fitted with a swivel connection to facilitate correct positioning.

CLOSED CIRCUIT OPERATION

The exhaled air containing carbon dioxide flows from the mouth through the exhalation tube, to the exhalation valve, and then to the regenerative canister, where the carbon dioxide is absorbed. The absorption process is accompanied by the production of heat, increasing the temperature of the canister and the air flowing through it. The air, freed of carbon dioxide, and respirable then flows into the breathing bag.

During inhalation, the air is drawn from the breathing bag and flows through the valve assembly, to the inhalation valve, the inhalation tube, to the facepiece connection. The air within the apparatus is thus continuously inhaled and exhaled in a closed circuit. Its direction of flow is controlled by valves and in the valve assembly.

CONSTANT FLOW METERING

In normal operation, the oxygen consumed during respiration is replaced by constant flow metering at the rate of 1.5 litres per minute. With the bottle valve open, high pressure oxygen control assembly. The oxygen pressure is there reduced to a pressure of 57 psi at which it flows through the oxygen line, the metering orifice, and into the valve assembly where it replenishes the closed circuit air.

RELIEF VALVE

If the oxygen consumption is less than the supply through the constant flow metering system, the breathing bag becomes over-inflated during exhalation. The excess pressure thus produced in the breathing bag causes the control diaphragm in the valve assembly to move to the left against a spring. An orifice in the centre of the diaphragm is equipped with a sealing lip which is lifted off a sealing plate, enabling the excess air to flow through the diaphragm and escape through a non-return valve to outside air.

AUTOMATIC DEMAND VALVE

Under conditions of extreme physical effort, the oxygen requirement may exceed that supplied by constant flow metering. In such circumstances the breathing bag fills to a progressively smaller degree with each breathing cycle until finally its contents no longer supply the wearer with oxygen. A negative pressure is then created which immediately moves the diaphragm of the valve assembly to the right. The sealing plate of the relief valve is then actuated so that a plunger pushes the lever of the demand valve to the right, opening the valve. Oxygen then flows through the oxygen line into the valve assembly and into the inhalation chamber until the requirements are again fully met.

WARNING SIGNAL

The oxygen line is provided with a bellows line in the valve assembly leading to the bellows. The control bellows is hinged by a double-arm lever to the warning signal flap. This flap covers the breathing bag connection in the valve assembly when the apparatus is not under pressure. If an attempt is made to breathe while it is without pressure, the air drawn from the breathing bag passes through slits in the flap covered by acoustic reeds. A clear musical note is then heard, warning the wearer that the bottle valve has not been opened.

As soon as the bottle valve is opened and the oxygen line pressurized, oxygen flows through an orifice to the bellows, compressing it so the warning signal flap is moved away from the breathing bag connection.

PRE-FLUSHING

When the oxygen bottle valve is opened, oxygen flows through the reducing valve to the pre-flushing unit. The pressure opens the control valve so that oxygen flows through the pre-flushing line into the circuit and fills the breathing bag. Simultaneously, oxygen flows through an orifice into the diaphragm chamber of the pre-flushing unit. As soon as pressures are balanced on each side of the diaphragm, the valve is closed by spring pressure, thus completing the pre-flushing process. The pre-flushing unit functions so that a minimum of six litres of oxygen flows into the apparatus.

MANUAL BY PASS VALVE

Depressing the button of the manual by-pass valve causes oxygen to flow from the high pressure side of the oxygen control assembly directly to the pre-flushing line and from there into the circuit. This emergency oxygen supply is thus independent of the reducing valve, the demand valve and the constant flow metering orifice.

PRESSURE GAUGE AND GAUGE TUBE

The gauge tube branches from the high pressure side of the oxygen control assembly. The pressure gauge is provided with luminous markings on the dial and pointer so the bottle pressure can be constantly checked even in complete darkness.

The gauge tube may be closed by a valve in the event of a leak in the tube or gauge.

DRAEGER BENCH TEST

The following points are suggested as STANDARD PRACTICE for all persons who are involved in the use of Draeger oxygen breathing apparatus while preparing the apparatus for use.

1. REMOVE EQUIPMENT FROM CASE

This includes the removal of the apparatus from the carrying case as well as the tool kit and the facepiece and also includes removing the tools from the tool kit and removing the facepiece from the plastic bag. Set apparatus on the bench with the back facing you.

2. EXAMINE HARNESS ON APPARATUS

This includes the examination of all buckles, belts, straps, snaps, and connectors.

3. REMOVE COVER

Set the apparatus cover in a standard location.

4. REGENERATOR

Remove the regenerator from the apparatus and clean out any particles which may plug the screens. Do this with a brush or with air pressure if available. Fill regenerator canister with cardoxide - it holds approximately five pounds. Check the gasket and replace the cap.

Place the canister back in position with the cap down to the right side. Check gaskets on breathing bag connections and connect to the canister.

OR Replace with pre-filled four-hour canister.

5. INHALATION - EXHALATION VALVES

Check inhalation valve by attempting to exhale and inhale while placing mouth over hose connection on the apparatus. Follow same procedure for exhalation valve.

With the bottom "inhalation" valve you should be able to inhale but not exhale.

With the top "exhalation" valve you should be able to exhale but not inhale.

6. EXAMINE AND ATTACH BREATHING HOSES

Examine your breathing hoses by holding your cupped hand partly over the connection of one hose and by blowing through the other. The air should flow freely through the hoses. Check gaskets and attach the breathing hoses to the apparatus. Inhalation hose with the saliva trap goes on the bottom connection.

Hand tightened connections are satisfactory.

7. BOTTLE AND MOISTURE TEST

Remove bottle from apparatus. Place bottle cap of O_2 outlet and tighten open bottle valve and immerse valve assembly in water. Note any leaks. Close bottle valve and remove cap. Immerse in water to check leaks in bottle valve. Check bottle for moisture by holding bottle horizontally and pointing O_2 outlet toward dry surface. Open and close bottle valve and note any moisture released from bottle. Replace bottle in apparatus.

8. BOTTLE PRESSURE CHECK

Open the main bottle valve and read the pressure registered on the high pressure gauge and close pressure gauge valve.

9. HIGH PRESSURE TEST

At present the high pressure test will consist of applying soap suds to the following:

(1) BOTTLE VALVE CONNECTION AND BOTTLE VALVE

(2) GAUGE LINE CONNECTION AT THE REDUCING VALVE

(3) GAUGE LINE CONNECTION AT THE PRESSURE GAUGE

(4) GAUGE LINE SHUT OFF VALVE

If a leak is present, it can be easily detected by watching for a bubbling action.

10. LOW PRESSURE TEST

(1) Remove diaphragm assembly and press inwards on the demand valve. If it is functioning properly you will note a sudden hissing from the oxygen release.

(2) Check the by pass valve to ascertain that it is functioning properly by pressing up on the by pass button. Observe

the breathing bag. You will note that it quickly inflates with the inflow of oxygen.

(3) Check the diaphragm by blowing through the relief valve. You should be capable of inhaling only. Exhalation will thrust the pressure pin forward.

(4) Replace diaphragm, placing the relief hole at six o'clock.

(5) Close the main bottle valve.

(6) Cover the relief hole with your finger and press on the breathing bag with your right hand. Observe the breathing hose movements. If the breathing hoses expand and contract with applied pressure on the breathing bag, it indicates that there are no leaks on the low pressure side of the apparatus. If, however, when you apply pressure to the breathing bag, the bag deflates, this would indicate a poor connection, missing gasket, or a rupture and if this occurred you would have to find the cause.

11. NOTE PRESSURE ON PRESSURE GAUGE

Any leak in pressure gauge or pressure gauge line will be noted by the drop in pressure. Open pressure gauge valve.

12. NEGATIVE LEAK TEST

Attach breathing hoses to R. Z. 35 Tester. Draw a negative pressure of 80 M.M.W.G. and watch needle for a period of 15 seconds. Any leak will be detected as needle will retreat toward zero. A drop of not more than 10 M.M.W.G. insures wearer of a satisfactory apparatus.

13. REPLACE COVER

Place the cover in the proper location at the top of the apparatus. Tilt the apparatus slightly forward (away from you) and press the cover in place while making certain the lock clips and holes are lined up. When the cover locks in position, you will hear a clicking action.

14. PREPARE FACEPIECE

Squirt sufficient anti fog on the wiper apparatus inside the facepiece to thoroughly soak it, then turn the wiper back and forth four or more times to assure that the inner surface of the lens has been treated with solution. Set the facepiece back on the bench.

15. PUT APPARATUS ON

Turn the apparatus around on the bench so that the harness is facing you, slide your left arm through the left shoulder strap and pick up the breathing hoses with your left hand. Put the left shoulder strap in position on your shoulders by assisting with the right hand. Slide the right arm through the right shoulder strap. Allow the breathing hoses to drop from the left hand and place your thumbs through the rings on the harness. Pull down to position the apparatus on your back.

Tighten into position your belt and connect the breathing hose support strap from the harness to the ring assembly on the breathing hoses.

16. CONNECT FACEPIECE

Connect the facepiece to the breathing hoses by first removing the screw cap and then attaching the facepiece to the threaded fitting.

17. PRE-FLUSH

Open the main bottle valve fully, then close half turn. The pre-flush automatically takes place when six litres of oxygen is released and flows throughout the apparatus.

18. PUT FACEPIECE ON

Put your facepiece on by first placing the chin and nose into the space provided, then pull the straps over the head. Next tighten the two neck straps and then the two temple straps.

19. CHECK FOR AIR TIGHTNESS

In order to determine whether or not there is a leak around the facepiece seal or at the junction of the hose assembly and face-piece, simply close off the flow of both breathing hoses by squeezing them with your hands while at the same time trying to inhale and exhale. Failure to obtain or expel air indicates a good seal.

20. PREASSEMBLY

(This work could be done as soon as a team reports to the bench or may be done for them.)

(1) Remove Equipment from case.

(2) Examine harness.

(3) Remove cover.

(4) Check, clean, and fill regenerator or install pre-filled canister.

(5) Remove bottle and check for leaks with caps on. Remove cap and place on bench.

(6) Apply anti fog and check facepiece. Team is now ready to assemble.

21. ASSEMBLY

(1) Check bottle with caps off and attach to apparatus.

(2) Examine inhalation and exhalation valves.

(3) Examine and attach breathing hoses.

(4) Test for leaks using R. Z. 35 tester.

(5) Check bottle pressure and leaks on high pressure side gauge line, bottle connections, etc.

(6) Check demand valve and by pass valve.

(7) Replace cover, turn machine and report condition when asked by captain.

(8) Put on and adjust harness.

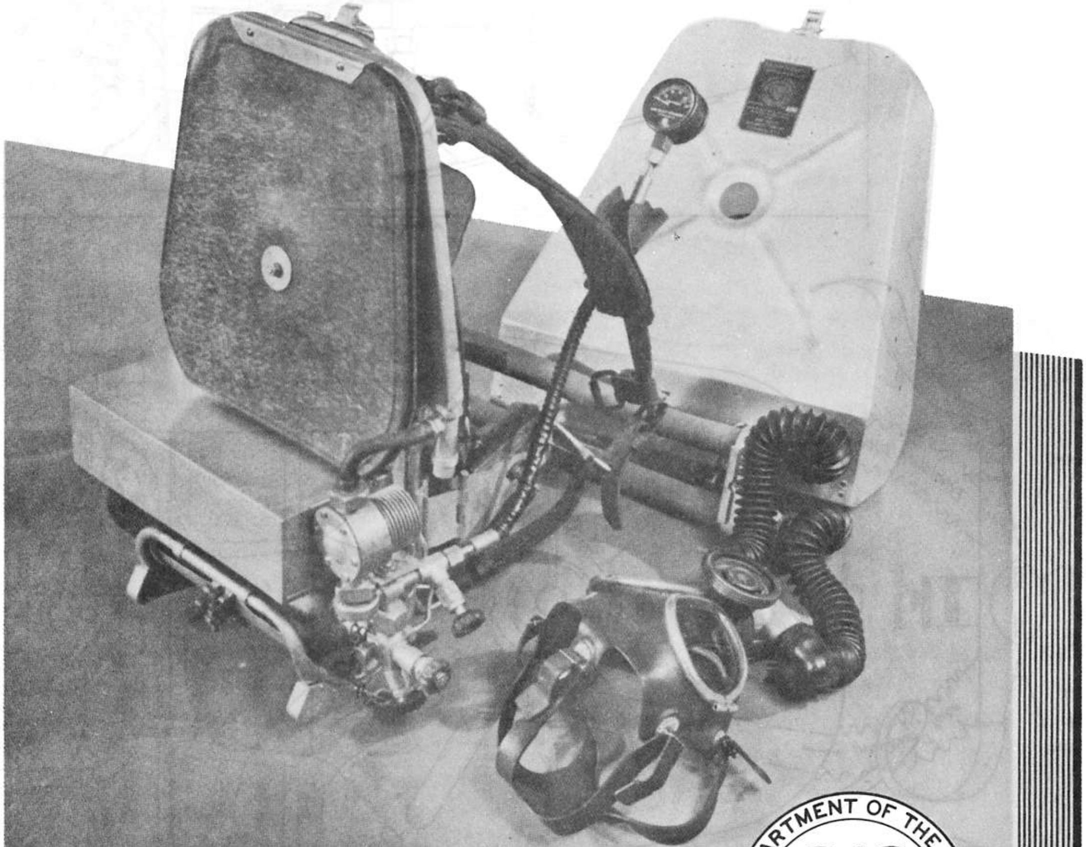
(9) Check and attach facepiece to hoses.

(10) Pre-flush machine and put on facepiece, check for tightness.

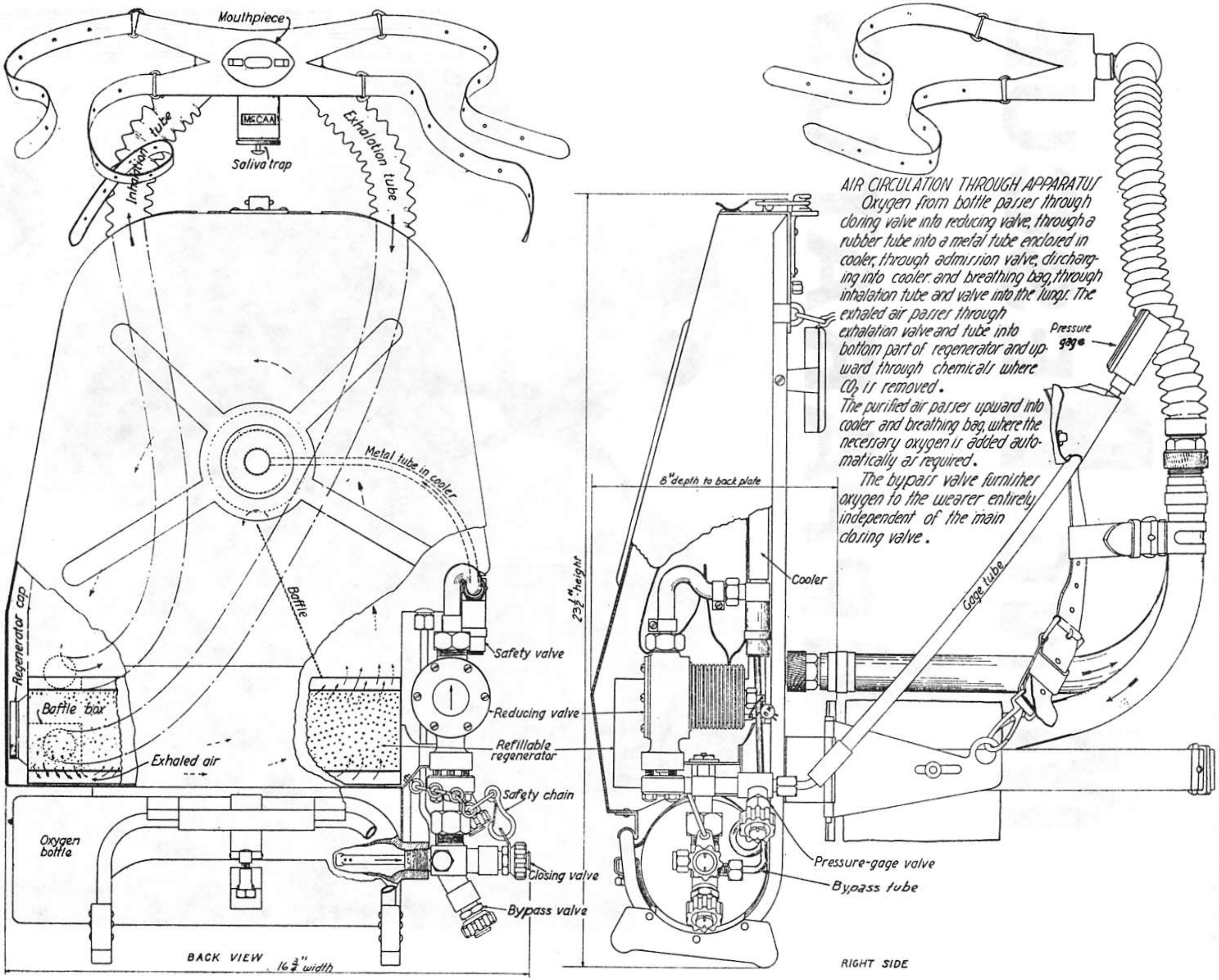
(11) Team to be examined by captain.

MSA McCAA

MINE RESCUE APPARATUS



U.S. DEPARTMENT OF THE INTERIOR ★ BUREAU OF MINES ★



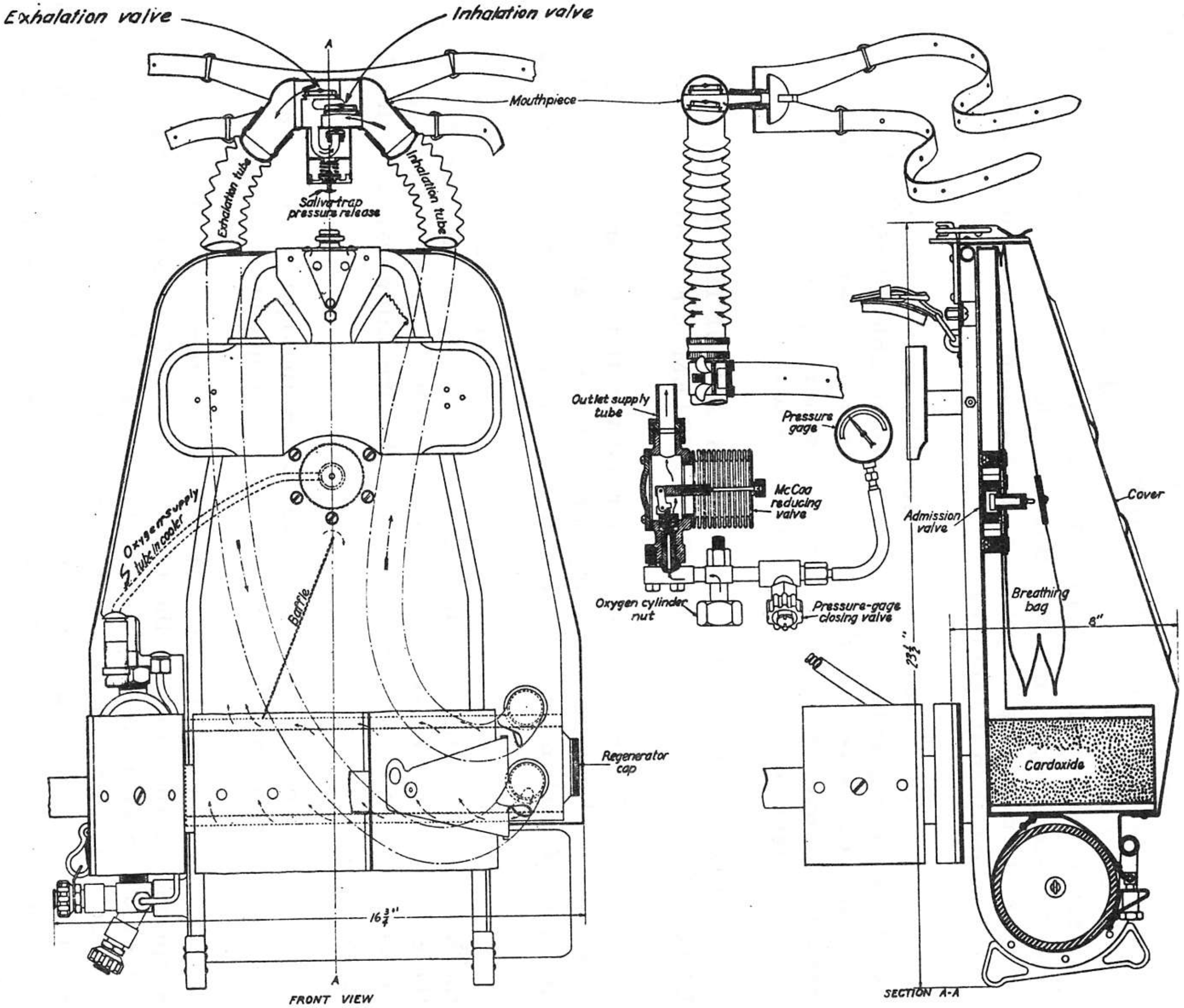
AIR CIRCULATION THROUGH APPARATUS

Oxygen from bottle passes through closing valve into reducing valve, through a rubber tube into a metal tube enclosed in cooler, through admission valve, discharging into cooler and breathing bag, through inhalation tube and valve into the lungs. The exhaled air passes through exhalation valve and tube into bottom part of regenerator and upward through chemicals where CO_2 is removed.

The purified air passes upward into cooler and breathing bag, where the necessary oxygen is added automatically as required.

The bypass valve furnishes oxygen to the wearer entirely independent of the main closing valve.

—Circulatory System of McCaa 2-Hour Apparatus.



—Details of McCaa 2-Hour Apparatus.

SELF-CONTAINED OXYGEN BREATHING APPARATUS

PHYSIOLOGICAL EFFECTS OF BREATHING PURE OXYGEN

Many persons believe that the breathing of pure oxygen is dangerous to health, that it "burns up" the person who breathes it. The quantity of oxygen consumed by the body varies with the amount of exertion expended. A man at rest consumes approximately 16 cubic inches of oxygen per minute. During violent exercise the consumption may increase to more than eight times that amount. The body consumes no more oxygen than it requires.

The pure oxygen breathed by the wearer of a self-contained oxygen breathing apparatus causes no noticeable ill effects, even after several successive periods of use, unless the wearer is subjected to air pressure in excess of the normal atmospheric pressure of 14.7 psi such as might be encountered in Caisson work.

THE ELIMINATION OF DANGEROUS AMOUNTS OF CARBON DIOXIDE IN THE CIRCULATORY SYSTEM OF THE APPARATUS

One of the most important functions of any closed circuit self-contained oxygen breathing apparatus is the elimination of dangerous amounts of carbon dioxide from the circulatory system of the apparatus.

In the types of apparatus in use prior to the introduction of the McCaa, this elimination of CO_2 was usually accomplished by passing the exhaled air over sodium or potassium hydroxide held on trays in the regenerator or loose in the bottom of the breathing bag as in the Proto apparatus.

In the Chemox apparatus the absorption takes place in a cannister where oxygen is generated simultaneously.

In the McCaa apparatus the materials used for CO_2 absorption are known under the trade names of Cardoxide or Safe-T-Sorb; either one may be used. Cardoxide consists of a combination of lime, caustic soda, Portland cement, Kieselguhr and water. The ingredients are mixed in proper proportions, made into slabs, dried, crushed, and screened to about eight to twelve mesh in size. Safe-T-Sorb has the same chemical composition but is manufactured under a different process. The advantages of these CO_2 absorbants over caustic soda or caustic potash are:

1. They are more efficient absorbers of carbon dioxide.

2. They keep the temperature of the exhaled air lower.

3. They do not fuse or solidify and therefore do not block the air passages or build up resistance to breathing.

4. They can be readily removed from the regenerator after being used allowing the use of an easily refillable regenerator.

5. They can be used after a regenerator has been left charged and the apparatus has been left standing over an indefinite period.

6. They can be handled without danger of burns to the hands or clothing.

McCAA 2-HOUR OXYGEN BREATHING APPARATUS

1. A steel cylinder or bottle for containing oxygen under high pressure.

2. A reducing valve. This reduces the pressure of the oxygen passing to the admission valve and supplies the wearer as needed at a pressure slightly above normal (from 3-3.5 pounds above atmospheric pressure).

3. A container called the "regenerator" which holds chemicals for absorbing the carbon dioxide in the exhaled air.

4. A breathing bag which operates an auxiliary admission valve and serves as an air reservoir. This is attached to a metal cooler which cools the regenerated oxygen.

5. A mouthpiece containing inhalation, exhalation, which makes the air circulation positive in direction. The saliva trap and relief valves are also situated in the metal mouthpiece.

6. The body of the apparatus, which holds the apparatus in one piece and has the harness attached.

NOTE: Never use grease or oil around oxygen or attempt to do repairs to the apparatus with greasy hands or clothing, as oxygen coming in contact with grease or oil could cause spontaneous combustion.

BENCH TEST

These tests should be made immediately before the apparatus is used. This assures the wearer that the machine is fit for use without taking the word of any other person. Should the wearer not be satisfied that the machine is in fit condition for wear, he should report his dissatisfaction to the person in charge and not "get under the oxygen" until he has satisfied himself that the machine is in good working order. These bench tests have been devised to give him that assurance.

Without the aid of auxiliary gauges or other testing apparatus, and without spending much time (20 minutes is ample for complete test), the operator can ascertain whether his machine is fit to wear by means of these apparatus tests.

See that all the necessary items of equipment, mouthpieces, breathing hose, head harness, wrenches, goggles, self-rescuer, hammers, nails, cap lamp, etc. are present and complete and that all necessary straps and buckles are in order. Remove the cover from the machine.

1. REGENERATOR TEST

This test is very important. A man wearing a machine with no absorbant in the regenerator will become unconscious in a few minutes, even though his machine is mechanically perfect.

(a) With the cover of the machine still removed, carefully turn the machine on its side so the regenerator is on the top.

(b) Unscrew the regenerator cap, using the special two-pronged flat wrench. The regenerator should be empty and clean. If there is absorbant in the regenerator it should be emptied. Examine the screens and see that they are not clogged, and that no absorbant dust is present. If the regenerator brush is used to clean the screens, the residue should be shaken out of all openings, including those on the back of the cooler.

(c) Fill the regenerator with the new absorbant, making sure that the top corners are filled. This may be done by using the handle of the wrench to pack the absorbant into all the corners.

(d) Examine the gasket on the regenerator cap and replace the cap, making sure that it is screwed on tightly with the wrench.

(e) With the machine on its legs, connect the breathing hoses to their respective connections (long hose to the bottom or exhalation connection, short hose to the top or inhalation connection). Place the exhalation hose in the mouth and blow gently in the machine to see that there is no undue resistence in the circulation of the apparatus.

2. TEST OF HIGH PRESSURE SIDE

(a) With the breathing bag facing the wearer, tilt the machine so that the bumper plate on the breathing bag is away from the plunger of the admission valve.

(b) With the machine still tilted, turn on the oxygen at the main bottle valve, look at the high pressure gauge, and wait until the reading on the gauge is steady. This reading shows the pressure in the oxygen bottle which is calibrated in atmospheres (multiply the reading by 14.7 and you have psi pressure in the oxygen bottle).

(c) Shut off the main bottle valve and watch the needle on the gauge very carefully for approximately 15 seconds. If the needle drops back towards zero there is a leak on the high pressure side. The leak should be found and remedied before doing any other tests, although a drop in one or two atmospheres in 15 seconds may be ignored.

(d) If no leaks are indicated, with the machine in the same position, lightly touch the bumper plate on the breathing bag against the plunger of the admission valve causing the admission valve to open momentarily. Do this two or three times, and watch the gauge carefully. The needle should start towards zero as the valve opens, and stop when the valve closes. The starting and stopping of the needle on the gauge indicates the admission valve is functioning properly. A small leak on the high pressure side of the machine is not dangerous to the wearer, except that it reduces the efficiency of the life of the apparatus by wasting oxygen.

3. MOUTHPIECE TEST

(a) Examine the rubber parts of the mouthpiece and corrugated breathing tubes, paying attention to any worn parts.

(b) Adjust the mouthpiece in the mouth.

(c) Breathe rapidly into the mouthpiece and listen to the valves opening and closing. There is a difference in the tone of the inhalation and exhalation valve. The tone of the inhalation valve is higher than that of the exhalation valve. Both should have a clear ringing noise.

(d) Block off the right hand, or exhalation breathing tube. It should be possible to inhale, but not exhale. Do this quite forcibly several times. This tests the inhalation valve.

(e) Release the exhalation tube, then block the left hand or inhalation tube and repeat the forcible breathing. If the exhalation valve is working properly, it should be possible to exhale, but not to inhale. Repeat several times.

(f) After being satisfied that both the inhalation and exhalation valves are in good condition, block off both tubes. This may be done by grasping the two tubes in one hand and squeezing them together. Then, with the fingers of the other hand on top of the metal mouthpiece, open the finger release valve with the thumb, keeping the finger release valve open, breathe forcibly into the mouthpiece. The air should be discharged to the outside atmosphere but it should not be possible to inhale through this valve.

(g) If the inhalation and exhalation valves and the saliva trap and finger release valve are in good shape, examine the nose clip, adjusting the spring to the nose clip, so the two pads are just touching, and place it in the nose, so that the pads are just below the bony structure of the bridge. If the nose clip is properly adjusted, inhalation through the nose is not possible. Any leaks in the mouthpiece, or, if you consider the valves are not working properly, it should be reported to the person in charge and another mouthpiece obtained.

NEVER TAKE A CHANCE ON A MOUTHPIECE THAT IS NOT CONSIDERED PERFECT. CHECK AND RECHECK THIS PIECE OF APPARATUS.

4. LOW PRESSURE TEST

(a) Connect the mouthpiece breathing tubes to the breathing hoses, making sure all gaskets are in place and in good condition.

(b) Place the left thumb lengthwise over the mouthpiece opening, thus blocking it off.

(c) Inflate the breathing bag by means of the by pass valve, taking care that the bag does not extend more than one inch beyond the regenerator. With the right arm covering as large an area as possible, apply a steady pressure to the bag. Should the low pressure side be tight, the pressure in the breathing bag will remain constant. If there is a leak, the pressure will reduce. This can be quite readily felt. Any leaks or defective parts should be repaired or replaced. Await the order to get under the oxygen.

(d) Replace the cover on the machine and stand it upright with the harness toward the operator. Report the pressure in the oxygen bottle and the results of the bench tests to the team captain.

GETTING UNDER THE OXYGEN

This procedure should be followed whenever the apparatus is worn:

After testing the apparatus and finding it to be fully charged, air tight and in good condition, proceed as follows:

(a) Put the apparatus on and adjust the body straps to fit.

(b) Place the rubber mouthpiece in the mouth and adjust it snugly to the head harness by means of the mouthpiece straps and buckles. Tighten the bottom straps first.

(c) Inhale deeply from the apparatus, then place the tongue on the roof of the mouth and exhale through the nose to the outside air. This should be repeated until the plate on the breathing bag strikes the plunger of the admission valve, indicating that the apparatus is completely empty of normal air.

(d) Without allowing any outside air to enter the apparatus, open the main bottle valve to its fullest extent, inhale from the apparatus, and exhale through the nose to the outside air at least three times, then without delay place the nose clip on the nose.

(e) Finally, pinch the exhalation tube firmly, open the finger release valve on the mouthpiece, and exhale forcibly to the outside air three times.

CLEARING THE MACHINE OF NITROGEN AND SALIVA

If the residual air is not properly cleared from the machine, an accumulation of nitrogen may result, with a consequent reduction of oxygen in the breathing circuit. This accumulation will build up to such an extent that it may prevent the breathing bag from operating the admission valve, and allowing a fresh supply of oxygen to enter the breathing bag.

The apparatus should be cleared of nitrogen and saliva every 15 or 20 minutes, or when the team captain directs. If these directions are followed, the wearer should be provided with air containing a high percentage of oxygen at all times.

After getting under oxygen in fresh air, and the captain has checked each team member, and had himself checked, the team should travel a short distance ahead of fresh air and stop for approximately two minutes to allow the team to be checked by the captain. This will give the captain a chance to detect any nervousness or excitement amongst the team members.

If leaks are detected in any machine, the entire crew should return to fresh air immediately.

In assembling the apparatus, always check the connection for gaskets, rubber, or leather, on the lower pressure side, and fibre or copper on the high pressure side.

BENCH COMMAND FOR McCAA 2-HOUR APPARATUS (MASK TYPE)

1. (a) Mask: Sterilize and clean lens, and treat with anti fog.

   (b) Mouthpiece: Sterilize and fill goggles with sterile water.

2. Test cylinder for gauge pressure (if assembled).

3. Stand to bench; call team numbers and test horns.

4. Remove shield and bottles from apparatus. Examine harness and all rubber parts for deterioration.

5. Clean regenerator with brush and fill with cardoxide or Safe-T-Sorb.

6. (a) With cap on cylinder, open valves and test in water for leaks at valve stems.

   (b) Turn valves off; remove caps; test valve orifice for leaks and clear moisture.

7. Mount cylinders in frame; examine for gaskets couple up cylinder.

8. Test inhalation and exhalation hoses; couple up; make resistance test from exhalation to regenerator to cooler to inhalation. Test breathing tubes, valves, mask, nose clip, mouthpiece, and head strap. Couple up breathing tubes to hoses.

9. Test for leaks from breathing bag to mouthpiece or mask.

   (a) Stand apparatus up; open main valve; place thumb over orifice of mouthpiece assemble or squeeze inhalation tube or BOTH close to mouthpiece when using the mask.

   (b) Fill breathing bag with oxygen by pressing open admission valve or by opening by pass valve in spurts--being careful when using by pass, not to fill breathing-bag too full.

   (c) Press breathing bag with hand and feel; listen for leaks.

10. With main valve still open, read gauge; close main valve; watch and listen for leaks from main valve to admission valve, test admission valve and safety valve.

11. Put on shield; turn apparatus around; check buckles and straps, put apparatus on.

12. (a) Put on headpiece; squeeze exhalation tube and inhale dead air from apparatus; exhale through nose (for mouthpiece assembly). Squeeze exhalation tube; press open slava valve; inhale dead air from apparatus; exhale through slava valve or mask, when using mask assemble.

   (b) Holding your breath, open main valve, take deep breath from apparatus; exhale through slava valve or mask or nose. Repeat this three to five times.

(c) Put on nose clip (with mouthpiece assemble). Release slava trap every 10 to 15 minutes or when required.

RECOGNIZING EMERGENCIES

1. Sudden changes in ventilation
2. Blasts of air
3. Fire alarm systems:
    (a) Stench warning system
    (b) Visual or audible warning
4. Smell of contaminants
5. Interruption of normal procedures

MINE VENTILATION

The British Columbia mining laws require that sufficient quantities of fresh air be distributed throughout a mine's workings so that gases and dust in the air that men breathe are kept to a healthy standard. Harmful dust in the air must be below a specified number of particles per cubic foot of air and all gases in the air must be below the threshold limit values set by the American Conference of Industrial Hygienists.

The mine ventilation system must therefore be designed so that an adequate volume of fresh air is delivered to all working places and that gases and dust are removed from the working places or are diluted to a safe level of concentration.

WHY AIR MOVES IN A MINE

When we open an air valve in a mine, the higher pressure in the air line causes the air to rush out to the lower pressure outside the air pipe.

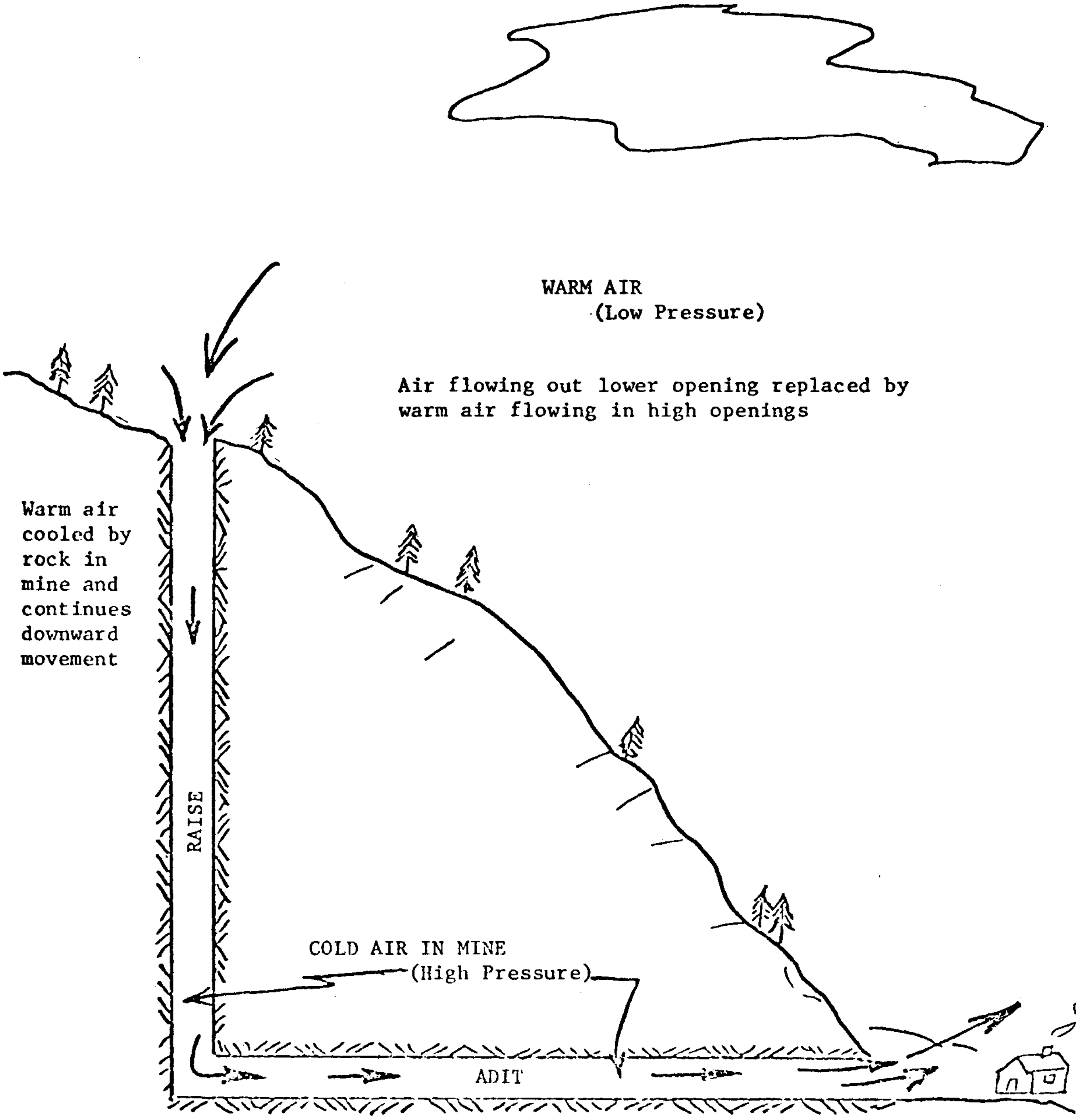
When we watch a television weather forecast we recall that the announcer often says that a warm front or a cold front is approaching and that windy conditions can be expected as the front passes. A weather front is simply the contact line between an area of high pressure and an area of low pressure. The winds we experience at a weather front is the air in the high pressure area rushing to the low pressure area.

Horizontal air movements are caused by differences in air pressure with the air always moving from a high pressure area to an area of relatively lower pressure.

A fan, an airplane propellor, evening breezes, hurricanes, a draughty room, and air moving in a mine are all examples of air moving from an area of relatively high pressure to one of lower pressure.

The greater the pressure differential, the faster the air will move.

A difference in relative weight also causes air to move but movements caused by differences in weight are in the vertical direction. Hot air is lighter than cold air and rises, cold air is heavier and will sink to lower places.



Air flowing out lower opening replaced by warm air flowing in high openings

Warm air cooled by rock in mine and continues downward movement

Heavy, high pressure air in mine flows down and out to lower outside air pressure

NATURAL VENTILATION
(1)

NATURAL VENTILATION

Many mines, especially in mountainous country, have natural ventilation caused by differences in pressure inside and outside of the mine and by differences in the relative weight of warm and cold air.

Consider the simple mine section shown on the preceding page.

If during a warm time of the year the outside air is warmer than the air in the mine the air will begin to flow out of the lower mine openings.

The outside air being warmer will be less dense and thus will have a lower pressure and relative weight than the heavier cool air inside the mine.

The denser and thus higher pressure air in the mine will tend to flow out of the lower mine openings to the low pressure area outside of the mine.

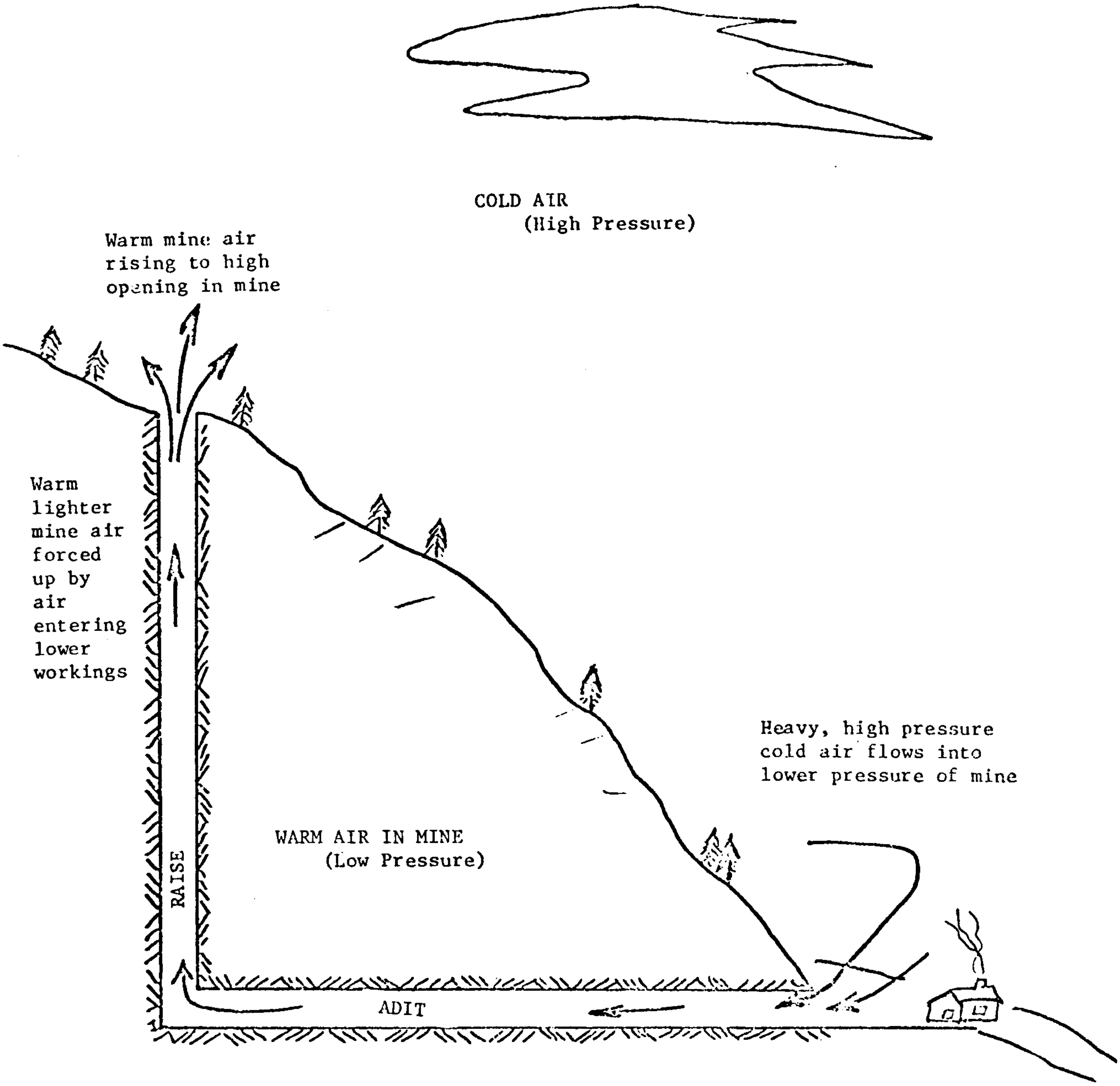
As the air in the mine flows out the lower openings it must be replaced, otherwise a vacuum would be created in the mine. The outflowing air is replaced by outside warm air entering the upper mine workings.

As the warm outside air enters the upper openings of the mine, it is cooled by contact with the cool rock of the mine. Once cooler than the outside air it will continue to flow down through the mine to the lower openings.

The reason the air flows is because of a pressure difference inside and outside the mine. The direction of flow (downwards) is due to the heavier air's tendency to seek a lower elevation.

If air outside the mine is warmer than air in the mine the natural ventilation will be downwards and the lower mine openings will be outcast.

The reverse situation occurs when the outside air is colder and thus at a higher pressure than warm mine air. The high pressure air outside will flow into the lower pressure inside the mine. As the warm lighter mine air tends to seek a higher elevation, the flow will be upwards. The lower openings will therefore be incase and the upper openings will be outcast (see the drawing on the following page).



NATURAL VENTILATION
(2)

Natural mine ventilation when it occurs can be very effective, however it is not too reliable. If outside air temperatures change and become the same as the mine air temperature, then the air flow will stop. If outside air changes from warmer than mine air to colder than mine air, the ventilation will reverse.

It is quite common to have natural ventilation flows in one direction during the summer months and in the opposite direction during the winter months. At certain times of the year (usually during the spring and fall) daily temperature variations can cause ventilation reversals within a few hours. Mines can be upcast at night and downcast during the day.

MECHANICAL VENTILATION

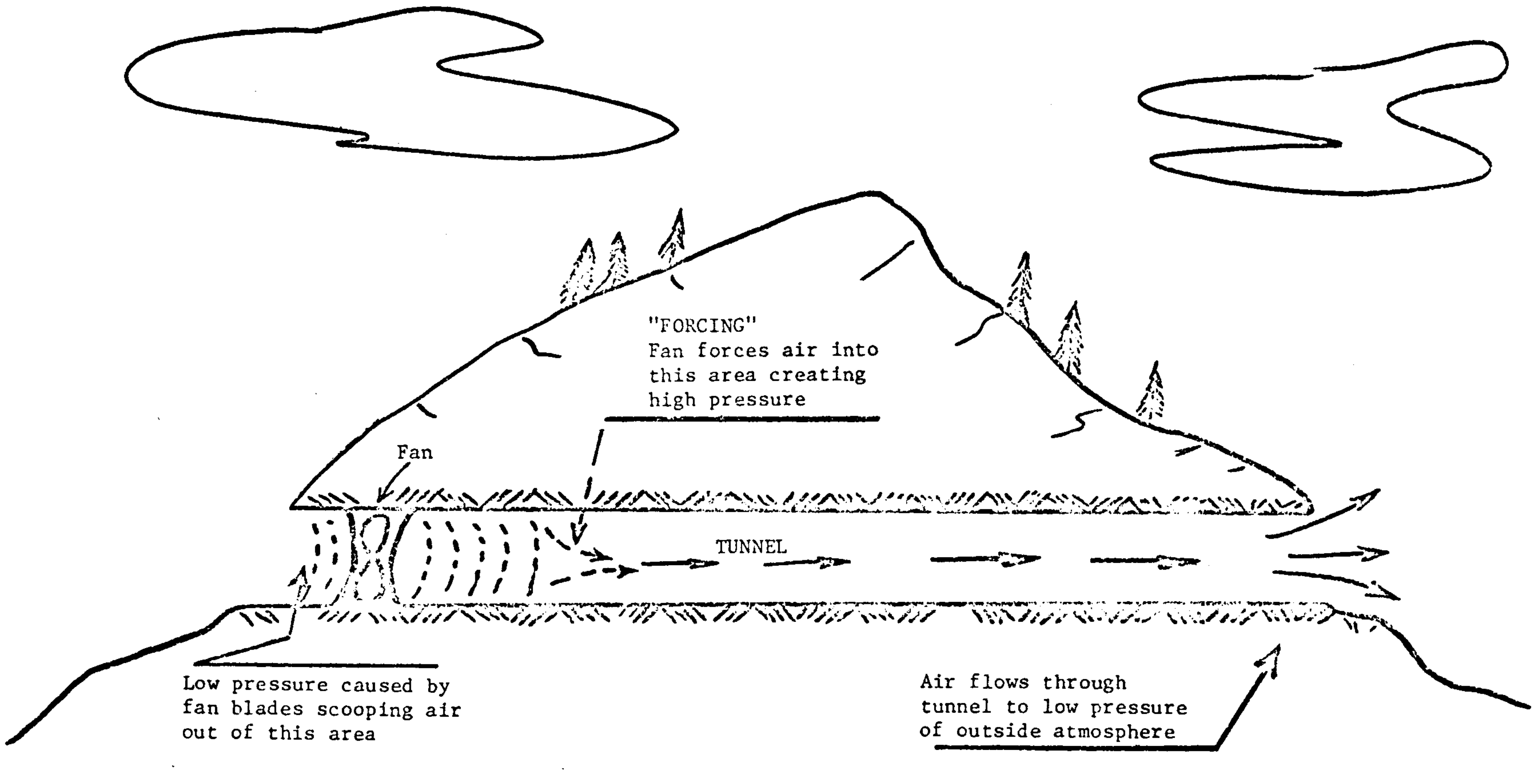
If natural ventilation cannot be relied upon to provide adequate ventilation, then mechanical ventilation must be provided. This is accomplished by installing fans at mine openings or in the mine.

Mine fans are simply a means of changing the air pressure at a specified point in the mine. This is illustrated in the drawings on the following two pages.

The first drawing illustrates a fan set up near the portal of a tunnel driven through a mountain. The blades of the fan scoop up air from behind the fan and force it to the front side of the fan. When this is done the air that has been taken from behind the fan creates a partial vacuum or low pressure area here. The air from behind the fan has been pushed to the front side of the fan increasing the air pressure on the front side. As we now have a difference in pressure between two points, air will begin to flow as long as it has a place to which it can flow. In the illustration given, the high pressure air in front of the fan will flow to the lower pressure areas further from the fan. The scooping action of the fan blades prevents the air from flowing back through the fan. The fan in the first sketch is called a forcing fan as it is forcing high pressure air into the mine.

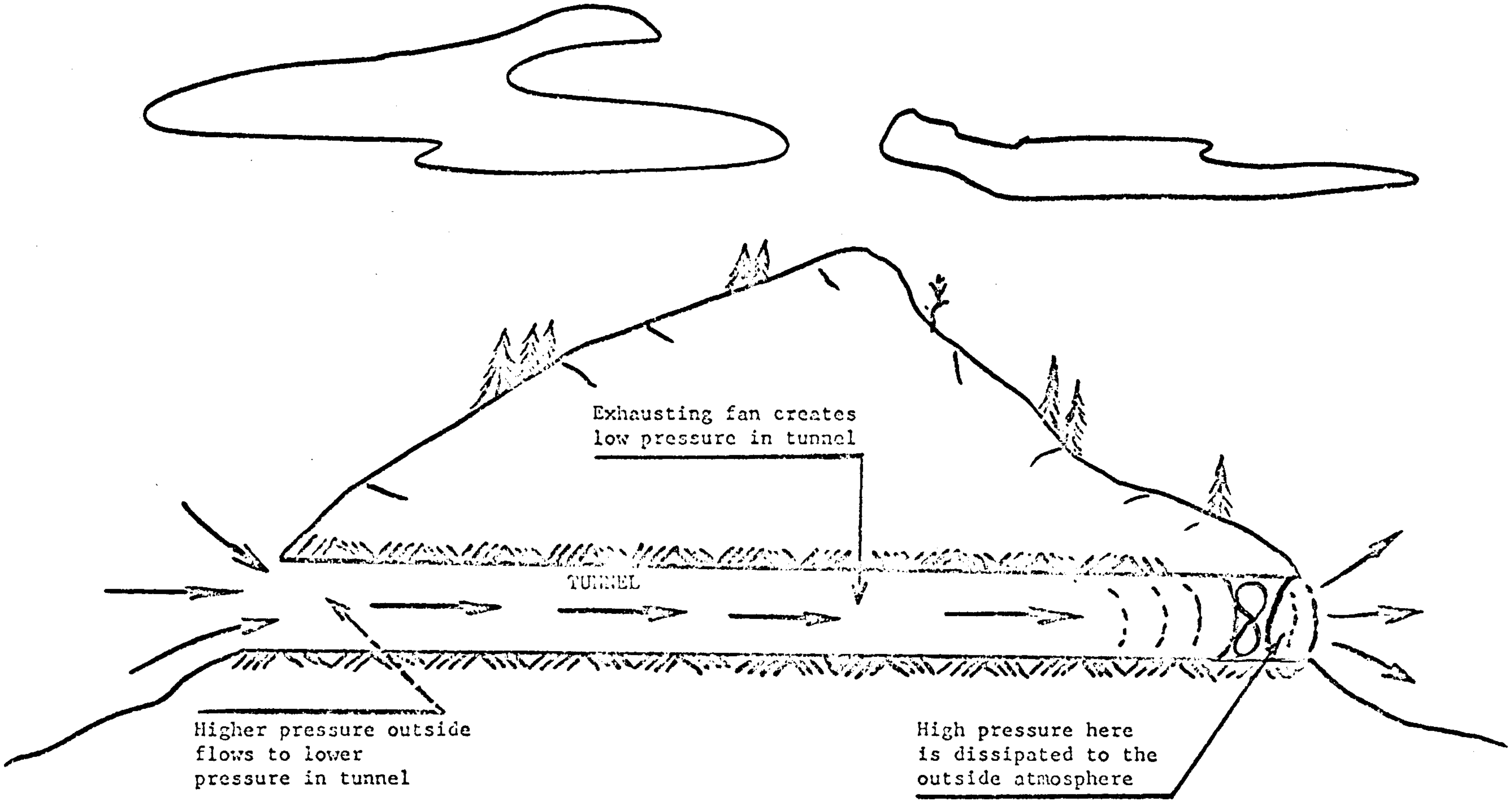
The second drawing illustrates an exhausting fan. This fan is creating a high pressure area in front of the fan which is soon dissipated to the outside atmosphere. The low pressure air behind the fan is filled by high pressure air flowing in from the rest of the tunnel and from outside the tunnel portal.

Whether a fan is a forcing fan or an exhausting fan the same principle of pressure differences are valid. The greater pressure difference the fan can create, the faster will be the air flow. The air however must have a place to which it can flow.



MECHANICAL VENTILATION

(FORCING FAN)



Exhausting fan creates low pressure in tunnel

Higher pressure outside flows to lower pressure in tunnel

High pressure here is dissipated to the outside atmosphere

MECHANICAL VENTILATION

(EXHAUSTING FAN)

If the exhausting portal of drawing No. 1 were plugged, the fan would still increase the pressure in the tunnel but as the high pressure air would have nowhere to go, it would simply stay there. The higher pressure in the tunnel would be maintained by the fan blades. If the fan were to stop the high pressure air in the mine would flow back out through the stationery fan blades until the pressure in the mine was the same as the pressure outside.

AIR DISTRIBUTION

As air flows through a mine it always takes the easiest path, that is the path which offers the least effective resistance.

The resistance to air flow is determined by (1) the amount of the air passing, (2) the roughness of the openings it is passing through, (3) the size of the openings, and (4) the length of the opening.

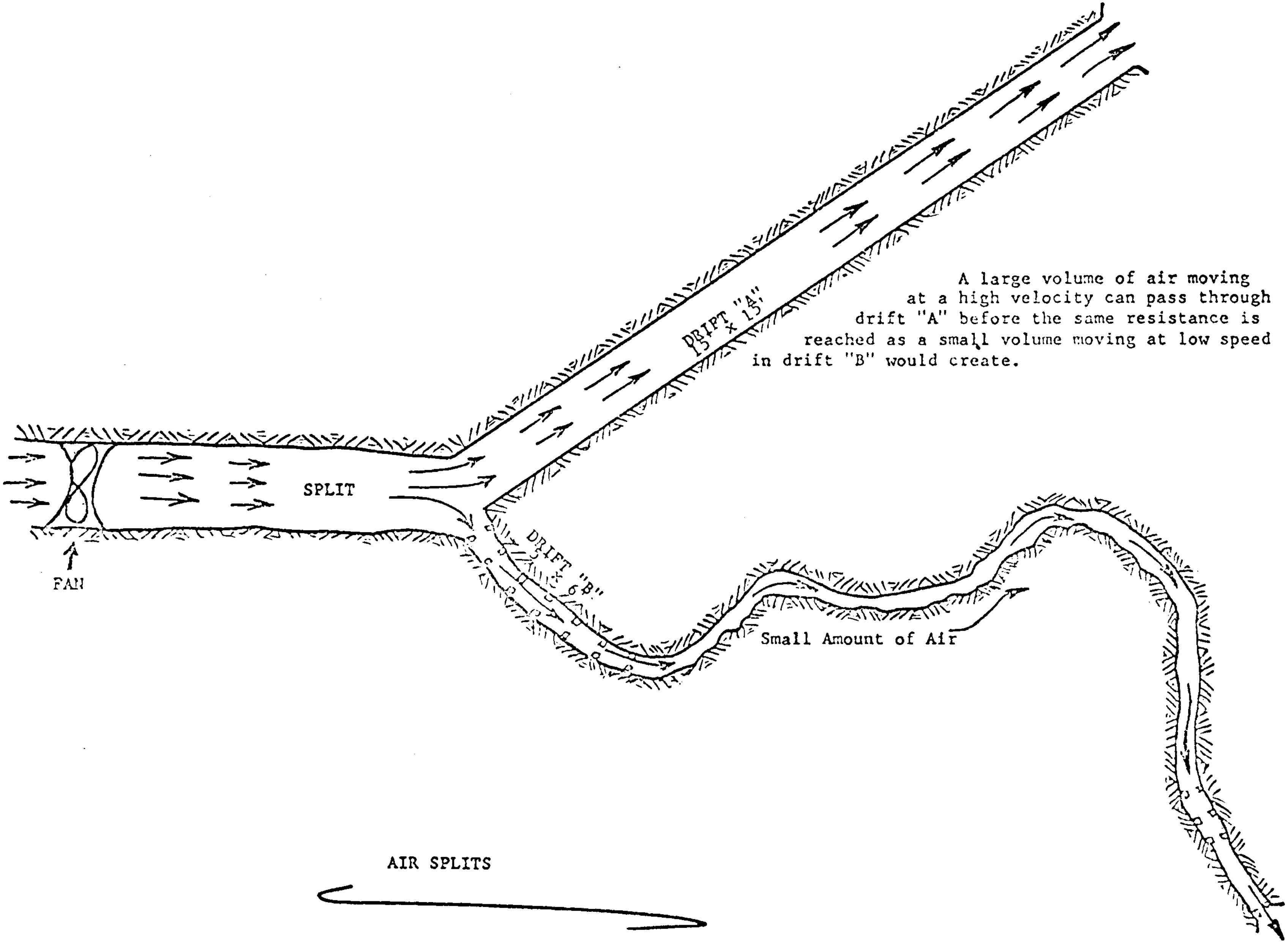
Air will pass much more easily through a large diameter, smooth-walled tunnel than it will through a small diameter, heavily-timbered tunnel. Restrictions in tunnels such as locomotives, trackless mining equipment, conveyors, ventilation regulators, etc. will add to the effective resistance of a mine opening and make it more difficult for air to pass.

SPLITS

If air flowing through a mine opening comes to a place where the opening branches into two or more openings, the air will split and a portion of it will flow through each opening. The amount which flows through each opening will be determined by the effective resistance in each opening.

If one of the openings is smaller in size and/or longer and/or has a rougher surface, then it will offer more resistance and a smaller amount of air will pass through it. Each of the openings will have the same total resistance. However, the larger, smoother, shorter opening will allow more air to pass before it builds up the same resistance as the small-sized opening. The drawing on the following page illustrates this principle.

When a split occurs in an airway more air will flow in large smooth-lined openings than in small rough-walled openings. Air will not flow into drifts unless it has somewhere to go. It will not flow into dead-end drifts.



A large volume of air moving at a high velocity can pass through drift "A" before the same resistance is reached as a small volume moving at low speed in drift "B" would create.

AIR SPLITS

Quite often air will not flow to the places it is required in the quantities that are required. In such cases it must be routed to where it is needed. The most common methods of routing air to where it is required is by using one or more of the following:

(1) Ventilation stoppings and doors

(2) Ventilation regulators

(3) Auxiliary fans

(4) Auxiliary fans with ventilation ducting

(5) Line brattices

Ventilation doors and ventilation stoppings are used to stop air from going where it is not wanted or required and thus to force it to go where it is required.

Two examples of the use of stoppings and doors are given on the following pages.

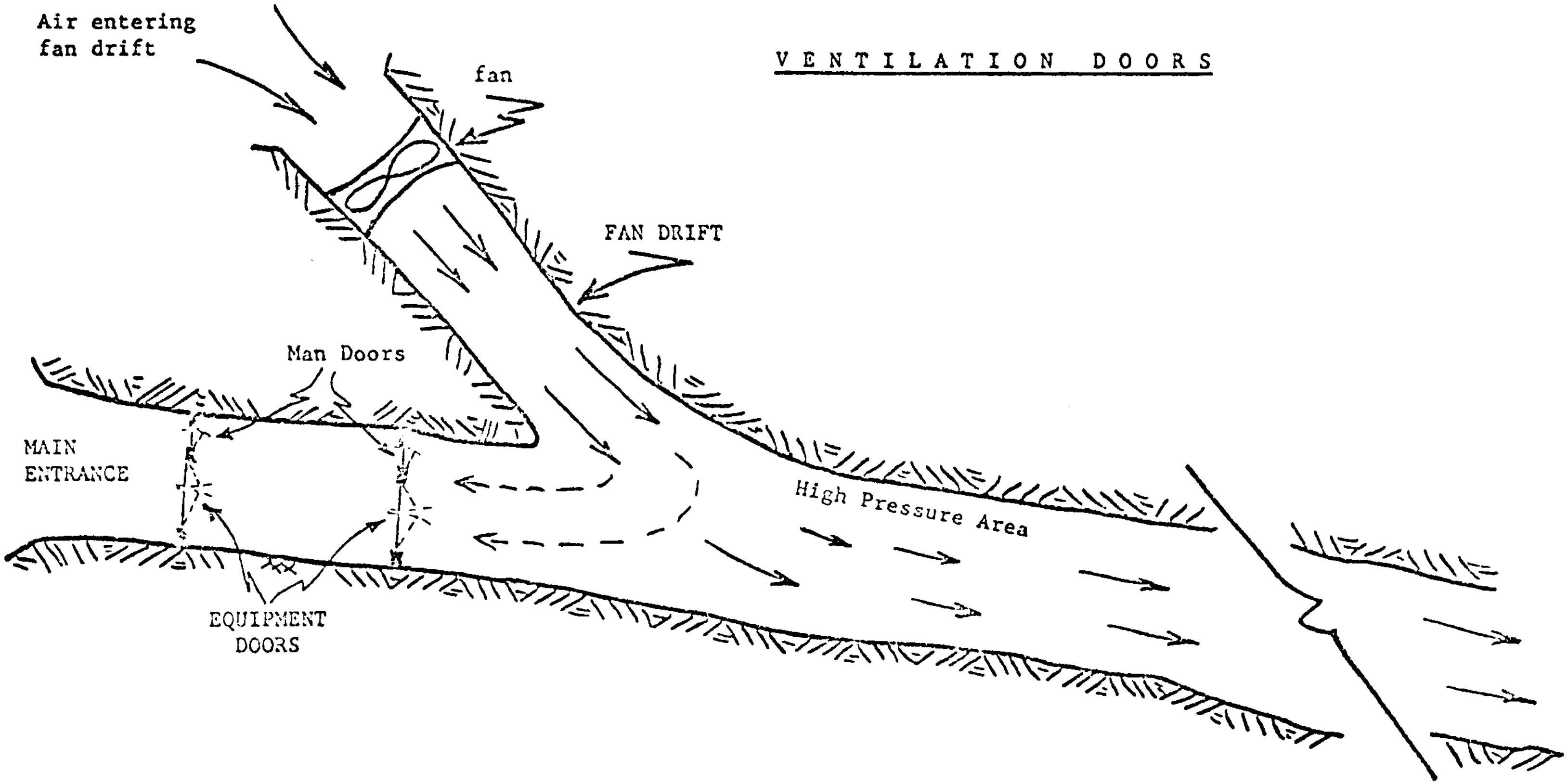
When main fans are installed in a mine they are offset from the main mine entrance. When air is forced into the main opening, the high pressure produced would simply "short circuit" back out of the mine entrance if ventilation doors are not provided. Because of the high pressure produced by the fans it would be difficult to open or close these doors if just one door was installed. For this reason two doors are usually installed so that a neutral pressure area is created between the doors. To travel through such an "air lock" only one door is opened or closed at a time. Such air locks usually have two sets of doors, large ones for equipment and small doors for men. Men then need not open the large doors to pass through.

It is important that doors be kept in their proper positions so as not to interrupt or change ventilation in the mine.

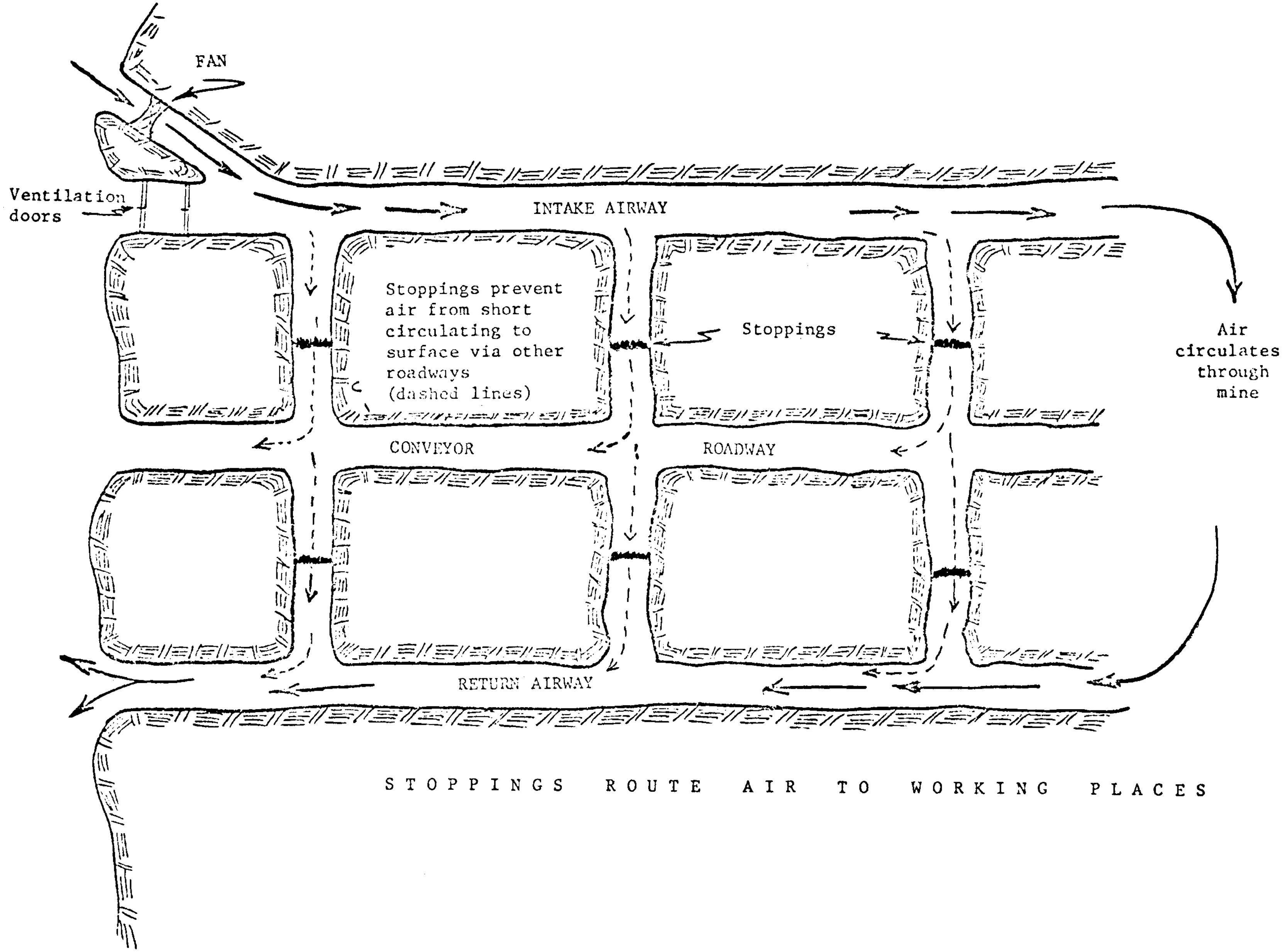
Stoppings are used when travel is not required, doors are used when travel is required.

There are many ways in which stoppings and doors are used in routing air through mines but all they do is isolate high pressure areas from low pressure areas where air is not required.

VENTILATION DOORS



Without ventilation doors the high pressure would simply short-circuit out through the main entrance and would not properly ventilate the mine (see dashed lines).
Double doors make it possible to open doors against the high pressure produced by the fan.



STOPPINGS ROUTE AIR TO WORKING PLACES

Fire doors are used to control air flows in the event of mine fires and at such times they serve the same purpose as stoppings or ventilation doors. Fire doors are often built at strategic locations in mines such as at shaft stations. In the event of fires they are simply closed so as to isolate sections of the mine.

If installed, fire doors must be kept clear of obstructions and in working condition at all times.

Ventilation regulators are used to reduce the amount of air through certain airways and thus increase the amount through other airways.

A regulator increases the amount of resistance in an airway and thus makes it more difficult for large amounts of air to pass. A regulator is simply a stopping with an adjustable-sized opening in it. A partially opened door will cause the same effect as a regulator and is often used as a regulator.

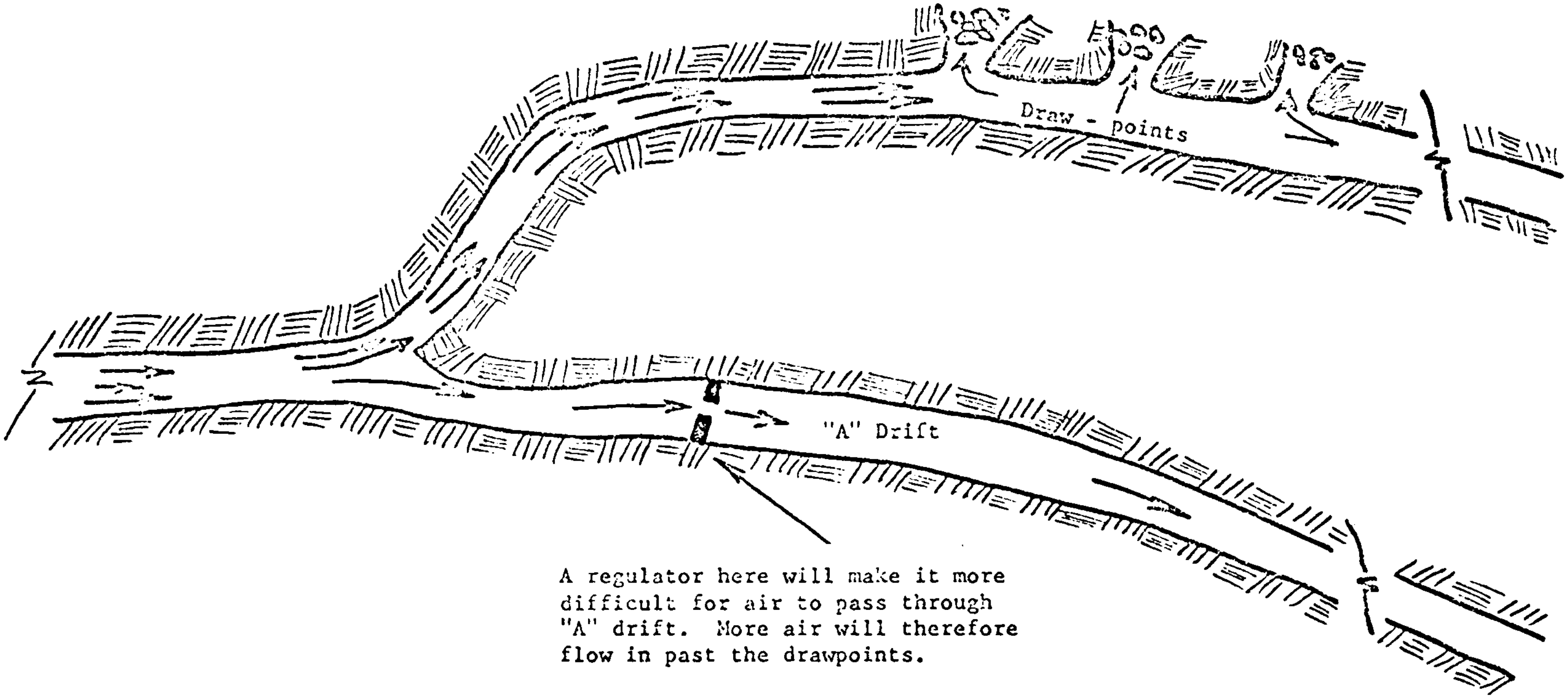
An example of the use of a regulator is given in the drawing on the following page.

As regulators are used to regulate the amount of air flowing to the various parts of a mine it is important that their settings are not changed by unauthorized personnel, otherwise unwanted ventilation changes will occur and some areas may not receive the required amounts of air.

Auxiliary fans are often set in places in mines where it is necessary to increase air pressure to force air through workings that are difficult to ventilate in other ways. Dusty places or places where blasting gases may accumulate often require auxiliary fans for proper ventilation. The "scram" drift illustrated on page 167 is a good example. The auxiliary fan in this drawing forces relatively large quantities of fresh air past the operator. After passing the operator the air carries the dust and blasting smoke out of the scram drift to the ventilation exhaust system.

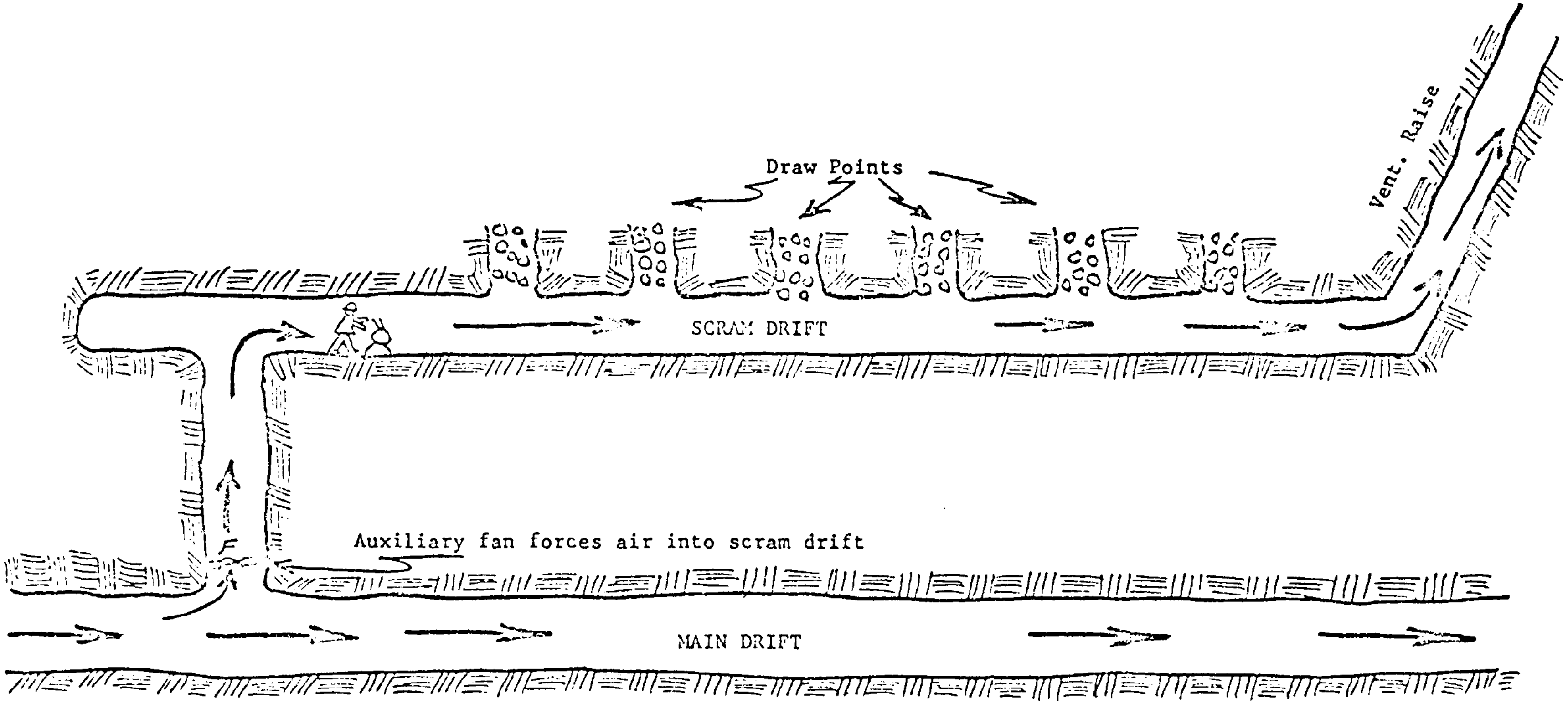
If a fire were to occur in this mine and the main drift were to become filled with dangerous gases, what action should a crew in the scram drift take?

When dead-end working places require ventilation it is often necessary to use auxiliary fans in conjunction with ventilation ducting. Air will not flow into a working place unless it has a place to



A regulator here will make it more difficult for air to pass through "A" drift. More air will therefore flow in past the drawpoints.

REGULATOR



AUXILIARY FAN

go. The ducting provides a path for the air to enter the heading and it can then flow out through the main part of the heading.

The fan forcing air through a duct must be located so that air coming out of the heading does not re-enter the ducting and go back into the working place. The drawing on page 170 illustrates the use of ducting to ventilate an active drift heading.

As in the case of the scram drift if the main drift was to be contaminated by fumes and smoke from a fire and the drift crew had to stay in the heading, the fan would draw the gases into the drift unless it was shut down.

Coal miners often use lines of brattice cloth to serve the same purpose as ventilation ducting. Brattice cloth is a tightly-woven heavy fire-resistant cloth which is hung from roof to floor to create a second air path in a dead-end heading.

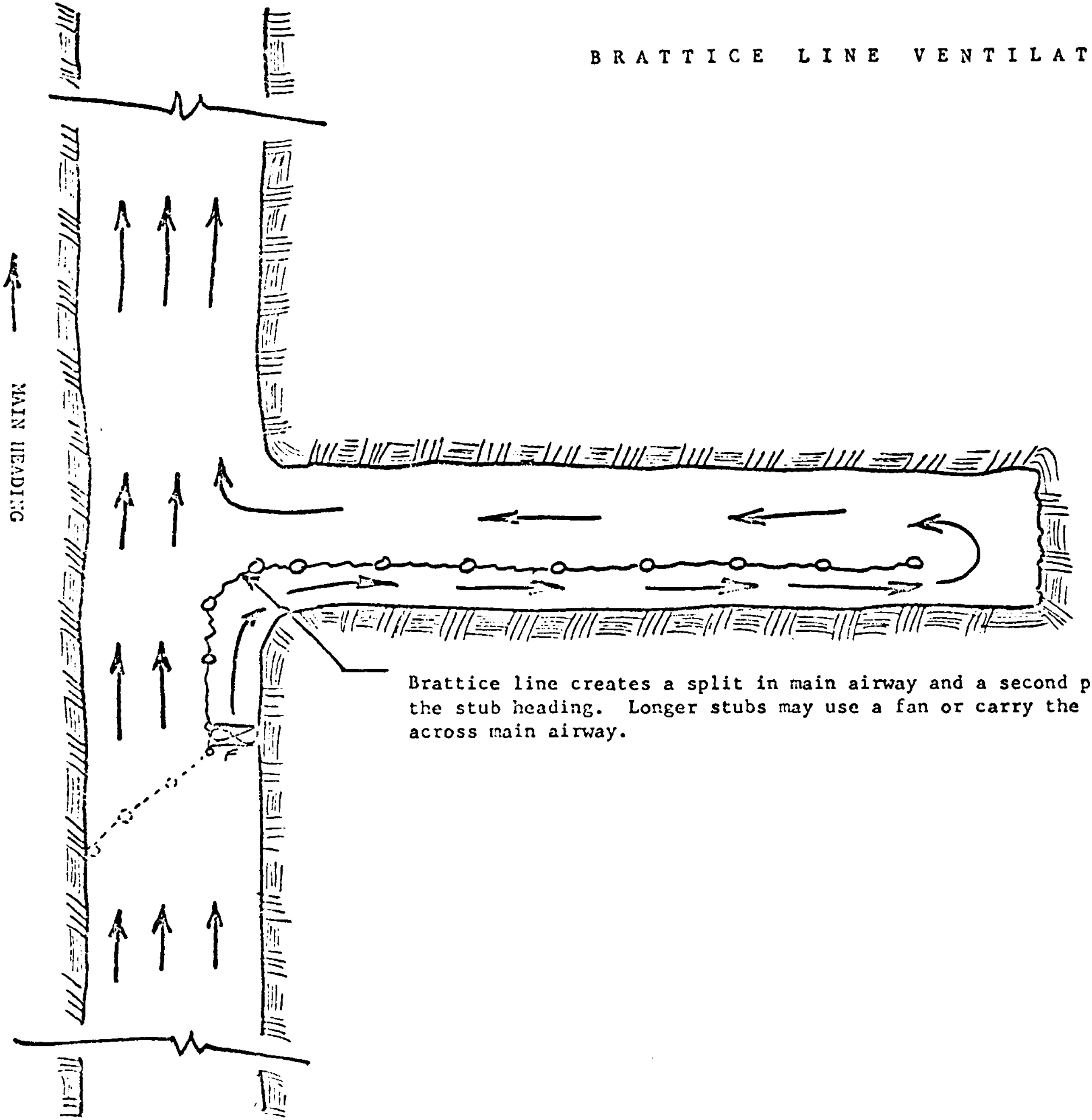
The sketch on the following page illustrates the use of brattice cloth for auxiliary ventilation. Auxiliary fans may be used in conjunction with brattice cloth, but more often the brattice just creates an artificial second path in the airway. If the dead-end is short the brattice need not go right across the main airway and only a part of the air in the main airway will go into the dead-end. For longer dead-ends the brattice is carried right across the main airway and all of the air is circulated into the dead-end (see dashed lines in drawing on next page).

This chapter has explained some of the principles of air movement in mines and some of the methods used to ventilate mine workings.

Underground workmen should never, unless instructed to do so, change mine ventilation by disturbing regulator, altering door positions, or shutting off fans as your fellow workers could be seriously affected.

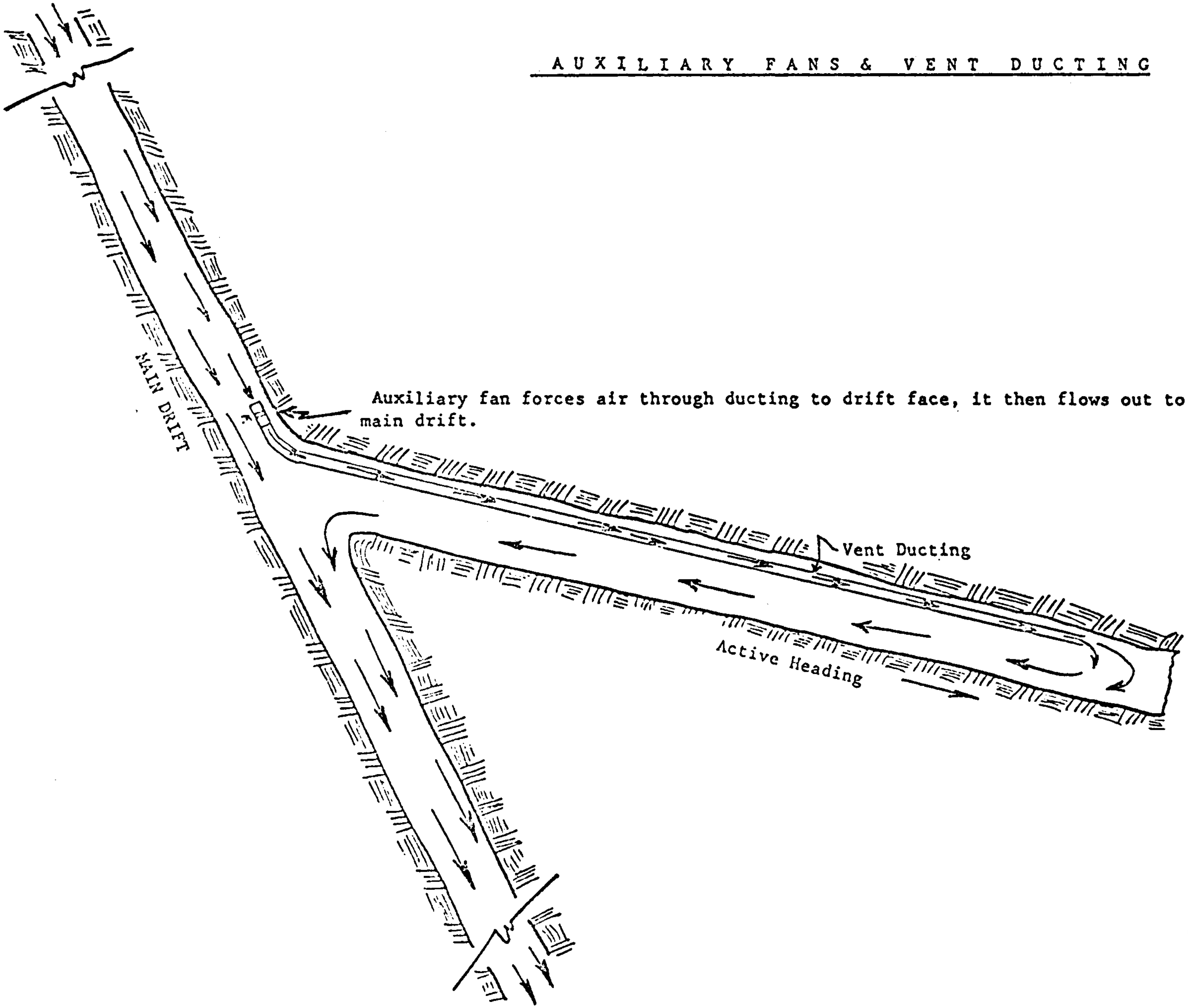
Keep in mind that air will always travel from a high pressure area to an area of lower pressure and warm, lighter air will tend to rise to higher places.

BRATTICE LINE VENTILATION



Brattice line creates a split in main airway and a second path for air in the stub heading. Longer stubs may use a fan or carry the brattice right across main airway.

AUXILIARY FANS & VENT DUCTING



Auxiliary fan forces air through ducting to drift face, it then flows out to main drift.

MINE RESCUE COMPETITION PROCEDURE

The following notes are written with the view of standardizing the procedure to be used in all mine rescue competitions. This applies to the general solution of any particular problem as well as to the method or methods to be used in performing the various phases or parts constituting the problem. Every solution must observe in proper order of precedence the four fundamental principles of mine rescue training. In correct order these principles are:

1. Ensuring the safety of the rescuing team.
2. Endeavouring to rescue or ensuring the safety of the lives of the trapped men.
3. Protecting the mine property from further damage.
4. Rehabilitating the mine.

A breakdown of the vaious parts making up the average problem or problems and how they should be done will, we believe, do much to standardize the team work of competing teams, and will also assist the judges in arriving at a fair decision.

GENERAL PROCEDURE PRIOR TO ENTERING A MINE

Teams of six men are summoned and given a mine plan of a disaster area or mine and whatever information is available with respect to the disaster such as: what happened, the number of men in the mine, and such information as available that may be pertinent to aid the rescuers. A limited time is permitted to digest this information after which each member is required to answer two questions on mine gases, rescue equipment or rescue procedures. Following this the captain and/or vice-captain may be required to make actual gas tests. During this period the remainder of the team shall check and assemble whatever rescue equipment, tools, etc., as are available to complete the problem.

On completion of the gas testing and assembly of equipment all team members shall report to the bench where the team will obtain their breathing machines and under the direction of the captain (No. 1 man) make such assembly and test checks as are necessary. The captain shall be assisted by the vice-captain (No. 5 man). The No. 6 man shall be designated the fresh air base man and outside co-ordinator. When this procedure is completed a smoke chamber test shall be made after which the team is ready to report to the mine manager.

If the qualifications of a team or any member is inadequate or if the performance of their work at the bench is inadequate or inaccurate deductions shall be made on the following basis:

1. FAILURE OF ALL TEAM MEMBERS TO BE FULLY QUALIFIED

All team members should conform to Rules two and three in "Rules Governing Mine Rescue Competitions". If any of the men do not comply, the team will not be barred from the competition, but will have five points per offence added to their score.

2. FAILURE TO ANSWER QUESTIONS

Each team member shall be questioned by the bench judges regarding his knowledge of the construction and operation of self-contained breathing apparatus, Type "N" gas masks, self-rescuers and devices for the testing of mine gases. The captain and vice-captain may be questioned on mine plans and mine rescue procedures.

3. LACK OF PROFICIENCY IN ASSEMBLING AND CHECKING APPARATUS

Team members will be given self-contained breathing apparatus in good condition, but will be expected to assemble if necessary and check the equipment to assure themselves that it is in good working order.

4. LACK OF DISCIPLINE

The captain should take charge of the routine in assembling and checking apparatus and should finally check each team member. The vice-captain should check the captain's apparatus. This routine should be done in a smart and orderly manner.

The order used in checking and assembling apparatus is not too important, but all members of each team should follow the same procedure.

5. FAILURE TO COMPLETE ASSEMBLY ON TIME

Twenty minutes will be allowed for checking and assembling high pressure and liquid oxygen apparatus.

6. FAILURE TO COMPLETE WALK AND STAY IN SMOKE ROOM

Walk is 117 yards in two minutes. Smoke room two minutes, with pulses checked before and after entering.

7. FAILURE TO CHECK EQUIPMENT SUPPLIES

The team should check the stretcher(s) and equipment, particularly and respiratory protective equipment taken into the mine to be used for the rescue of any persons within the mine. This must be done to ensure serviceability. Whatever equipment and supplies as are available shall be provided and may be augmented with anything practical that may be found underground.

PROCEDURE AT MINE PORTALS

On reporting to the mine manager the captain may remove his mouthpiece or facepiece to be able to speak to the manager. On speaking to the manager the captain will advise what team he is captaining, inquire if any further information is available concerning the accident, ascertain from the manager or judges the condition at any mine openings not readily accessible, and have the flame safety lamp and any gas testing devices checked by the mine manager or a judge. It is recommended that questioning be kept to a minimum as the period from reporting to the captain to the time the team enters the mine will have a time limitation. When the foregoing is completed the captain will replace his mouthpiece or facepiece and ensure his machine is functioning after which he, with the team, shall examine all accessible mine openings to determine the conditions existing. The signs at the openings will indicate the conditions found after the necessary test has been made. (It is to be noted at this point that at every sign outside or inside the mine the necessary test or examination must be made the first time the sign is encountered. The information indicated is what has been determined only after the test or examination has been made. Deductions will be made for each instance the captain fails to determine the information.)

On completion of this examination the captain will advise the judge of his planned procedure asking for any required guarding of portals and direct the baseman to take up his position. The captain may at his discretion permit the baseman to remove his mask. The captain will again seal up, check his team and in turn be checked himself pick up the team checks or tags, record the name of team and time of entry on the board and start the time clock if one is provided, then immediately enter the mine. The baseman or outside co-ordinator will be in charge of communications which extend into the mine workings. He will keep a map on which he records information as relayged to him from the team captain. He may make suggestions to the captain, but the captain must be responsible for all decisions.

PROCEDURES AFTER ENTERING THE MINE

The procedures to be observed after entering the mine will be governed by the conditions encountered but all actions should be governed by the following considerations.

DISCIPLINE

It is of the utmost importance that a mine rescue team be well trained in the use and care of their apparatus. They should be efficient in performing the various duties they will be called on to do. Their morale should be of the highest, such as constant training and expert knowledge of their apparatus will provide.

The team must act as a unit and must obey the signals of the captain and vice-captain promptly and efficiently. The captain should give his signals distinctly and with authority. There must not be any arguing or dissention among the team members while performing their duties as a unit. The captain and his team should have every confidence in each other's ability to handle any situation that requires their united effort.

When facepieces are worn, a limited amount of talking will be permitted between team members and to men found in the mine, however if talking becomes excessive, deductions will be made with respect to team discipline. Notwithstanding this permission, all executive commands must be given by horn signal.

SAFETY OF THE TEAM

(a) The safety of the team members is of primary importance and the captain must at all times do his utmost to bring his team out of the mine alive. It is understood that any team that enters a mine after an explosion or to fight a mine fire is taking a calculated risk. The captain should give each situation encountered underground careful thought before proceeding; in plain words, he should endeavour to have the odds in favour of his team under any given circumstance.

The captain should advance through the mine cautiously, giving particular attention to the roof and sides, and the condition of the mine atmosphere.

The team should be rested at regular intervals and also after completing arduous work or before entering a dangerous atmosphere. At the end of each rest, the gauges of each member's apparatus should be checked, as well as the mental and physical condition of each member.

The team should be rested briefly immediately after entering the mine so that the captain may check and encourage each member.

Work done by the team should, as far as is practical, be distributed equally so as not to overtax any member unduly.

(b) Route of Travel

It is fundamental that a rescue team should explore a mine via the fresh air route whenever practical to do so. This way of travel offers two good reasons for its adoption.

(1) The danger to an exploring team is lessened.

(2) The site of a fresh air base may be located near to the scene of action if such a course becomes necessary. However, conditions such as caves in the intake will alter the above method of operation.

(c) Indication of Route of Travel

The route of travel may be indicated by any or a combination of the following methods: fencing, use of chalk or spray paint, or a voice communication line. These methods are herewith described but in all cases all mine entries excepting that used by the rescue team shall be fenced. This entry shall be guarded by the No. 6 or base man. The team captain must advise the judges what method or methods will be used prior to the bench exercise so that the mine attendants may have the mine adequately prepared.

(1) Fencing

When this method is used the team must fence off all entrances to roadways branching off the road they are using, with the possible exception of stub ends only a few feet in length. A fence shall consist of a single board across the roadway being closed off. It shall be nailed at both ends to the legs of a timber set and if possible placed at waist height.

(2) Chalk or spray paint

The team may indicate its route of travel by marking with spray paint or chalk (the only acceptable form of marking in coal mines) a horizontal line from one to two feet in length, wherever possible on the right wall or rib of the roadway. On coming out of the roadway, a line of approximately equal length should be made at right angles to the first, making a cross. On re-entry, the route shall be effectively indicated in a manner similar to the foregoing.

(3) Voice Communication Line

A team may carry a voice communication line which is unreeled as the team advances and may be wound up as the team retreats. If the team goes beyond the length of line available, then one of the two foregoing methods should be used.

(d) Timbering of Bad Ground

On arriving at bad ground, the captain shall examine and test the ground carefully. He shall not expose himself or any member of the team to any danger. He will indicate to the Nos. 2 and 3 team members where he wants a post or posts to be set. These men will bar down and clear away enough cave debris, if any, to allow the post to be set in the proper place and then measure for the post. While the above two men are engaged in doing the work outlined, Nos. 4 and 5 team members will prepare the post for cutting.

If the post is of normal thickness, say six to eight inches, then Nos. 4 and 5 team members should do the cutting, while Nos. 2 and 3 men are resting. On completion of the cutting, Nos. 2 and 3 men will erect the post and wedge it firmly in position. If, however, the post is extra thick, then the team members could spell one another while sawing the post.

(e) Goggles and Life-Lines

Goggles and life-lines must be put on prior to a team entering a smoky atmosphere and worn throughout while travelling through such atmosphere.

If conditions are such that four men can be used on the stretcher, it will be sufficient to have the captain and the No. 2 man on the stretcher roped together. If two men only are used, all must be roped continuously, except the stretcher bearers.

(f) Examination of workings

It is essential that the team proceed and work as such, hence no unduly large gaps should separate team members. Deductions shall be made in each instance where the space between team members exceeds eight feet.

When proceeding into headings where it is not considered necessary to carry the stretcher one man shall remain beside the stretcher while the team may extend out with the use of their safety ropes or by clasping hands but in no instance shall the intervals between two adjacent men be greater than eight feet.

TESTING OF MINE ATMOSPHERE

When the signs in the mine indicate CH_4, CO, good air, or an atmosphere depleted of oxygen, the captain should go through the procedure of making the correct tests with his instruments. The signs are there to indicate to the captain what he finds after making the tests. In plain words, when a sign is noticed in a mine or at a portal of a mine, the captain must make all the tests (for CH_4, CO and depletion of oxygen) to ascertain the condition of the atmosphere, as if he was actually in a mine after an explosion or in a mine to combat a mine fire.

When gas test boxes are used the captain or vice-captain using the testing equipment should determine what gas or gases are present and the percentage or parts per million of the gas or gases. Carbon monoxide tests shall be made first. These test boxes will be outside the mine workings. This test will be made prior to entering the mine.

STRETCHER PROCEDURE

With but one exception the team must endeavour not to become separated from its supplies and stretcher. The sole exception is when a patient is being carried in the stretcher and only under these circumstances the tools, etc. may be left in the mine to be recovered immediately on re-entry. No patient should be left alone on a stretcher and no person should be taken by a team into any unexplored areas of a mine.

It has been customary while exploring a mine for the Nos. 3 and 4 team members to carry the stretcher. This method is quite satisfactory when the team is travelling along level roadways or climbing ladderways (where more than two men to a stretcher is impossible).

Wherever possible, while the team is travelling along rougher inclined roadways, Nos. 2 and 5 team members should assist in carrying the stretcher. The width and travelling conditions of roadways are always factors in governing the number of men carrying the stretcher.

When a team is transporting a patient, there should, if space permits, be four men to the stretcher. At regular intervals, or when the nature of the roadways demand, the team should be rested, at which time the members will change positions so as to rest their hands and arms.

When travelling along level roads which are of ample width, the captain may stop his team for the purpose of changing the position of the carriers on the stretcher without a rest period being taken. This is at the captain's discretion.

CARE OF MEN FOUND IN THE MINE

The object of mine rescue teams is to save life and to do work after mine fires or explosions that cannot be done without using self-contained breathing apparatus.

When a man is found with a card indicating death, the captain must go through the motions of making the standard first aid checks to see if the man is dead. After ascertaining that the man is dead, he should be put to one side of the roadway out of the way. It isn't necessary to cover the man, as this would use brattice and waste time.

If the man is alive, then prompt first aid must be given. Bleeding must be checked, broken limbs splinted and bandaged, and shock treatment given. If the patient is to be carried out of the mine immediately, then he will be placed on the stretcher after being given first aid.

After the patient has been placed on the stretcher, the team should be rested while the captain checks the patient. The patient should be checked as often as the captain thinks necessary while being transported from the mine.

If the flat type of stretcher is used, it would be advisable to tie the patient to the stretcher so he cannot roll off, especially a patient who is unconscious.

If men have to be taken through a dangerous atmosphere, they will require to be equipped with a self-rescuer, or Type "N" mask, or when available, self-contained equipment, depending on the conditions existing. A person who is unconscious or irrational cannot be equipped with a self-rescuer but the Type "N" mask or self-starting self-contained equipment may be used.

When patients have to be left for any reason or while they are being walked out of a mine, their hands shall not be tied unless they are acting in an irrational manner.

When men are being left in the mine they should be advised to remain where they are until rescued and they should be encouraged by being informed this rescue will be done as promptly as conditions permit.

ERECTION OF BRATTICE AND STOPPINGS

It is a principle of mine rescue procedure that no seal or stopping be entered or torn down until the results of such act are apparent. Either of the above acts may, depending upon circumstances, allow bad air past the seal or establish ventilation through part of the mine as yet unexplored.

With the above in mind, a team, while exploring a mine to find men, shall erect a safety seal close to any seal found before entering or tearing down such seal. This method would also apply to stoppings that the team desires to go through. However, no seal shall be opened where an irrespirable atmosphere exists until all practical means to effectively ventilate the front of the seal have been exhausted.

In the erection of safety seals or stoppings, they should be nailed at the top and sides and dirt placed on the bottom of the brattice to make them as airtight as possible.

HANDLING MINE FIRES

When a team encounters a small fire underground, the captain should instruct his No. 2 man to use the fire extinguisher on it. While this is being done, the No. 3 man will take a shovel off the stretcher and, after the No. 2 man has completed his duty, he, the No. 3 man, will put dirt on the smouldering fire and pack same. After these men have completed their parts in extinguishing the fire, the captain will examine same to assure himself that the fire is actually quenched.

When a fire beyond control is met with underground, the only solution is to seal it off without undue delay. All approaches to the fire wherein air is free to travel must be sealed off, but before any sealing is commenced the captain must decide what effect the sealing will have, if any, on the ventilation of the rest of the mine. By this is meant, that the status quo of the mine ventilation must be maintained. It is presumed, for competition purposes, that after sealing the fire, the team has left the mine and has returned after waiting the necessary time.

RESTORING OR CHANGING VENTILATION

The re-establishment of the ventilation in a mine or section of a mine should not be done until the effect of such change is known.

DEFINITIONS

To further assist in standardizing mine rescue procedure, the following definitions and practices will be followed:

1. The sign "Smoke & Trace of CO" means a maximum of 0.01 per cent CO, and thus no mask is required.

2. The signs "Smoke & CO"; "Heavy Smoke & CO"; and "Dense

Smoke & CO" indicate a dangerous atmosphere but containing at least 16 per cent O_2, and necessitating the use of the Type "N" mask or self-rescuer.

3. Safety lamp must be extinguished and re-lit at the specific signs.

4. Safety lamp should be extinguished when the CH_4 percentage in the air exceeds 2 1/2 per cent.

5. Stoppings (Plank) shall not be broken unless it is deemed necessary.

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Ministry of
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