ENGINEERING STANDARD

FOR

APPLICATION OF BREATHING APPARATUS

IN SAFETY AND FIRE FIGHTING

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0. INTRODUCTION

This Standard is designed to assist in the selection of respiratory protective devices for use against atmospheric contaminants. Atmospheres can be contaminated by dust, or by gas, or deficient in oxygen. These hazards will occur singly or in any combination. The meaning of dust is taken to include mist and fume, and of gas to include vapor. Each contaminant can have special characteristics of its own which require protection in addition to this standard. For instance, radioactive or corrosive require the wearing of special clothing. Some gases, liquids and soluble solids absorb through the skin and these shall also require special protection.

Contaminated atmospheres are described generally as nuisance atmospheres which are not toxic or immediately dangerous to health; hazardous atmospheres which are of low toxicity or cause easily reversible biological changes; dangerous atmospheres of a high toxicity or where the health hazards are more severe; and atmospheres immediately dangerous to life.

Respiratory protective devices shall either filter the contaminated atmosphere to produce air suitable for respiration, or supply such air from an alternative source.

The air is supplied to the breathing area (the nose and mouth of the wearer) by one of the following: a mouthpiece and noseclip; a half-mask covering the nose and mouth; a full facepiece covering the eyes, nose and mouth; a hood covering the head down to the shoulders; or a blouse covering the head and body down to waist and wrists.

In this standard, for each type of respiratory protective device a nominal protection factor has been given.

This factor is explained fully in Appendix 1, and it is a guide to the effectiveness of the device when used correctly. It indicates the degree by which the atmospheric contaminant is reduced by the respirator within the breathing zone. Thus, a device which reduces the level of contamination ten times will have a nominal protection factor of 10, whilst one which reduces it one thousand times will have a nominal protection factor of 1000. These figures should be used in conjunction with the maximum allowable concentration, or threshold limit value, of the contaminant and its actual concentration in the atmosphere. Generally, a substance with a threshold limit value of 10 parts per million, which has a concentration of 1000 parts per million in the atmosphere, will require the use of equipment with a nominal protection factor of at least 100. Further examples are given in the Appendix 1 together with a list of respirators and their nominal protection factors.

1. SCOPE

The scope of this Standard includes minimum requirements for protection of the respiratory system from inhalation of particulate matter, noxious gases and vapors, and oxygen deficiency. The factors affecting the choice of such equipment will be discussed which make it possible for the selection and their use.

Items covered are:

a) Respirators for dusts, gases and gases with dusts;
b) Breathing apparatus self-contained closed and open circuits;
c) Airline, fresh air and compressed types;
d) Dust hoods and blouses (positive pressure, powered);
e) Underwater breathing apparatus;
f) Ventilatory resuscitators.

2. SOURCES AND REFERENCES

2.1 Sources

In preparation of this Standard in addition to the reference codes and standards mentioned in 2.2. the following standards and publication have also been considered:

BSI (BRITISH STANDARD INSTITUTION)

BS 2091	"Respirators for Protection against Harmful dusts and Gases"
BS 4001 Part 1	"Recommendations for the Compressed Air Open Circuit Type"
BS 4275	"The Selection, use and Maintenance of respiratory Protective Equipment"
BS 4555	"High Efficiency Dust Respirators"
BS 4558	"Positive Pressure, Powered Dust Respirators"
BS 4771	"Positive Pressure, Powered Dust Hoods and Blouses"
BS 4667 Parts 1 and 2	"B.A. Compressed Air Open and Closed Circuit Type"

ANSI (AMERICAN NATIONAL STANDARDS INSTITUTE)

Z.88.2	"Practices for Respiratory Protection for the Fire Service"
Z.88.5	"Practices for Respiratory Protection for the Fire Service"

ISO (INTERNATIONAL ORGANIZATION FOR STANDARDIZATION)

8382	"Resuscitators Intended for use with Humans"

2.2 References

Throughout this Standard the following standards and codes are referred to. The addition of these Standards and codes that are in effect at the time of publication of this Standard shall, to the extent specified herein, form a part of this Standard. The applicability of changes in standards and codes that occur after the date of this Standard shall be mutually agreed upon by the Company and the Vendor.

Certified authorities:

UL (UNDERWRITER LABORATORY)

MSHA (MINE SAFETY AND HEALTH ADMINISTRATION)

HSE (HEALTH SAFETY EXECUTIVE)

ISO (INTERNATIONAL ORGANIZATION FOR STANDARDIZATION)

A-5.14 Annex (c)

IPS (IRANIAN PETROLEUM STANDARD)

IPS-E-GN-100 Units

AHA (AMERICAN HEART ASSOCIATION)

AHA Standards for CPR and ECC:
JAMA June 6 Vol. 25, #1

3. DEFINITIONS AND TERMINOLOGY

3.1 Airway

Passageway for gas into and out of the lungs.

3.2 Automatic Resuscitator

Resuscitator in which the cyclic flow of gas for inflation of the lungs is independent of any inspiratory effort of the patient or repetitive action of the operator.

3.3 Bag Inlet Valve

Valve activated by the sub-atmospheric pressure in the compressible unit of the resuscitator to refill the compressible unit with gas at ambient pressure.

3.4 Bag Refill Valve

3.5 Valve, with no manual trigger, activated by the sub-atmospheric pressure in the compressible unit of the resuscitator to refill the compressible unit from a compressed gas source.

3.6 Back Leak

Volume of expired gas which does not pass through the expiratory port but returns to the resuscitator.

3.7 Blouse

A garment covering the upper part of the body from the head to the waist, and the arms to the wrist to which air suitable for respiration is supplied.

3.8 Canister

A container of materials which will remove certain contaminants in the air passing through them.

3.9 Cartridge

A small, sealed, replaceable unit containing materials, which will remove certain contaminants in the air passing through them.

3.10 Closed-circuit Apparatus

An apparatus in which the exhaled air is rebreathed by the wearer after the carbon dioxide has been removed and a suitable oxygen concentration restored.

3.11 Delivered Oxygen Concentration

Average concentration of oxygen in the gas delivered from the resuscitator.

3.12 Demand Valve

A device fitted in a breathing apparatus whereby the wearer receives air on demand from an air supply.

3.13 Exhalation Valve

A non-return valve to release exhaled air.

3.14 Expiratory Port

Opening through which gases and/or vapors pass from the patient during expiration.

3.15 Eyepiece

A gas-tight, transparent window(s) or lens(es) in a full facepiece through which the wearer can see.

3.16 Forward Leak

Volume of gas produced by the resuscitator during the inspiratory phase which does not pass through the patient port to the patient but passes to the atmosphere.

3.17 Head Harness

An arrangement of straps for holding a facepiece or mouthpiece securely in place.

3.18 Helmet

A device that shields the eyes, face, neck, and other parts of the head.

3.19 Hood

A device that completely covers the head, neck, and portions of the shoulders.

3.20 Particulate Matter

A suspension of fine solid or liquid particles in air, such as dust, fog, fume, mist, smoke or sprays. Particulate matter suspended in air is commonly known as an aerosol.

3.21 Respirator

A device designed to protect the wearer from inhalation of harmful atmospheres.

3.22 Self-contained Breathing Apparatus (SCBA)

A portable device that includes the supply of respirable breathing gas for the fire fighters.

3.23 Speaking Diaphragm

A device integral with the face-piece designed to improve direct voice communication.

3.24 Ventilatory Frequency, f

Number of ventilatory cycles per minute.

4. UNITS

International System of Units (SI) in accordance with IPS-E-GN-100 shall be used.

5. GENERAL REQUIREMENTS

5.1 The following requirements should be considered in subsequent sections of this standard.

In the control of those occupational diseases caused by breathing air contaminated with harmful dusts, fogs, fumes, mists, gases, smokes, sprays, or vapors, the primary objective shall be to prevent atmospheric contamination. This shall be accomplished as far as feasible by accepted engineering control measures (for example, enclosure or confinement of the operation, general and local ventilation, and substitution of less toxic materials). When effective engineering controls are not feasible, or while they are being instituted, appropriate B.A.* shall be used.

5.2 Employer Responsibility

5.2.1 Respirators shall be provided by the employer when such equipment is necessary to protect the health of the employee.

5.2.2 The employer shall provide the respirators which are applicable and suitable for the purpose intended.

5.2.3 The employer shall be responsible for the establishment and maintenance of a respiratory protective program which shall include the general requirements outlined in 5.4.

5.3 Employee Responsibility

5.3.1 The employee shall use the provided respiratory protection in accordance with instructions and training received.

5.3.2 The employee shall guard against damage to the respirator.

5.3.3 The employee shall report any malfunction of the respirator to the responsible person.

5.4 Minimal Acceptable Program

5.4.1 Standard operating instructions governing the selection and use of respirators shall be observed.

5.4.2 Respirators shall be selected on the basis of hazards to which the worker is exposed.

5.4.3 The user shall be instructed and trained in the proper use of respirators and their limitations.

5.4.4 All types of B.A.'s shall be regularly cleaned and disinfected. Those issued for the exclusive use of one employee should be cleaned after each day's use, or more often if necessary. Those used by more than one employee shall be thoroughly cleaned and disinfected after each use.

5.4.5 Appropriate surveillance of work area conditions and degree of employee exposure or stress shall be maintained.

5.4.6 There shall be regular check up and evaluation to determine the continued effectiveness of the program.

6. PROGRAM ADMINISTRATIONS

The plant or company industrial hygiene, health physics, safety engineering, or fire department shall administer the program in close liaison with the plant medical department. Responsibility for the program shall be vested in one individual.

In small plants having no formal industrial hygiene, health physics, safety, fire, or medical department, the respirator program shall be administered by an upper-level superintendent, foreman, or other qualified individual responsible to the principal manager.

The administrator shall have sufficient knowledge of the subject to properly supervise the program.

*** B.A. : Breathing Apparatus.**

7. MEDICAL LIMITATIONS

A fire fighter shall be assigned to tasks requiring use of respiratory protective devices only if it has been determined that he is able to perform these tasks while using the device(s). Fire fighters with punctured eardrums shall wear earplugs. The designated physician shall determine what health, physical, and psychological conditions are pertinent. The fire fighter's medical status pertaining to use of respiratory protective devices shall be reviewed at least annually.

8. COMMUNICATION

8.1 Although full facepieces distort the human voice to some extent, the exhalation valve usually provides a pathway for speech transmission over short distances. Also, most types of full facepieces are available with speaking diaphragms, which afford better speech intelligibility. In addition, there are a variety of electronic communication units which utilize a microphone inside the full facepiece, connected directly to an amplifier and speaker, to a telephone, or to a radio transmitter. Connecting cables from microphones pass through the facepiece. If the cables are removed for any reason, they shall be carefully replaced or the resultant hole in the facepiece shall be carefully sealed.

9. USE

9.1 Use of Unapproved Respiratory Protective Devices

Unapproved self-contained breathing devices are a risk and shall not be purchased or used.

9.2 Use in Low Temperatures

Major problems in the use of full facepieces at low temperatures are poor visibility and freezing of exhalation valves. All full facepieces should be designed so that the incoming fresh air sweeps over the inside of the eyepieces to reduce misting.

Anti-mist compounds shall be used to coat the inside of eyepieces to reduce misting at room temperatures and down to temperatures approaching 0°C.

Full facepieces are available with inner masks that direct moist exhaled air through the exhalation valves, and when properly fitted are likely to provide adequate visibility at low temperatures.

At very low temperatures the exhalation valve collects moisture and freeze open allowing the wearer to breathe contaminated air, or freeze closed, preventing normal exhalation. Dry air suitable for respiration should be used with self-contained and compressed air line breathing apparatus at low temperatures. The dew-point of the breathed gas should be appropriate to the ambient temperature.

High pressure connections on self-contained breathing apparatus will leak because of metal contraction at low temperatures but the only penalty is likely to be an outward leakage.

9.3 Use in High Temperatures

A man working in areas of high ambient or radiant temperatures is under stress and any additional stress caused by the use of respiratory protective devices should be minimized. This can be done by using devices having a low weight and low breathing resistance. Supplied air respirators and hoods and blouses, having an adequate supply of cool breathing air shall be used.

10. SELECTION OF RESPIRATORY PROTECTIVE EQUIPMENT

10.1 General Considerations

The multiplicity of hazards that may exist in a given operation requires careful evaluation followed by intelligent selection of protective equipment. This selection is made even more complex by the many types of equipment available, each having its limitations, areas of application and operational and maintenance requirements.

Fig. 1 present a brief description and guide to the selection of the various protective devices.

The selection of correct respiratory protection equipment for any given situation requires consideration of the nature of the hazard, the severity of the hazard, work requirements and conditions, and the characteristics and limitations of available equipment. Where there is any doubt about the suitability of respirator, breathing apparatus should be used. Particular care is necessary in the case of odorless gases or fumes as these do not give a warning of their presence

Some respirators and breathing apparatus deliver air to the user at pressures slightly above ambient pressures.

These can provide greater protection since any gas flow through leaks in the system will be outwards. For this to be so, however, the pressure bias needs to be sufficient to ensure that the pressure within the mouth and nose remains positive throughout the respiratory cycle. In the case of breathing apparatus, should the leak rate be excessive, the duration will be reduced.

Since the reductions in pressure on inhalation depend upon respiratory resistance, the performance of positive pressure devices should always be checked with all resistances to respiration attached.

10.2 Severity and Location of the Hazard

10.2.1 Only protective devices that arrange for the provision of an independent atmosphere suitable for respiration are appropriate for use in oxygen deficient atmospheres and self-contained, air line, or fresh air hose apparatus should be used.

10.2.2 The concentration of the contaminant and its physical location should be considered and account should also be taken of the length of time for which protection will be needed, entry and exit times, accessibility of a supply of air suitable for respiration, and the ability to use air lines or move about freely while wearing the protective device.

10.2.3 Where flammable or explosive atmospheres shall arise, the equipment should be suitable for use in such circumstances.

10.3 Nature of the Hazard

The chemical and physical properties, toxicity, and concentration of the hazardous materials shall be considered in the selection of respiratory protective devices (see Section 13 for classification and discussion of respiratory hazards).

10.3.1 Immediately dangerous atmospheres

It shall be assumed that atmospheres immediately dangerous to life or health-either oxygen-deficient or containing high concentrations of dangerous gases and vapors will be encountered by the fire fighter.

10.3.2 Oxygen-deficient atmospheres

Self-contained breathing apparatus of suitable service time shall be used where oxygen deficiency exists or may exist.

10.3.3 Unusual hazards

Unusual factors can add new dimensions to a hazardous situation and should be anticipated in selecting respiratory protective devices. Some examples are provided in 10.3.4 and 10.3.5.

10.3.4 Absorption through, or irritation of, the skin

Some airborne contaminants are extremely irritating to the skin (for example, ammonia and hydrochloric acid) while others are capable of being absorbed through the skin and into the bloodstream with serious, possibly fatal results.

Hydrocyanic-acid gas and many of the organic-phosphate pesticides, such as thiophosphate insecticides and tetraethyl pyrophosphate (TEPP), will penetrate the unbroken skin. The respiratory protective device will not afford complete protection against these contaminants. If such materials are encountered, an effective full body-covering suit of impermeable material shall be worn with appropriate respiratory protection (see table 4).

10.3.5 Ionizing radiation of skin and whole body

The respiratory protective device will not protect the skin or whole body against ionizing radiation from airborne concentrations of certain radioactive materials.

11. STORAGE

Respiratory protective devices shall be stored in the original carrying or storage case or in a wall or apparatus rack specially designed for quick removal and for protection of the breathing apparatus. Breathing apparatus of the demand type shall be stored with the main line regulator valve open, and the main cylinder valve and regular bypass valve closed.

The facepieces of all devices shall be positioned carefully to avoid distortion of rubber parts during storage.

Head-harness straps should be fully extended.

12. SPECIAL PROBLEMS

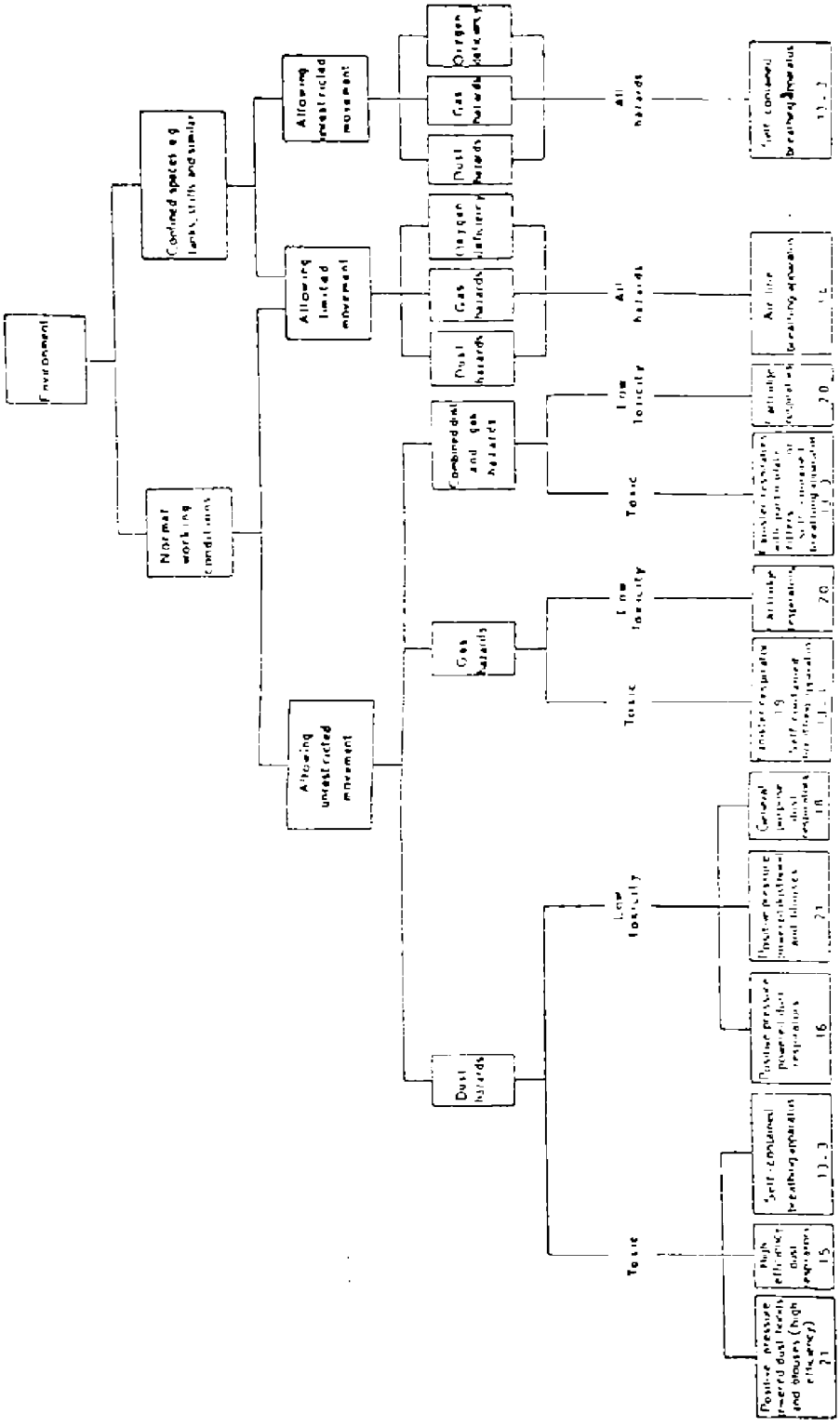
12.1 Corrective Lens with Full Facepiece

Providing respiratory protection for individuals wearing corrective glasses is a serious problem. A proper seal cannot be established if the temple bars of eye glasses extend through the sealing edge of the full facepiece. As a temporary measure, glasses with short temple bars or without temple bars may be taped to the wearer's head. Wearing of contact lenses in contaminated atmospheres with a respirator shall not be allowed.

Systems have been developed for mounting corrective lenses inside full facepieces. When a workman must wear corrective lenses as part of the facepiece, the facepiece and lenses shall be fitted by qualified individuals to provide good vision, comfort, and a gastight seal.

12.2 Eyewear with Half-Mask Facepiece

If corrective spectacles or goggles are required, they shall be worn so as not to affect the fit of the facepiece. Proper selection of equipment will minimize or avoid this problem.



The figures refer to clause numbers in the content of standards.

SELECTION OF RESPIRATORY PROTECTIVE EQUIPMENT
Fig. 1

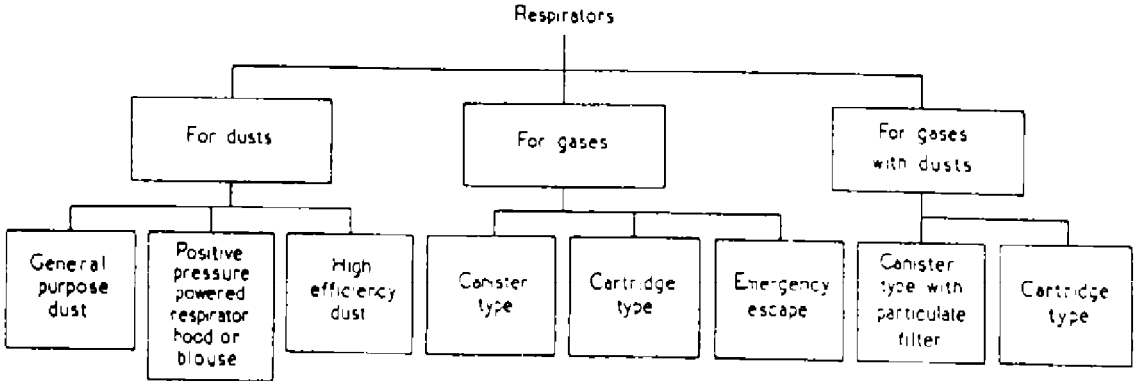
13. CLASSIFICATION OF RESPIRATORY PROTECTIVE EQUIPMENT

There are two distinct methods of providing personal protection against contaminated atmospheres.

13.1 By Purifying the Air Breated

The inhaled air is drawn through a medium that removes the harmful substances, the nature of the medium depending on the contaminating agent. Devices that achieve this are known as respirators.

The different types of respirators are represented below.



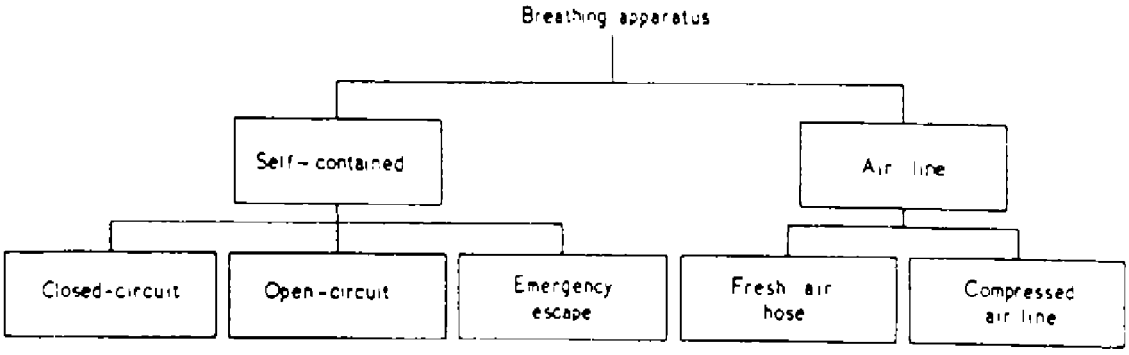
Note:

In addition to dust respirators, other devices are available which consist of a filtering medium held to the nose and mouth by simple means to remove coarse nuisance dusts from the inhaled air. They should never be used in the presence of harmful or toxic dusts.

13.2 By Supplying Air or Oxygen from an Uncontaminated Source

The inhaled air is conveyed by air line, or alternatively, air or oxygen is supplied from cylinders or other containers carried by the person at risk. Devices that achieve this are known as breathing apparatus.

The main types of breathing apparatus are represented below.



Note:

The description of standards of respirators and breathing apparatus are given in Table 1.

TABLE 1 - DESCRIPTION OF RESPIRATORS AND BREATHING APPARATUS ATMOSPHERE-SUPPLYING RESPIRATORS

A respirable atmosphere independent of the ambient air is supplied to the wearer.

Self-Contained Breathing Apparatus (SCBA)

Supply of air, oxygen, or oxygen-generating material carried by wearer. Normally equipped with full facepiece, but some with a mouthpiece for escape purposes.

1) Closed-Circuit SCBA (oxygen only)

a) Compressed or liquid oxygen type

High-pressure O_2 from a gas cylinder passes through a high-pressure reducing valve and, in some designs, through a low-pressure admission valve to a breathing bag or container. Liquid oxygen is converted to a low pressure gaseous oxygen and delivered to the breathing bag. The wearer inhales from the bag through a corrugated tube connected to a mouthpiece or facepiece and a one-way check valve. Exhaled air passes through another check valve and tube into a container of carbon dioxide removing chemical and re-enters the breathing bag. Make up O_2 enters the bag continuously or as the bag deflates sufficiently to actuate an admission valve. A pressure relief system is provided and a manual bypass system and saliva trap is also provided depending upon the design.

b) Oxygen-generating type

Water vapor in the exhaled breath reacts with chemical in the canister to release O_2 to the breathing bag. The wearer inhales from the bag through a corrugated tube and one-way check valve at the facepiece. Exhaled air passes through a second check valve breathing tube assembly into the canister. The O_2 release rate is governed by the volume of exhaled air. CO_2 is removed by the canister fill.

2) Open-Circuit SCBA (compressed air, compressed oxygen, liquid air, or liquid oxygen)

a) Demand type (see note 1)

The demand valve permits oxygen or air flow only during inhalation. Exhaled breath passes to ambient atmosphere through a valve(s) in the facepiece. A bypass system is provided in case of regulator failure except on escape-type units.

b) Pressure-demand type (see note 2)

Equipped with full facepiece only. Positive pressure is maintained in the facepiece at all times. The wearer usually has the option of selecting the demand or pressure-demand mode of operation.

Hose Mask and Air-Line Respirator

1) Hose Mask

Equipped with full facepiece, nonkinking breathing tube, rugged safety harness and a large diameter heavy-duty nonkinking air supply hose. The breathing tube and hose are securely attached to the harness.

A check valve allows airflow only toward the facepiece. The facepiece is fitted with an exhalation valve. The harness has provision for attaching a safety line.

a) Hose mask with blower

Air is supplied by a motor-driven or hand-operated blower.

b) Hose mask without blower

The wearer provides motivating force to pull air through the hose. The hose inlet is anchored and fitted with a funnel or like object covered with a fine mesh screen to prevent entrance of coarse particulate matter. Up to 23 m of hose length is permissible.

2) Air-Line Respirator

Respirable air is supplied through a small-diameter air-line from a compressor or compressed air cylinders.

The airline is attached to the wearer by belt and can be detached rapidly in an emergency. A flow-control valve or orifice is provided to govern the rate of airflow to the wearer. Exhaled air passes to the ambient atmosphere through a valve(s) or opening in the enclosure (facepiece, hood, suit). Upto 76 m. of air-line is permissible.

a) Continuous-flow of air

Equipped with a half-mask or full facepiece, or a helmet (abrasive blasting) or hood covering the wearer's head and neck. At least four cubic feet of air per minute to tight-fitting facepieces and six cubic feet per minute to loose-fitting hoods and helmets shall be required.

b) Demand type (see note 1)

Equipped with a half mask or full facepiece. The demand valve permits flow of air only during inhalation.

c) Pressure-demand type (see note 2)

Equipped with a half-mask or full facepiece. A positive pressure is maintained in the facepiece at all times.

3) Supplied Air Suit

A form of continuous air-line respirator (see air-line respirator above). The suit is one or two piece and of leak-resistant material. Air is supplied to the suit through a system of internal tubes to the head, trunk, and extremities. Air exhausts through valves located in appropriate parts of the suit.

Combination Self-Contained and Air-Line Respirators

Normally a demand or pressure-demand type air-line respirator with full or half-mask facepiece, together with a small compressed-air cylinder to provide air if the normal supply fails. Wearer immediately returns to a respirable atmosphere if the normal air supply fails.

Notes:

1) Equipped with a demand valve that is activated on initiation of inhalation and permits the flow of breathing atmosphere to the facepiece. On exhalation, pressure in the facepiece becomes positive and the demand valve is deactivated.

2) A small positive pressure is maintained at all times in the facepiece by a spring-loaded or balanced regulator and exhalation valve.

AIR-PURIFYING RESPIRATORS

Half-mask, full facepiece, or mouthpiece respirator equipped with air-purifying units to remove gases, vapors, and particulate matter from the ambient air prior to its inhalation. Some air-purifying respirators are blower-operated and provide respirable air to the facepiece (or hood) under a slight positive pressure.

Gas and Vapor-Removing Respirators

Packed sorbent beds (cartridge or canister) remove single gases or vapors (for example, chlorine gas), a single class of gases or vapors (for example, organic vapors) or a combination of two or more classes of gases and vapors (for example, acid gases, organic vapors, ammonia, and carbon monoxide) by absorption, adsorption, chemical reaction or catalysis or a combination of these methods.

1) Full Facepiece Respirator (Gas Mask)

Equipped with a single large chin canister or harness mounted canister with breathing tube and inhalation and exhalation valves. Canisters come in the "super" size, "industrial" size (regular), and chin style. The service life is approximately proportional to the canister size for a given type of canister.

Canisters are marked in bold letters with the contaminant against which they protect and are color coded for quick identification.

The maximum concentration in which the canister can be safely used is indicated on the label.

2) Half-Mask Respirator (Chemical-Cartridge Respirator)

Equipped with one or more cartridge and exhalation and inhalation valves.

3) Mouthpiece Respirator

A compact device designed for quick application when the atmosphere unexpectedly is contaminated with a hazardous material. Normally consists of a housing with a mouthpiece and a single cartridge, a nose clamp, exhalation and inhalation valves, and a neckband.

Particulate-Removing Respirators

Filter media in pads, cartridges, or canisters remove dust, fog, fume, mist, smoke or spray particles. Filters are designed to remove a single type of particle (silica dust) or classes of particles (dust and fumes).

Filters may be replaceable or a permanent part of the respirator. Some filters can be used only once; others are reusable and should be cleaned according to the manufacturer’s instructions.

1) Full Facepiece Respirator

Normally equipped with a high-efficiency filter canister designed to protect against hazardous particulates. Equipped with inhalation and exhalation valves.

2) Half-Mask Respirator

Normally equipped with one or two dust, mist or fume filters designed to protect against nuisance and low to moderate toxicity dusts, fumes, and mists, an exhalation valves. A knitted fabric cover is sometimes worn on dust respirators to decrease discomfort.

3) Mouthpiece Respirator

Infrequently used as a particulate respirator. (See Mouthpiece Respirator, Gas and Vapor-Removing, in item 3 page 18).

Combination Gas, Vapor, and particulate-Removing Respirators

Some canisters and cartridges contain both filters and sorbents to provide protection against contaminants. Some filters are designed to be attached to a sorbent cartridge as a pre-filter (for example, for paint spray operation).

Combination Atmosphere-Supplying and Air-Purifying Respirators

These provide the wearer the option of using either of two different modes of operation. They may be an airline respirator with an airpurifying attachment to provide protection in the event the air supply fails or an air-purifying respirator with a small air cylinder in case the atmosphere unexpectedly exceeds safe conditions for use of an air-purifying respirator.

TABLE 2 - COVERS CAPABILITIES AND LIMITATIONS OF RESPIRATORS ARRANGED TO CORRESPOND TO THE SUBJECT HEADING IN TABLE 1

ATMOSPHERE-SUPPLYING RESPIRATORS

Atmosphere-supplying respirators provide against oxygen deficiency and most toxic atmospheres. The breathing atmosphere is independent of ambient atmospheric conditions.

General Limitations: Except for the supplied-air suit no protection is provided against skin irritation by materials such as Ammonia and HCL, or against sorption of materials such as HCN, tritium, or organic phosphate pesticides through the skin. Facepieces present special problems to individuals required to wear prescription lenses.

Self-Contained Breathing Apparatus (SCBA)

The wearer carries his own breathing atmosphere. Use is permissible in atmospheres immediately dangerous to life or health.

Limitation: The period over which the device will provide protection is limited by the amount of air or oxygen in the apparatus, the ambient atmospheric pressure (service life is cut in half by a doubling of the atmospheric pressure), and work load. A warning device shall be provided to indicate to the wearer when the service life has been reduced to a low level. Some SCBA devices have a short service life (few minutes) and are suitable only for escape (self-rescue) from an irrespirable atmosphere. Chief limitations of SCBA devices are their weight or bulk or both, limited service life, and the training required for their maintenance and safe use.

1) Closed-circuit SCBA

The closed circuit operation conserves oxygen and permits longer service life.

2) Open-circuit SCBA-demand and Pressure-demand

The demand type produces a negative pressure in the facepiece on inhalation whereas the pressure-demand type maintains a positive pressure in the facepiece and is less apt to permit inward leakage of contaminants.

Hose Mask or Air-line Respirator

The respirable air supply is not limited to the quantity the individual can carry, and the devices are light weight and simple.

Limitations: The wearer is restricted in movement by the hose or airline and must return to a respirable atmosphere by retracing his route of entry. The hose or air-line is subject to being severed or pinched off.

1) Hose Mask

a) Hose mask with blower

If the blower fails, the unit still provides protection, although a negative pressure exists in the facepiece during inhalation. Use is permissible in atmospheres immediately dangerous to life or health.

b) Hose mask without blower

Limited to use in atmospheres from which the wearer can escape unharmed without aid of the respirator.

2) Air-Line Respirators (Continuous-Flow, Demand and Pressure-Demand Types)

The demand type produces a negative pressure in the facepiece on inhalation whereas continuous flow and pressure-demand types maintain a positive pressure in the facepiece at all times and are less apt to permit inward leakage of contaminants.

Limitation: Air-line respirators are limited to use in atmospheres not immediately dangerous to life or health. Air-line respirators provide no protection if the air supply fails.

3) Supplied-Air Suit

These suits protect against atmospheres that affect the skin or mucous membranes or is absorbed through the unbroken skin.

Limitations: Some contaminants, such as tritium, shall penetrate the suit material and limit its effectiveness. Other contaminants, such as fluorine, shall react chemically with the suit material and damage it.

These suits are limited in use to atmospheres not immediately dangerous to life or health.

Combination Self-Contained and Air-Line Respirators

The equipping of an air-line respirator with a small cylinder of compressed air to provide an emergency air supply qualifies the respirator for use in immediately dangerous atmospheres.

AIR-PURIFYING RESPIRATION

General Limitations: Air-purifying respirators do not protect against oxygen-deficient atmospheres nor against skin irritation by, or sorption through the skin of, airborne contaminants.

The maximum contaminant concentration against which an air purifying respirator will protect is determined by the designed efficiency and capacity of the cartridge, canister, or filter. For gases and vapors and for particles having a TLV of less than 0.1 mg/m^3, the maximum concentration for which the air purifying unit is designed is specified on the label. Respirators without a blower to maintain a constant positive pressure within the facepiece will not provide the maximum design protection specified unless the facepiece is carefully fitted to the wearer's face to prevent inward leakage. The time period over which protection is provided is dependent on canister, cartridge, or filter type, concentration of contaminant, and the wearer's respiratory rate.

The proper type of canister, cartridge or filter shall be selected for the particular atmosphere and conditions. Air-purifying respirators generally cause discomfort and objectionable resistance to breathing although these problems are minimized in blower-operated units. Respirator facepieces present special problems to individuals required to wear prescription lenses. These devices do have the advantage of being small, light, and simple in operation.

Gas and Vapor-Removing Respirators

Additional Limitations: No protection is provided against particulate contaminants, unless specified on canister or cartridge label. A rise in canister or cartridge temperature indicate that a gas or vapor is being removed from the inspired air. This is not a reliable indicator of canister performance. An uncomfortably high temperature indicates a high concentration of gas or vapor and requires an immediate return to fresh air.

1) Full Facepiece Respirator (Gas Mask)

Should avoid use in atmospheres immediately dangerous to life or health if the contaminant(s) lacks sufficient warning properties (that is, odor or irritation).

2) Half-Mask Respirator (Chemical-Cartridge Respirator)

Shall not use in atmospheres immediately dangerous to life or health and should be limited to low concentrations of gases and vapors.

A fabric covering shall not be worn on the facepiece since it will permit gases and vapors to pass.

No protection is provided to the eyes.

3) Mouthpiece Respirator (Chemical Cartridge)

Shall not be used in atmospheres immediately dangerous to life or health. Mouth breathing prevents detection of contaminants by odor. The nose clip shall be securely in place to prevent nasal breathing

No protection is provided to the eyes.

4) Self-Rescue Mouthpiece Respirator

Designed for self-rescue from immediately dangerous atmospheres of gases and vapors. Mouth breathing prevents detection of contaminants by odor. The nose clip shall be securely in place to prevent nasal breathing.

No protection is provided to the eyes.

Particulate-Removing Respirators

Additional Limitations: protect against non-volatile particles only. No protection against gases and vapors. The filter shall be replaced or cleaned when breathing becomes difficult due to plugging by retained particles. These respirators shall not be used during shot and sand blasting operations. Abrasive-blasting respirators shall be used.

1) Full Facepiece Respirator

Should avoid use in atmospheres immediately dangerous to life or health if the contaminant(s) lacks sufficient warning properties (that is, odor or irritation).

2) Half-Mask Respirator

Shall not be used in atmospheres immediately dangerous to life or health.

A fabric covering on the facepiece is permissible only in atmospheres of coarse dusts and mists of low toxicity.

No protection is provided to the eyes.

3) Mouthpiece Respirator (Filter)

Shall not be used in atmospheres immediately dangerous to life or health. Mouth breathing prevents detection of contaminants by odor. The nose clip shall be securely in place to prevent nasal breathing.

No protection is provided to the eyes from irritating aerosols.

4) Self-Rescue Mouthpiece Respirator (Filter)

Designed for self-rescue from atmosphere having immediately dangerous concentrations of toxic particles. Mouth breathing prevents detection of contaminants by odor. The nose clip shall be securely in place to prevent nasal breathing.

No protection is provided to the eyes from irritating aerosols.

Combination Particulate and Vapor and Gas-Removing Respirators

The advantages and disadvantages of the component parts of the combination respirator as described above will apply.

Combination Atmosphere-Supplying and Air-Purifying Respirator

The advantages and disadvantages, expressed above, of the mode of operation being used will govern. The mode with the greater limitations (air-purifying mode) will mainly determine the overall capabilities and limitations of the respirator since the wearer may for some reason fail to change the mode of operations even though conditions would require such change.

13.3 Self-Contained Breathing Apparatus (SCBA)

13.3.1 The following standards shall be considered in the use of breathing apparatus.

13.3.1.1 SCBA shall be certified by the recognized organization such as U. L. Mine Safety and Health Administration (MSHA), International Organization for Standardization (ISO) and HSE (Health Safety Executive) or any other organization approved by the I. P. I.

13.3.1.2 Since additional weight can reduce the fire fighter's ability to carry out assigned tasks, weight reduction is a prime concern. SCBAs shall be rated 30-minute duration, the predominant SCBA used by the fire service, should be

limited to a maximum composite weight of 11.4 kg. Purchasers are advised to specifically address weight in their purchase specifications regardless of the rated service time.

13.3.1.3 There are requirements in many standards and regulations covering the quality of air to be used in SCBA. However, it is most important to remind the user that the quality of the air in the cylinder is of great concern, and that it should have a dew point compatible with the ambient temperature to be encountered.

13.3.1.4 SCBA that is certified by the recognized organizations as positive pressure but capable of supplying air to the user in a negative pressure, demand-type mode may not meet the requirements of this standard.

13.3.1.5 The SCBA manufacturer shall provide, with each SCBA, instructions and information for maintenance, cleaning, disinfecting, storage, and inspection.

13.3.1.6 The SCBA manufacturer shall provide, with each SCBA, specific instructions regarding the use, operation, and limitations of the SCBA, and training materials.

13.3.1.7 The use of self-contained breathing apparatus (SCBA) by fire fighter is always assumed to be in atmospheres immediately dangerous to life or health (IDLH). There is no way to predetermine hazardous conditions, concentrations of toxic materials, or percentages of oxygen in air in a fire environment, during overhaul (salvage) operations, or under other emergency conditions involving spills or releases of hazardous materials. Thus, SCBA are required at all times during any fire fighting, hazardous materials, or overhaul operations.

13.3.1.8 Although SCBA that meet this standard have been tested to more stringent requirements than required for NIOSH / MSHA approval, there is no inherent guarantee against SCBA failure or fire fighter injury.

Even the best-designed SCBA cannot compensate for either abuse or the lack of a respirator training and maintenance program. The severity of these tests should not encourage or condone abuse of SCBA in the field.

13.3.1.9 To assure proper utilization of equipment in actual situations, after training and instruction, it shall be for the users to gain confidence by actually using the SCBA in a series of tasks representing or approximating the physical demands likely to be encountered.

In addition to the degree of user exertion, other factors that may affect the service time of the SCBA include:

a) the physical condition of the user;

b) emotional conditions, such as fear or excitement, that may increase the user's breathing rate;

c) the degree of training or experience the user has had with such equipment;

d) whether or not the cylinder is fully charged at the beginning of use;

e) the facepiece fit;

f) use in a pressurized tunnel or caisson. At two atmospheres the duration will be one-half the duration obtained at one atmosphere; at three atmospheres, the duration will be one-third the duration obtained at one atmosphere;

g) the condition of the SCBA.

13.3.1.10 Compressed oxygen shall not be used in supplied-air respirators or in open-circuit self-contained breathing apparatus that have previously used compressed air. Compressed air might contain low concentrations of oil. When high-pressure oxygen passes through an oil or grease-coated orifice, an explosion or fire will occur.

Breathing air shall be supplied to respirators from cylinders or air compressors. Cylinders shall be tested and maintained in accordance with applicable standards.

Compressors shall be designed so as to avoid entry of contaminated air into the system and suitable in-line air purifying sorbent beds and filters installed to further assure breathing air quality.

A receiver of sufficient capacity to enable the respirator wearer to escape from a contaminated atmosphere in event of compressor failure, and alarms to indicate compressor failure and over-heating shall be installed in the system. Air-line coupling shall be incompatible with outlets for other gas systems to prevent inadvertent servicing of air-line respirators with nonrespirable gases or oxygen.

13.3.2 Open circuit escape B. A.

13.3.2.1 This section specifies requirements for the design, construction and performance of two types of open-circuit escape breathing apparatus using a source of compressed air. Type 1 is for use under hard work conditions such as walking up flights of stairs and running. Type 2 is for use under less arduous conditions such as walking on the level, walking down flights of stairs and climbing a few stairs.

Note :

Type 1 equipment is also suitable for type 2 applications.

The apparatus shall be designed and constructed to enable the wearer to breathe air on demand from a high pressure air cylinder or other approved container via either a lung-governed demand valve or another device that adequately controls the air supply and is connected to a facepiece, hood or mouthpiece. The exhaled air shall pass from the facepiece, hood or mouthpiece either via an exhalation valve or directly to the atmosphere.

13.3.2.2 Demand valve

Without positive pressure. The opening pressure of the lung-governed supply mechanism, measured at a constant air flow rate of 10 L/min., shall not exceed 3.5 mbar* at all cylinder pressures above 50 bar.

13.3.2.3 With positive pressure. The demand valve shall operate such that the minimum facepiece or hood cavity pressure shall be not less than 0 mbar at a sinusoidal air flow rate of 80 L/min (2.5 L tidal volume × 32 respirations per minute) at all cylinder pressures above 50 bar.

13.3.2.4 Duration

All apparatus shall have a rated duration of not less than 5 min.

*** (1 mbar= 100 N/m^2 = 100 pa.)**

Note:

A minute volume of 40 L is appropriate to the work rate of a man walking at a steady speed of 6.5 km/h for type 1 and a minute volume of 30 L is appropriate to the work rate of a man walking at a steady speed of 5.5 km/h for type 2. In practice, the time for which protection is afforded shall be longer or shorter than the rated duration and will depend upon the work rate, stress level and physical characteristics of the wearer.

13.3.2.5 Condition of the inhaled air

a) oxygen content

When the apparatus is tested the oxygen content of the inhaled air shall not fall below 17% (by volume);

b) carbon dioxide content

The maximum carbon dioxide content of the inhaled air throughout the rated duration shall not exceed the value corresponding to the rated duration of the apparatus.

13.3.2.6 Resistance to breathing

a) without positive pressure

Neither the inspiratory side nor the expiratory side of the circuit shall have a dynamic resistance greater than 6 mbar;

b) with positive pressure

The expiratory side of the circuit shall have a dynamic resistance not greater than that indicated by a straight line jointing a value of 6 mbar at zero flow to a value of 9 mbar at a sinusoidal air flow rate of 80 L/min.

13.3.3 Closed-circuit escape breathing apparatus

13.3.3.1 This section specifies requirements for the design, construction and performance of two types of closed circuit escape breathing apparatus using a source of compressed oxygen or chemically bound oxygen.

Type 1 is for use under hard work conditions such as walking up flights of stairs and running.

Type 2 is for use under less arduous conditions such as walking on level ground, walking down flights of stairs and climbing a few stairs.

Note :

Type 1 equipment is also suitable for type 2 applications.

The apparatus shall be designed and constructed so that exhaled air passes from a facepiece, hood or mouthpiece, into the breathing circuit where it is purified, fresh oxygen is added to the air and returned to the wearer via a breathing bag.

Notes:

1) In the compressed oxygen type chemicals in the canister absorb the exhaled carbon dioxide, and fresh oxygen is supplied to the breathing circuit.

2) In the chemical oxygen type chemicals in the canister react with the exhaled carbon dioxide and moisture to produce oxygen.

13.3.3.2 Rated duration

All apparatus shall have a rated duration of not less than 5 min using a breathing simulator set at a flow rate of 40 L/min for type 1 and 30 L/min for type 2 apparatus.

Note:

A minute volume of 40 L is appropriate to the work rate of a man walking at a steady speed of 6.5 km h for type 1 and a minute volume of 30 L is appropriate to the work rate of a man walking at a steady speed of 5.5 km/h for type 2. In practice, the time for which protections afforded shall be longer or shorter than the rated duration and will depend upon the work rate, stress level and the physical characteristics of the wearer.

13.3.3.3 Condition of the inhaled air

a) Oxygen content

When the apparatus is tested the oxygen content of the inhaled air shall not fall below 17% (by volume).

b) Carbon dioxide content

The maximum carbon dioxide content of the inhaled air throughout the rated duration shall not exceed the value corresponding to the rated duration of the apparatus.

13.3.3.4 Resistance to breathing

Neither the inspiratory side nor the expiratory side of the circuit shall have a dynamic resistance greater than 6.5 mbar.

14. FRESH AIR HOSE AND COMPRESSED AIR LINE BREATHING APPARATUS

14.1 This Standard covers types of fresh air hose and compressed air line breathing apparatus designed to enable a man to work in irrespirable or hazardous atmospheres for longer periods than are generally possible with closed-circuit types of breathing apparatus and open-circuit types of breathing apparatus. It does not deal with apparatus designed only for escape purposes.

For guidance on the type of respiratory protection that should be provided for particular conditions, and the provision of suitable air supplies for air line breathing apparatus, reference should be made to clause 10. In addition particular care should be taken in the choice of breathing apparatus itself, where such equipment is to be used in very high or very low ambient temperatures.

Certain toxic substances which may occur in some atmospheres can be absorbed by the skin. Where these do occur, respiratory protection alone is not sufficient and the whole body should be protected.

When this apparatus is being used in atmospheres immediately dangerous to life, a full facepiece should be worn.

For conditions of very heavy work a flow in excess of 120 1/min is desirable.

14.2 This type of apparatus includes:

14.2.1 Fresh air hose apparatus

a) without blower (short distance);
b) with hand blower;
c) with motor operated blower.

14.2.2 Compressed air line apparatus

a) constant flow type;
b) demand valve type.

14.3 General Requirement

14.3.1 Fresh air hose apparatus (without blower)

The apparatus consists of a full facepiece or mouthpiece with noseclip, with a valve system, connected by an air hose to uncontaminated air which is drawn through a hose of adequate diameter to enable a flow of 120 L/min. to be achieved by the breathing action of the wearer. The hose should not normally exceed 9 m in length.

14.3.2 Fresh air hose apparatus (with hand blower)

The apparatus consists of a full facepiece or mouthpiece with noseclip, with a valve system, by which uncontaminated air is forced through a hose of adequate diameter by a hand operated blower, at a minimum flow of 120 L/min., and

through which the wearer can inhale in an emergency whether or not the blower is operated. The hose should not exceed 36m in length.

14.3.3 Fresh air hose apparatus (with motor operated blower)

The apparatus consists of a full facepiece air hood or blouse or half-mask, with a valve system, by which uncontaminated air is forced through a hose of adequate diameter by a motor operated blower at a flow of not less than 120 L/min and through which the wearer can inhale in an emergency whether or not the blower is operated. The hose should not exceed 36 m in length.

14.3.4 Compressed air line apparatus (constant flow type)

The apparatus consists of a full facepiece, a half-mask or an air hood or blouse connected to a supply of breathable air fed continuously to the wearer. The air flow is regulated by a flow control valve from a source of compressed air.

An airline connects the wearer to a supply of fresh air which is fed to him at a flow of at least 120 L/min at the stated operating pressure.

14.4 Compressed Air Line Apparatus (Demand Valve Type)

14.4.1 The apparatus consists of a full facepiece connected to a demand valve that admits breathable air to the wearer when he inhales and closes when he exhales. An air line connects the wearer to a supply at compressed air. The air flow available to each wearer shall meet the requirements of demand valve. (Pressure between 345 KN/m^2 and 1035 KN/m^2).

14.5 Resistance To Breathing

14.5.1 With the air supply system working at any flow chosen by the testing authority but within its designed range of pressures and air flow, or with a blower operated in such a way that the operator would not become unduly fatigued after 30 min, or with the fresh air hose alone (if not supplied with blower or bellows), then with the maximum length of tube for which the apparatus has been submitted for approval, half of it coiled to an inside diameter of 500 mm, or, for compressed air apparatus, with half the maximum length of the air line coiled either on the drum supplied by the manufacturer or, if a drum is not supplied, on a drum not exceeding 300 mm in diameter neither the inspiratory nor the expiratory side of the apparatus shall have a dynamic resistance greater than 50 mm H_2O (1 mm H_2O = 10 N/M^2).

14.5.2 If any of the air supply systems detailed ceases to operate, the wearer shall still be able to inhale through the tube without undue distress. This provision shall be satisfied if the total inspiratory resistance, with the air supply system inoperative but not disconnected and with the maximum length of the tube for which the apparatus has been approved is not greater than 125 mm H_2O at a continuous air flow of 85 1/min.

14.6 Requirements for Fresh Air Hose Apparatus

14.6.1 Fresh air hose supply systems with blower

14.6.1.1 Hand operated blowers shall be capable of being operated by one man without undue fatigue for at least 30 min.

14.6.1.2 Rotary type blowers shall be capable of maintaining a positive air pressure with either direction of rotation, or else be made to operate in one direction only. In the former case the direction of operation in which the blower delivers the lesser volume of air against the designed working pressures shall be used in the tests.

When motor operated blowers are used where flammable surroundings shall arise it is essential that the suitability of the equipment for use in such surroundings be considered.

Note:

An air flow indicator should be the blower to indicate the flow rate.

14.6.2 Without blower

The hose shall be fitted with a strainer at the free end to exclude debris. Provision shall be made for securely anchoring the free end of the hose and strainer so that it cannot be dragged into the contaminated atmosphere.

14.7 Requirements for Compressed Air Line Apparatus

14.7.1 Compressed air line supply systems

14.7.1.1 The air supply should be in the range 138 kN/m^2 to 1035 kN/m^2, a pressure regulator being fitted if necessary.

14.7.1.2 When the supply of air is from high pressure cylinders the flow from a pressure regulator of constant flow type must remain constant to within 10% of the preset flow at all pressures above 1000 kN/m^2. The pressure regulator shall not be capable of adjustment without the use of tools.

In addition where the air is supplied from cylinders the apparatus shall be provided with an alarm signal on the high pressure side to indicate the approach of the exhaustion of the air supply. This device should not substantially deplete the remaining air supply.

14.7.1.3 Pressure gages shall be provided on the high and low pressure sides if cylinders are used.

15. HIGH EFFICIENCY DUST RESPIRATORS

15.1 General

This Standard covers respirators for use in areas where highly toxic particulate materials (including radioactive substances) are handled.

The best personal respiratory protection is provided by positive pressure, supplied-air equipment. In many cases, however, it is not reasonably practicable to use such equipment and high efficiency respirators provide an alternative form of protection.

These respirators have definite limitations and should be issued and fitted only by persons who are competent to do so and who are aware of the conditions surrounding their use. They afford no protection against oxygen deficiency.

When a respirator is used in an atmosphere containing radioactive particles these will necessarily be trapped in the filter and will themselves constitute a hazard and shall emit ionizing radiations that, over a period of time, could effectively reduce the protecting properties of the filter. In the absence of specialist advice a respirator should not be re-used in such conditions without changing the filter after each period of use and monitoring the inside of the facepiece. Since the health of the wearer depends upon the condition of the apparatus, it is essential that adequate provision is made for cleaning and maintenance as necessary, for regular examination, and for supervision to ensure proper storage and use.

15.2 Design

The design shall be such that the respirator provides protection against solid particles or, in certain cases, water-based mists, where no hazard from toxic gas or vapor exists. Respirators shall consist of a facepiece covering the eyes, nose, mouth and chin, held securely in position by a head harness, and connected in an airtight manner to.

15.2.1 A filter or filters through which the inhaled air passes. Filters shall be readily replaceable and shall be capable of being fitted without edge leakage or other loss of efficiency; they shall be encapsulated. For some applications it is desirable that readily replaceable pre-filters shall be available.

15.2.2 A valve system such that air inhaled by the wearer passes through the filter(s), and exhaled air passes direct to the surrounding atmosphere through a non-return valve.

The weight of the assembled respirator shall be as low as practicable and preferably symmetrically balanced to ensure the maximum retention of the face seal, and to minimize muscular strain particularly when worn in circumstances involving vigorous movement.

16. POSITIVE PRESSURE, POWERED DUST RESPIRATORS

16.1 General

This Standard has been prepared to meet situations in which the face seal leakage of typical half-masks and of some full face dust respirators is unacceptably high.

Positive pressure, powered dust respirators provide increased comfort and reduce the respiratory load to negligible proportions whilst providing an overall standard of protection equivalent to that specified in clause 15 'High efficiency dust respirators' (if high efficiency filters are used), or to clause 17, 'Respirators for use against harmful dusts and gases' (if standard filters are used).

This standard specifies two types of such respirators, one for use with high efficiency filters and giving a standard of performance equal to that of the high efficiency dust respirator dealt with in clause 15 and the other designed for use with standard filters and giving a standard of performance equal to that of the dust masks specified in clause 17.

Should the positive pressure supply fail, the degree of protection is reduced and the wearer should retire from the hazardous atmosphere as quickly as possible. These respirators should not be used in atmospheres immediately dangerous to life, and filters should be checked periodically for clogging.

Such devices afford no protection against oxygen deficiency. Respirators, moreover, have very definite limitations and should only be issued and fitted under the supervision of a competent person aware of the conditions in which they are to be used.

When determining the type of protection that should be provided for any particular conditions, reference should be made to clause 10 and 13.

This Standard is for a respirator comprising a mask supplied with filtered air from a power pack which provides protection in adverse environmental conditions (particulate hazards) while reducing the respiratory load.

16.2 Design

The design shall be such that the respirator provides protection against solid particles or, in certain cases, water-based mists, where no hazard from toxic gas or vapor exists. The respirator shall consist of:

16.2.1 A full facepiece covering the eyes, nose and mouth, or a half-mask covering the nose and mouth, held securely in position by a head-harness.

16.2.2 A power pack supplying filtered air directly to the facepiece by means of a flexible hose.

16.2.3 A filter(s) through which all the air supplied to the facepiece passes. Filters shall be readily replaceable and shall be capable of being fitted without edge leakage or other loss of efficiency. For some applications it is desirable that a readily replaceable pre-filter(s) shall be available.

16.2.4 A valve system such that both the exhaled and surplus air pass direct to the surrounding atmosphere through a non-return valve.

16.3 Power Pack

16.3.1 The power pack shall be capable of supplying air to the facepiece at a minimum rate of 120 liters / min (4.24 ft^3/min) for a period of 4 h without replacement of the power source.

16.3.2 If a rechargeable battery is used, it shall be possible to recharge it completely within 14 h and it shall be of the nonspillable type. Unless the battery is of a sealed type, a safe venting device shall be incorporated in the pack.

17. RESPIRATORS FOR PROTECTION AGAINST HARMFUL DUSTS AND GASES

17.1 General

This Standard deals with respirators for protection against harmful dusts and gases.

When determining the type of protection that should be provided for any particular conditions, reference should be made to clause 10 and 13.

Respirators afford no protection against oxygen deficiency and have very definite limitations, and should only be issued and fitted under the supervision of a competent person aware of the conditions surrounding their use.

Reference can be made to clause 15 for Standard covering respirators for use against highly toxic materials (including radioactive substances) in particulate form.

This Standard specifies for dust respirators giving protection against dusts and other particulate matter; it also specifies requirements for gas respirators (canister type) affording protection against the limited concentration of the gases listed in Tables 3 and 4, and gas respirators (cartridge type) providing protection against low concentrations of certain relatively non-toxic gases referred to in Table 5.

For the purposes of this standard the word ‘dust’ is taken to include other particulates such as mists and fumes, and the word ‘gas’ is taken to include vapour.

This standard does not cover mouthpiece type respirators for emergency escape, respirators for protection against radioactive and other highly toxic particulate materials.

17.2 Application

Every respirator shall comply with the general requirements and with the specific requirements of the particular section applicable to the respirator type as follows:

Dust respirators		clauses	15-16-17-18
Gas respirators,	canister type	clause	19
Gas respirators,	cartridge type	clause	20

18. DUST RESPIRATORS

18.1 General

This standard covers two types of dust respirator, Types A and B. Type A respirators are low resistance respirators in that the test requirements impose a maximum inhalation resistance of 2 mbar* (20 mm H_2O). They are intended for use against dusts of low toxicity in work conditions where low breathing resistance is important.

Type B are higher resistance respirators and the test requirements impose a maximum inhalation resistance of 3.2 mbar* (32 mm H_2O) they are required to be more efficient in stopping particles of fine dusts than are Type A respirators.

*** 1 mbar = 10^2 N/m^2**

18.2 Design

The design of dust respirators shall be such that they will provide protection against solid particles or, in certain cases, mists, where no toxic gas or vapor is present. Dust respirators shall consist of:

a) a facepiece held securely in position by a head harness;

b) a filter(s) through which all the inhaled air passes. Filters shall be readily replaceable, and shall be capable of being fitted without edge leakage or other loss of efficiency; they shall be encapsulated. For some applications it is desirable that readily replaceable pre-filters shall be available, and

c) a valve system such that all air inhaled by the wearer passes through the filter(s). The exhaled air shall pass direct to the surrounding atmosphere through a non-return valve.

19. GAS RESPIRATORS, CANISTER TYPE

19.1 Design

Gas respirators (canister type) are designed to protect the wearer from the gases listed in Tables 3 and 4. The life of the canisters is given in Table 4 in terms of the time of exposure at the maximum concentration; allowance must be made for facepiece leakage. Gas respirators shall be of one of the following types:

a) a full facepiece connected to a canister or canister containing absorbent and/or adsorbent materials, by means of a breathing tube, and arranged with valves so that all air inhaled by the wearer passes through the canisters. The exhaled air shall pass direct to the surrounding atmosphere through a non-return valve(s);

b) similar to a above but with the canister or canisters connected directly to the facepiece.

19.2 Canisters

19.2.1 The canister shall be connected to the facepiece in an airtight manner so that when fitted all the inhaled air passes through it. It shall be readily replaceable without the use of special tools.

19.2.2 Metal canisters shall be varnished internally and painted or varnished externally, or otherwise rendered corrosion resistant and, where necessary, shall be provided with a suitable carrying harness.

19.2.3 The colour marking of canisters shall be visible when the canister is fitted in the harness.

19.2.4 The particulate filter, if provided, shall be integral with the canister and in such a position that the inhaled air passes through it first.

19.2.5 The charcoal employed in this type of canister shall be impregnated with not less than 0.01% w/w of silver (on the dry charcoal).

20. GAS RESPIRATORS, CARTRIDGE TYPE

20.1 Design

20.1.1 The design of gas respirators (cartridge type) shall be such as to provide protection against low concentrations of certain relatively non-toxic gases.

20.1.2 The respirator shall consist of a facepiece held securely in position with a head harness and connected to a cartridge or cartridges containing absorbent or adsorbent material, and arranged with valves so that all air inhaled by the wearer passes through the cartridges. The exhaled air shall pass direct to the surrounding atmosphere through a non-return valve(s). A particulate filter shall be incorporated and for some applications it is desirable that readily replaceable prefilters shall be available.

20.1.3 The cartridge shall be readily replaceable without the use of special tools, and shall be designed or marked to prevent incorrect assembly.

TABLE 3 - LIST OF SUBSTANCES SHOWING APPLICATION OF CANISTERS

Substance	Canister type	Substance	Canister type
Acetaldehyde	C.C	Ketene	C.C
Acetone	C.C	Mercury and compounds	
Acetone cyanohydrin	S.H.C	on mercury	C.C
Acridine	C.C	Methanol	C.C
Acrylaldehyde (acrolein)	C.C	Methyl bromide	O.
Ammonia	A.		
Amyl acetate	C.C	Nitrous fumes	N.F.
Amyl alcohol	C.C		
Aniline	C.C	Particulate smokes	C.C
Arsine	C.C	Particulate smokes	S.H.C.
Benzene	C.C	Particulate smokes	N.F.C.
Bromine	C.C	Petroleum vapor (see Note 1)	C.C
Bromomethane	O.	Phenol	C.C
Carbon disulphide	C.C	Phosgene	C.C
Carbon tetrachloride	C.C	Pyridine	C.C
Chlorine	C.C	Sulphur dioxide	C.C
Chloromethane	O.	Sulphur dioxide	S.H.C.
Cyanide dusts	C.C	Sulphur chloride	C.C
Cyanogen chloride	O.	Sulphur trioxide	C.C.
Diazomethane	C.C	Sulphur trioxide	S.H.C.
Dichloromethane	O.	Sulphuric acid	C.C.
Diethyl ether	C.C	Sulphuryl chloride	C.C.
Diketene	C.C	Lead alkyl compounds	
Ethylene oxide	C.C	containing TEL and TML	C.C.
Formaldehyde	C.C	Thionyl chloride	C.C.
Hydrogen bromide	C.C. or S.H.C	Toluene	C.C.
Hydrogen chloride	C.C. or S.H.C	Trichloroethylene	C.C.
Hydrogen cyanide	D.		
Hydrogen cyanide	S.H.C	Xylene	C.C.
Hydrogen fluoride	C.C.or S.H.C		
Hydrogen sulphide	C.C	Organic compounds boiling at	
Hydrogen sulphide	S.H.C	temperatures above 60°C	C.C.

Notes:

1) Breathing apparatus should be used in connection with the lighter petroleum hydrocarbons.

2) Canister respirators should not be used to protect against coal gas or any other gas containing carbon monoxide.

3) Type O canisters may also be used for protection against gases and vapors listed against C.C. canisters, with the exception of those cases where a particulate filter is required.

4) 'C' denotes particulate filter incorporated.

TABLE 4 - LIST OF CANISTERS SHOWING SUBSTANCES COVERED AND COLOR MARKING

Canister type	British colour marking of canisters	Recommended for use against	Life		Absorption test		
			Maximum concentration by volume %	Maximum exposure to maximum concentration min	Test gas	Test concentration by volume %	Minimum exposure min
A	Blue	Ammonia	2	60	Ammonia	2	60
C.C.*	Black with grey stripe	Organic compounds boiling above 60°C, acetaldehyde, acetone, acridine, acrylaldehyde (acrolein), amyl acetate, amyl alcohol, aniline, arsine, benzene bromine, carbon disulphide, carbon tetrachloride, chlorine, cyanide dusts,diazomethane, diethyl ether, diketene, ethylene oxide, formaldehyde, hydrazine, hydrogen bromide, hydrogen chloride, hydrogen fluoride, hydrogen sulphide, isocyanates, ketene, mercury and compounds of mercury (organic and inorganic), methanol, particulate smokes and dusts, petroleum vapor, phenol, phosgene, pyridine, sulphur dioxide, sulphyr chloride, sulphur trioxide, sulphuric acid, sulphuryl chloride, sulphur monochloride, thionyl chloride, toluene, trichloroethylene, xylene	1	30	*(a)* Phosgene and *(b)* Carbon tetrachloride	1 1	30 30
D	White	Hydrogen cyanide	1	30	Hydrogen cyanide	1	30
H	Half black Half blue	All under C.C. (except particulates), ammonia	1	30	Ammonia Carbon tetrachloride	1 1	30 30
N.F.C.	Orange with grey stripe	Nitrous fumes, particulate smokes and dusts	1	20	Nitrous fumes (NO_2 /NO)	1	20
O	Black with orange stripe	All under C.C. (except particulates), bromomethane (methyl bromide,) chloroethane, chloromethane, cyanogen chloride, vinyl chloride, vinylidene chloride	1	30	*(a)* either chloromethane or cyanogen chloride and *(b)* As for C.C.	1	30
S.H.C.	Red with white and grey stripes	2-cyanopropan-2-ol (acetone cyanhydrin), hydrogen chloride, hydrogen bromide, hydrogen fluoride sulphur dioxide, sulphur trioxide, hydrogen sulphide; acid gases including hydrogen cyanide, particulate smokes and dusts	1	30	Hydrogen cyanide	1	30

TABLE 5 - SUBSTANCES COVERED BY CARTRIDGE TYPE RESPIRATORS
(see clause 20)

TYPE	COLOR	RECOMMENDED FOR USE AGAINST	Life	
			MAXIMUM CONCENTRA-TION BY VOLUME %	MAXIMUM EXPOSURE TO MAXIMUM CONCENTRA-TION min
CART-RIDGE(S)	BLACK	AS FOR C. C. CANISTERS PROVIDED THAT SUBSTANCES HAVE THRESHOLD LIMIT VALUES EXCEEDING ONE HUNDRED PARTS PER MILLION (0. 01 %)	0.1	20

21. POSITIVE PRESSURE, POWERED DUST HOODS AND BLOUSES

21.1 General

21.1.1 Under clause 16 the Standard for positive pressure, powered dust respirators has been prepared, however the use of a hood or a hood integral with a blouse in place of a respirator facepiece will for certain applications provide increased comfort. This standard specifies such an apparatus for use either with high efficiency filters and giving a standard of performance equal to that of the high efficiency dust respirator dealt with in clause No. 15 or with standard filters and giving a performance equal to that of the dust mask specified in clause No. 17.

Should the positive pressure air supply fail, the wearer should retire from the hazardous atmosphere as quickly as possible. These devices afford no protection against oxygen deficiency; they should not be used in atmospheres immediately dangerous to life, and filters should be checked periodically for clogging. Hoods should only be issued and fitted under the supervision of competent person aware of the conditions in which they are to be used. Where flammable surroundings shall arise, the suitability of the equipment for use in such surroundings must be considered.

When determining the types of protection that should be provided for any particular conditions, reference should be made to clauses 10 and 13.

This Standard specifies requirements for hoods and blouses supplied with filtered air, providing protection in adverse environmental conditions (particulate hazards) whilst reducing the respiratory load.

21.2 Design

The design shall be such that the equipment provides protection against solid particles or, in certain cases, mists, where no hazard from a toxic gas or vapor exists. It shall consist of the following.

21.2.1 A hood or a hood integral with a sleeved blouse which shall be so designed that all the exhaled and surplus air passes from the inside of the hood or blouse to the surrounding atmosphere at its lower extremities.

21.2.2 A power pack supplying filtered air directly to the hood.

21.2.3 A filter(s) through which all the air supplied to the hood or the blouse passes. These filters shall be readily replaced and shall be capable of being fitted without edge leakage or other loss of efficiency. For some applications it is desirable that one or more readily replaceable pre-filters shall be available.

21.3 Hood and Blouse

21.3.1 The hood should preferably be made in one size to fit all adult wearers. It shall have a transparent area for viewing, and be comfortable to wear.

21.3.2 The blouse, which shall be either of integral construction or otherwise sealed airtight with the hood, should be made in size to fit adult wearers, with sleeve and waist openings elasticated or otherwise designed to constrict the openings.

21.4 Power Pack

21.4.1 The power pack shall be capable of supplying air to the hood at a minimum rate of 120 liters per minute for a period of 4 h without replacement of the power source.

21.4.2 If a rechargeable battery is used, it shall be possible to recharge it completely within 14h and it shall be of the nonspillable type. Unless the battery is of a sealed type, a safe venting device shall be incorporated in the pack.

22. UNDERWATER BREATHING APPARATUS

22.1 General

Strict attention to the care and maintenance of all types of breathing apparatus used underwater is of vital importance at all times. More damage is probably caused to underwater apparatus by mishandling out of water, by incorrect maintenance and during storage, than is incurred during actual diving operations. It is essential that the complete equipment be thoroughly examined for damage or defect before and after every occasion on which it is used. All defects should be rectified before the equipment is used again.

The recommendations made in the following sections concerning the handling of the various components should be most carefully observed and the maker's instructions with regard to assembly, adjustment, replacement of components and maintenance should be obtained and followed.

It should be borne in mind that the lightweight construction of self-contained breathing apparatus renders it vulnerable to damage through mistreatment.

Careless manipulation with inappropriate tools may not only give rise to dangerous defects, but render further maintenance expensive or impossible.

The corrosive action of seawater and water-borne contaminants should never be underestimated, and if precautions are not taken to clean the apparatus properly after use, serious damage may be caused to all parts of the apparatus while it is stowed away. It is worth as chemical and petroleum wastes which are not noticeable at the time, but which will start corrosive action if left in contact with the apparatus.

22.2 Cylinders

22.2.1 Use of proper cylinder

Cylinders having a water capacity of approximately 5.4 liters or more to contain compressed air are subject to the statutory Gas Cylinders Regulations SR and 0,1931 No. 679 (as amended 1947 and 1959) and various Exemption Orders issued under these Regulations.

22.3 Storage

The condition of the inside of the cylinder shall be maintained by keeping it dry at all times. The under should be filled with dry air and never completely discharged as this can lead to water getting back into the cylinder and causing contamination.

Cylinders should be stored, preferably in the vertical position, in a cool, dry place adequately protected from the weather and away from excessive heat and direct exposure to the sun.

Once a cylinder has been put into service, it should never be left completely discharged.

A slight positive pressure should always register on the gage.

22.4 Care of cylinders

Accessories fitted to the cylinder, even if they are plated or of stainless steel, should be insulated from the cylinder by suitable means, either a plastics or nylon coating, or a rubber sleeve.

After use, particularly in seawater, the cylinder should be removed from its harness and boot and then washed carefully in clean, fresh water to remove all traces of salt water and dirt, especially from any cracks. The cylinder and valve should be thoroughly dried.

To ensure the good service of the cylinder valve, care should be taken when opening and closing it to ensure that excessive force is not applied once the stop has been reached as this causes damage to the internal components of the valve and could result in a leak through the valve.

Before storage, or when the cylinder has been completely discharged and seawater may have entered the cylinder, the cylinder valve should be removed and the cylinder washed internally and externally in clean fresh water and thoroughly dried.

This operation should normally be undertaken by a competent person. The cylinder should not be stored with the valve downwards.

Cylinders should be retested periodically in accordance with current regulations.

22.5 Compressed Air for Human Respiration

22.5.1 Preparation of compressed air cylinders

Cylinders should be internally and externally clean and free of scale or other foreign matter.

22.5.2 Compression of atmospheric air

Atmospheric air shall be compressed by means of suitable compressors to attain the air purity and pressure desired. Precautions should be taken to ensure that only uncontaminated air is admitted into the compressor intake. Attention should be paid to the location if the compressor intake and to the provision of suitable intake screening or filtration.

Where compressors are driven by an internal combustion engine, every care should be taken, by extending the exhaust of the engine or the inlet of the compressor, to avoid the compressor drawing in the exhaust gases of the engine. The compressor manufacturer should be consulted concerning the maximum length and the minimum cross-sectional area of such an extension to avoid reducing the efficiency of the engine or compressor. When compressors are being run in the vicinity of other machinery, adequate precautions should be taken to avoid intake of fumes from these machines.

The maintenance and operation of compressors should be carried out in accordance with the manufacturer's instructions, particular attention being paid to the condition of piston rings, driers, filters and accessories. No lubricant other than that recommended by the compressor manufacturer should be used.

The air discharged from the compressor should be subjected to the processes necessary to achieve the degree of purity specified in clause 22.5.3. At regular intervals, not exceeding six months and after major overhaul, a sample of the compressed air delivered by the compressor should be analysed to check that the standards of purity are being maintained.

22.5.3 Purity of the breathing air

A sample of air taken from the cylinder should not contain impurities in excess of the limits given in table 6.

The air should be free from all odors, and contamination by dust, dirt or metallic particles, and should not contain any other toxic or irritating ingredients.

Note:

Odor and cleanliness of compressed air is difficult to check accurately without special equipment. A rough check shall be made by cracking, open the cylinder valve and smelling the escaping air, and by noting any discoloration or moisture when the air is passed gently through a wad of tissue or filter paper. Filled cylinders whose contents have an objectionable odor or showing signs of discoloration or moisture, as described above, should not be used.

TABLE 6 - MAXIMUM LIMITS OF IMPURITIES IN CYLINDER AIR

IMPURITY	LIMIT
CARBON MONOXIDE	10 p.p.m. (V/V) (11 mg/m^3)
CARBON DIOXIDE	500 p.p.m (V/V) (900 mg/m^3)
OIL	1 mg/m^3
WATER	0.5 g/m^3

Notes:

1) At ambient temperature below 4°C there is a risk of freezing inside the apparatus and particular attention should be given to the dryness of the air under these circumstances. It is recommended that the air should be dried chemically under extremely cold conditions.

2) It is acknowledged that the above limits are not in total agreement, but the values are considered to be obtainable in practice for everyday use for underwater breathing apparatus.

23. VENTILATORY RESUSCITATORS

23.1 General

This section specifies performance and safety requirements for ventilatory resuscitators (hereinafter referred to as resuscitators) intended for use with patients of any body mass.

It covers both operator-powered 'nd gas-powered resuscitators.

Electrically-powered resuscitators, automatic pressure-cycled gas-powered resuscitators, devices which have been designed only to deliver gases to a patient breathing adequately, or devices which are designed to assist or provide for the ventilation of a patient for an extended period of time are outside the scope of this standard.

23.2 Classification

Resuscitators for use with patients up to 40 kg body mass shall be classified by the body mass range for which they are suitable. This range shall be derived on the basis that resuscitators shall deliver a tidal volume of 15 mL/kg body mass.

Resuscitators delivering a tidal volume of 600 mL and above, i.e. suitable for patients over 40 kg body mass, shall be classified as adult resuscitators.

Note:

Resuscitators designed to deliver a tidal volume of 20 mL to 50 mL are usually suitable for use with neonates.

23.3 Physical Requirements

23.3.1 Size

The resuscitator, with a container, if provided, shall pass through a rectangular opening 300 mm × 600 in size.

Resuscitators are required where access to patients is difficult, such as in crawl spaces and through manholes.

23.3.2 Resuscitator mass

Except for gas-powered resuscitators designed to be an integral part of a neonatal critical care system, the mass of the resuscitator container and contents (including any full gas cylinders) shall not exceed 18 kg.

23.3.3 Ease of operation

The resuscitator shall be designed to facilitate effective operation by one person when used with a face mask to provide adequate ventilation of the patient's lungs (as defined by this specification). All performance characteristics in this draft standard shall be satisfied when the resuscitated by one person unless otherwise specified by the manufacturer in the instructions for use.

23.3.4 Cleaning and sterilization

Components in contact with the patient breathing mixture shall withstand sterilization or be labeled for single-use only (disposable). The suggested methods of cleaning and sterilization shall be suggested methods of cleaning and sterilization shall be generally recognized as effective. Examine the manufacturer's instructions for sterilization or disinfection and deterermine if they recommend commonly described methods.

23.3.5 Disassembly and reassembly

A resuscitator designed to allow disassembly by the user (for example, for cleaning, etc.) shall be designed so as to minimize incorrect reassembly when all parts are mated. For resuscitators designed to be disassembled, the manufacturer shall include resuscitator disassembly and assembly instruction which shall include a schematic diagram showing the correct assembly. After reassembly the operator shall be instructed to perform the manufacturer's recommended test procedure to ensure proper functioning. Verify by inspection and testing for proper operation.

23.3.6 Pressure-Limiting system indication

If a resuscitator is equipped with an over-pressure limiting system, there should be an audible or visible warning to the operator when the pressure-limiting system is activated.

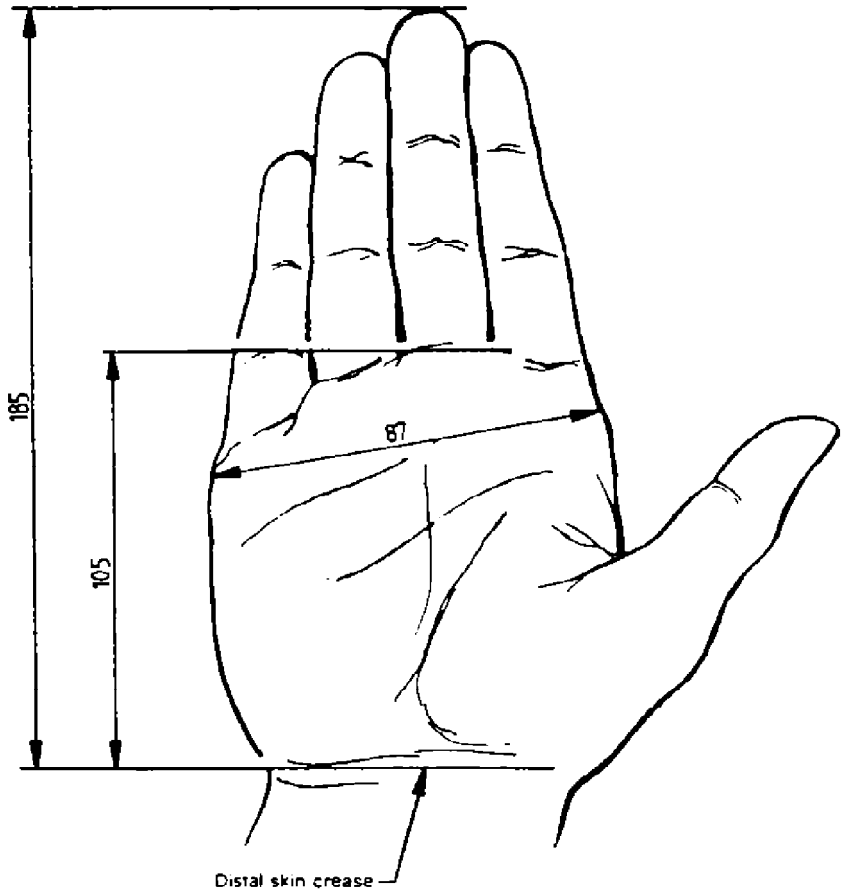
23.3.7 Operator-powered resuscitators

In accordance with the requirements of its classification an operator-powered resuscitator shall deliver a minimum oxygen concentration of at least 40% (V/V) when connected to an oxygen source supplying not more than 15 l/min, and shall be capable of delivering at least 85% (V/V) (see note).

The manufacturer shall state the range of concentrations at representative flows, e.g. 2 l/min, 6 l/min, 8 l/min, etc. If the resuscitator is intended to be hand-operated, only one hand shall be used to compress the compressible unit, and the hand of the person carrying out the test shall not exceed the dimensions given in figure (2).

Note:

The 85% (V/V) requirement shall be accomplished with the use of an attachment.



MAXIMUM HAND DIMENSIONS
Fig. 2

Although 40% (V/V) oxygen concentration is adequate under some circumstances, 85% (V/V) or higher oxygen concentrations are preferable for the treatment of severely hypoxemic patients during resuscitation.

This concentration should be achievable at supplementary oxygen flows of 15 l/min or less because to specify greater than 15 l/min would exceed the normal calibration of standard, clinically used flowmeters for adult use and could potentially lead to inaccurate control of oxygen flows and jamming of the patient valve in the inspiratory position.

23.3.8 Tidal volume

Resuscitators intended for use with infants and children up to 40 kg body mass shall be classified according to the body mass range for which they are suitable. This body mass range shall be derived from a requirement for a tidal volume of 15 ml/kg body mass.

Resuscitators delivering a tidal volume of 600 ml and over shall be classified as adult resuscitators.

The tidal volumes specified shall be delivered under the test conditions without the use of the override mechanism on any pressure-limiting system.

Note:

Resuscitators designed to deliver a tidal volume of 20 ml to 50 ml are usually suitable for use with neonates.

For adult ventilation a typical tidal volume is approximately 600 ml. The compliances and resistances are representative of the possible compliances and resistances found in adults and children needing resuscitation. The tidal volume requirements of 15 ml/kg are higher than normal and are commonly used during resuscitation to allow for mask leakage. The ventilatory frequencies are typical values used in pediatric and adult resuscitation.

23.3.9 Pressure limitation (operator-powered resuscitators)

Experience with infant resuscitation suggests that a maximum inspiratory pressure of 4,5 kPa (≈ 45 cm H_2O) will not produce lung damage and will permit adequate tidal volume in most patients weighing under 10 kg.

Pressure-Limiting systems are not specified for operator-powered resuscitators designed for use with patients weighing over 10 kg. However, it is essential that resuscitators with such systems satisfy the tidal volume requirements specified in this Standard without the use of any override mechanism.

When airway pressure is limited to below 6 kPa (≈ 60 cm H_2O), it was felt that an override mechanism is essential in order to ventilate those patients with low lung compliance and/or high airway resistance.

23.3.10 Pressure-limiting system

It is essential that maximum delivery pressure is limited on all gas-powered resuscitators. Airway pressure at 4,5 kPa (≈ 45 cm H_2O) was considered adequate for ventilation of the lungs, but unlikely to produce barotrauma. The selection of higher settings for difficult clinical problems necessitates risk of barotrauma.

23.4 Gas-Powered Resuscitators

23.4.1 The approximate duration of a single (gas cylinder 457 mm long and 102 mm outside diameter size cylinder) containing 340L of gas when the resuscitator is delivering a minute volume of 10L (or the nearest setting to this) and a concentration of:

a) at least 85% V/V oxygen and;

b) the manufacturer's selected concentration less than 85% V/V oxygen, if the resuscitator will deliver such a concentration.

23.4.2 If the resuscitator will deliver concentrations of oxygen less than 85% V/V, the concentration delivered at the maximum and minimum tidal volume settings.

23.4.3 The flow from the patient connection port against back pressures of 1.5 kPa and 3.0 kPa.

23.4.4 The recommended range of gas supply pressures and flows.

23.4.5 The duration of the gas cylinder supplied with the resuscitator under stated conditions.

High oxygen concentrations are important in resuscitating patients who are extremely hypoxemic. Lower percentages of oxygen will lengthen the duration of oxygen supply. The performance of air-entrainment, "mixing" devices is influenced by the flow settings of the resuscitator and the compliance and resistance of the patient.

23.4.6 Pressure-limiting system

A pressure-limiting system shall be incorporated in gas-powered resuscitators. When the resuscitator is supplied with gas at the range of pressures 270 kPa and 550 kPa the airway pressure shall not exceed 6 kPa (≈ 60 cm H_2O).

An override mechanism shall be provided to enable the operator to select a higher pressure. However, automatic, pressure-cycled, gas-powered resuscitators shall not be equipped with any type of override mechanism. If provided with

a locking mechanism, pressure override mechanisms shall be so designed that the operating mode, i.e. on or off, is readily apparent to the user by obvious control position, flag, etc.

Notes:

1) A setting for the pressure-limiting system higher than 6 kPa (≈ 60 cm H_2O) shall be made available for certain patients, although the selection of such a setting requires medical advice.

2) There should be an audible or visible warning to the operator when the pressure-limiting system is operating.

23.4.7 Expiratory resistance

In the absence of positive end-expiratory devices, the pressure generated at the patient connection port shall not exceed 0,5 kPa (≈ 5 cm H_2O).

To facilitate exhalation, expiratory resistance should be minimized unless there are special clinical indications to impose such resistance.

23.4.8 Inspiratory resistance

The design of a resuscitator should be such that it is possible for the patient to breathe spontaneously without excessive subatmospheric pressure when the resuscitator is applied to the patient's airway but is not activated by the operator.

The pressure at the patient connection port shall not exceed 0,5 kPa (≈ 5 cm H_2O) below atmospheric pressure.

23.4.9 Inspiratory flow

All gas-powered resuscitators shall be capable of delivering 40 l/min ± 10% inspiratory flow against a back pressure of 2 kPa (≈ 20 cm H_2O) when tested by the method described in A.5.14 ISO Annex (C).

Note:

Devices with fixed flows should be set to this value. Devices with operator-adjustable flows should include this value in their range of adjustment.

To minimize the risk of gastric distension, 40 l/min is considered to be the maximum flow which should be used when resuscitating with a mask. This is in accordance with the recommendations of the American Heart Association (AHA Standards for CPR and ECC: JAMA, June 6 Vol. 25, #1), and these recommendations are generally accepted worldwide. Higher flows may be used with intubated patients because of the decreased risk of gastric distension.

23.4.10 Automatic pressure-cycled, gas-powered resuscitators

It is required that pressure-cycled resuscitators meet the performance requirements of this Standard, but they are of limited use on patients with poor lung compliance and/or high airways resistance because the cycling pressure is achieved without adequate ventilation. A "negative" pressure phase should not be used as it is associated with a fall in functional residual capacity (FRC) and arterial oxygen partial pressure (Po_2).

23.4.11 Pressure for initiation

It is important that the patient should not have to generate large amounts of negative pressure to initiate gas flow from the demand valve in order to minimize respiratory work. A negative pressure of -0,2 kPa (≈ -2 cm H_2O) is physiologically acceptable.

23.4.12 Peak inspiratory flow

The minimum peak inspiratory flow shall be 100 l/min for at least 10 s, at an outlet pressure of no more than 0,8 kPa (≈ 8 cm H_20).

Peak flows as outlined in above are necessary in order to satisfy the inspiratory needs of the typical patient; large amounts of negative pressure should not be required to generate these flows as it would cause fatigue in a spontaneously breathing patient.

23.4.13 Termination pressure

Positive pressure indicates that adequate tidal volume has been delivered. When the pressure becomes slightly positive it indicates that the patient should be allowed to exhale and hence flow should stop.

23.5 Gas Supply

23.5.1 Gas cylinders, cylinder valves and yoke connections

If provided, gas cylinders, cylinder valves and yoke connections of the pin index type shall meet the requirements given in ISO 407, "small medical gas cylinders-yoke type, valve connections".

23.5.2 Duration of gas supply

Small, easily portable cylinders are commonly used with resuscitators. It is important that the operator have some idea of the duration of this size of oxygen supply under simulated conditions of use.

APPENDICES

APPENDIX A
NOMINAL PROTECTION FACTOR

A.1 There is now a range of Standard specifications dealing with the design construction and performance of respirators and breathing apparatus. In specifying equipment with different inward leakage characteristics, as determined by prescribed test procedures, the standards describe equipment offering different degrees of protection against inhalation of harmful substances. The selection of the most suitable type of equipment for particular circumstances requires an understanding of the limits of protection of the equipment available as well as an understanding of the hazard against which protection is required.

A.2 As an aid to the selection of respiratory protective equipment, the term 'nominal protection factor, has been introduced into this standard for each type of equipment. It is derived from a 'maximum allowed inward leakage' figure and is defined as the ratio of the concentration of contaminant present in the ambient atmosphere to the calculated concentration within the facepiece, at maximum allowed inward leakage, when the respirator or breathing apparatus is being worn, e.g.

Maximum allowed inward leakage = 10%

$$\text{Nominal protection factor} = \frac{\text{Concentration of contaminant atmosphere}}{\text{Concentration of contaminant in facepiece}} = \frac{C}{\frac{10}{100}C} = 10$$

A.3 Inward leakage of ambient atmosphere occurs at the face-seal of respirator or breathing apparatus when the design and operation of the equipment is such that the pressure within the facepiece falls below atmospheric pressure during inhalation. There are at the same time a small inward leakage through an exhalation valve and, in the case of a dust respirator, there will generally be a measurable penetration through the filter itself. An inward leakage can occur at the neck cord of a positive pressure hood or at the waist band and wrists of a positive pressure blouse.

The sum of the maximum leakages, or penetrations, allowed for each type of equipment is referred to by the expression 'maximum allowed inward leakage', expressed as a percentage.

Example 1: Dust respirator, Type B-clause 18

Maximum allowed inward leakage

(1) through the filter(s)		5%
(2) at the face-seal		5%
	Total	10%

Note:

Dust respirators are now available with face-seal leakage test figures significantly below 5% . Individual manufacturers should be consulted where the highest standard of fit is desirable.

(to be continued)

APPENDIX A (continued)

Example 2: Gas respirators, canister type clause 19

Maximum allowed inward leakage of gas

(1) through canister (penetration of the gas filter during serviceable life of the canister is negligible)		nil
(2) at the face-seal		0.25%
	Total	0.25%

Maximum allowed inward leakage of dust (where a particulate filter is incorporated)

(3) through the filter		0.25%
(4) at the face-seal		0.25%
	Total	0.5 %

Example 3: Compressed air line apparatus (demand valve type) clause 14

Maximum allowed inward leakage at the face-seal 0.05%

In other cases, maximum allowed inward leakages will be found to lie between 15% for a Type A dust respirator and 0.05% for a self-contained breathing apparatus.

Leakage into breathing apparatus in which a positive pressure is continuously maintained should, of course, be negligible.

A.4 It should be noted that the face-seal leakage figures of facepieces and hence, in part, nominal protection factors, are based on a test from which subjects whom the equipment under test clearly does not adequately fit are excluded. Abnormal face-seal leakages will result from poorly fitting facepieces. When a respirator or breathing apparatus is available in more than one size it is important that the best fitting size for the individual is worn.

A.5 For the estimation of the nominal protection factor of a dust respirator, the filter penetration figure to be taken is that of the mechanical type. In this way, allowance is made for deterioration in the performance of other types of filter during storage. Excessive loadings of dust filters can produce increased breathing resistance which tends to increase face-seal leakage, and in some cases, they shall increase the leakage of dust through the filters, with a consequent decrease in the protection given.

A.6 In any potentially hazardous situation a prior assessment, based on the best available information, should always be made of the maximum concentration of the contaminant in air that a person can be expected to breathe without ill-effect. It should be borne in mind that the estimated nominal protection factor can only be applied to respiratory protective equipment that has been properly maintained.

A.7 In order to make use of nominal protection factors in practice, it is necessary to know both the concentrations of harmful contaminants in air that are likely to be encountered and the maximum allowable concentration in the air inhaled by the wearer of the respiratory protective equipment. A comparison of these concentrations will indicate the protection factor required and hence the type of respiratory protective equipment.

(to be continued)

APPENDIX A (continued)

A.8 A guide to the maximum allowable concentration of a substance in inhaled air over extended periods of time is provided by its published threshold limit value (TLV). The TLV of a substance is defined as the concentration of that substance in air to which it is believed nearly all persons can be exposed, without adverse effect, for a 7 or 8 hour work-day and a 40 hour week. Most TLVs are to be taken as time-weighted average concentrations, i.e. excursions above the limit are permissible provided that they are compensated by equivalent excursions below the limit during the work day. In certain cases, the TLV is a ceiling value which should not be exceeded and is annotated to that effect in the list.

A.9 In the absence of a ceiling value, considerably higher concentrations of a substance in air is allowable when exposure is an isolated occurrence of short duration, e.g. an emergency situation, than when it is closely repetitive or of extended duration.

Example 4: Protection against prolonged exposure to a harmful air-burned dust

For the purposes of this example, assume that:

(1) the time-weighted average is known to be 20 mg/m^3;

(2) the TLV for the dust is 0.2 mg/m^3.

The protection factor required is thus $\frac{20}{0.2} = 100$

This requirement could be met by the followings:

Fresh air hose (with or without blower), full facepiece or mouthpiece and noseclip	Nominal protection factor 2000
Fresh air hose (with blower), half-mask	Nominal protection factor 2000
Fresh air hose (without blower), hood or blouse	Nominal protection factor 1000
Air line breathing apparatus	Nominal protection factor 2000
Positive pressure, powered dust respirator, high efficiency type	Nominal protection factor 500
High efficiency dust respirator	Nominal protection factor 1000
Self-contained breathing apparatus	Nominal protection factor 2000