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Indian Standard
RECOMMENDATIONS FOR THE SELECTION, USE AND MAINTENANCE OF RESPIRATORY PROTECTIVE DEVICES

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Industrial Safety Advisory Committee, ISAC

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Indian Standard
RECOMMENDATIONS FOR THE SELECTION, USE AND MAINTENANCE OF RESPIRATORY PROTECTIVE DEVICES

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 18 September 1980, after the draft finalized by the Industrial Safety Advisory Committee had been approved by the Executive Committee.

0.2 This standard is intended to be a guide for the use of respiratory protective devices in industry. It is stressed that where there is a risk arising from employees inhaling air-borne contaminants which may cause injury, efforts should be made to remove that risk by improving the environment of the plant and the methods of operation. Automation, isolation of processes, ventilation and exhaust systems should be provided wherever possible. Nevertheless, the use of respiratory protective devices becomes necessary in some operations and in these situations such devices should be readily available for immediate use.

0.3 Certain toxic substances can also be absorbed through skin. Where such hazards exist, respiratory protection alone is not sufficient and the whole body should be protected by a positive pressure tight suit including boots and gloves.

0.4 In the preparation of this standard, assistance has been taken from the following publications which is gratefully acknowledged:

AS CZ 11-1968 Repiratory protective devices. Standards Association of Australia.

BS 4275 : 1968 Recommendations for the selection, use and maintenance of respiratory protective equipment. British Standards Institution.

ANSI Z 88.2-1969 Practices for respiratory protection. American National Standards Institute.

1. SCOPE

1.1 This standard describes various types of personal respiratory protective devices, discusses the factors affecting the choice of such devices, and includes guidelines for their selection, use and maintenance.

2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions given in IS : 8347-1977* shall apply.

3. CLASSIFICATION AND SELECTION OF RESPIRATORY PROTECTIVE DEVICES

3.1 Respiratory protective devices are of various types, and work on different principles. It is therefore essential that a protective device is selected after careful consideration of the hazards involved so that it would give the desired protection.

3.2 Classification — Basically the respirators are of two types, namely, the air purifying type and the supplied air type. Detailed classification of respiratory protective devices is shown in Fig. 1.

3.3 Selection — In practice the work environment may be either ventilated or non-ventilated and pose a hazard due to toxic contaminants or due to oxygen deficiency. Guidance on how to select a suitable respirator for protection and attention to the incidental problems which should be taken into consideration are shown in Fig. 2.

4. DESCRIPTION OF RESPIRATORY HAZARDS ACCORDING TO THEIR BIOLOGICAL EFFECTS

4.1 Oxygen Deficiency

4.1.1 *Occurrence* — Oxygen deficiency is likely to be encountered in confined or unventilated cellars, wells, mines, ship holds, tanks, bins, vaults, burning buildings, and enclosures containing inert atmospheres.

4.1.2 *Effect* — There is normally 21 percent by volume of oxygen in the air, but a human being can get along on 17 percent, although this will cause his breathing to be laboured. At about 16 percent a candle or oil flame will be extinguished, whereas at 13 percent an acetylene flame goes out and most men cannot work. Below 13 percent concentration, dizziness and headaches occur. 8 to 10 percent concentration usually results in unconsciousness or death.

NOTE — The adverse effect of oxygen deficiency increases with decreasing atmospheric pressure or increased altitude.

4.2 Gaseous and Vapour Contaminants

4.2.1 *Asphyxiants* — They interfere with utilisation of oxygen in the body.

*Glossary of terms relating to respiratory protective devices.

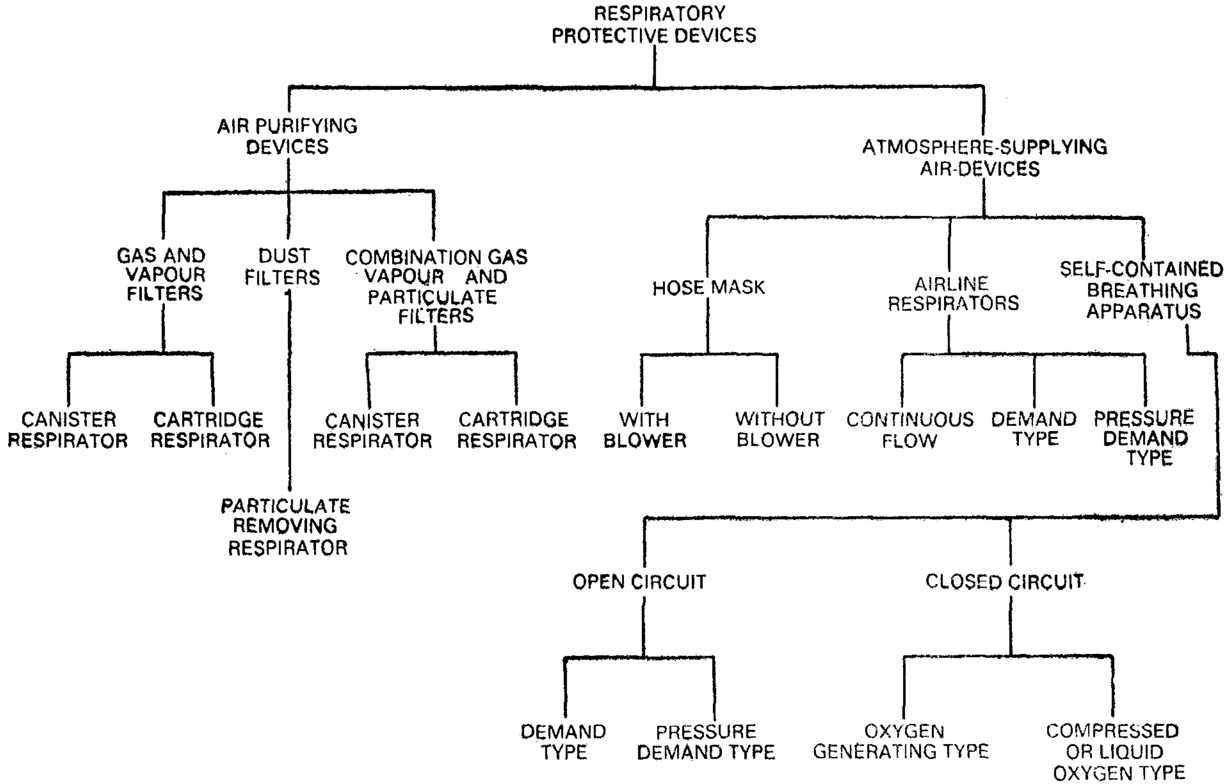

FIG. 1 CLASSIFICATION OF RESPIRATORY PROTECTIVE DEVICES

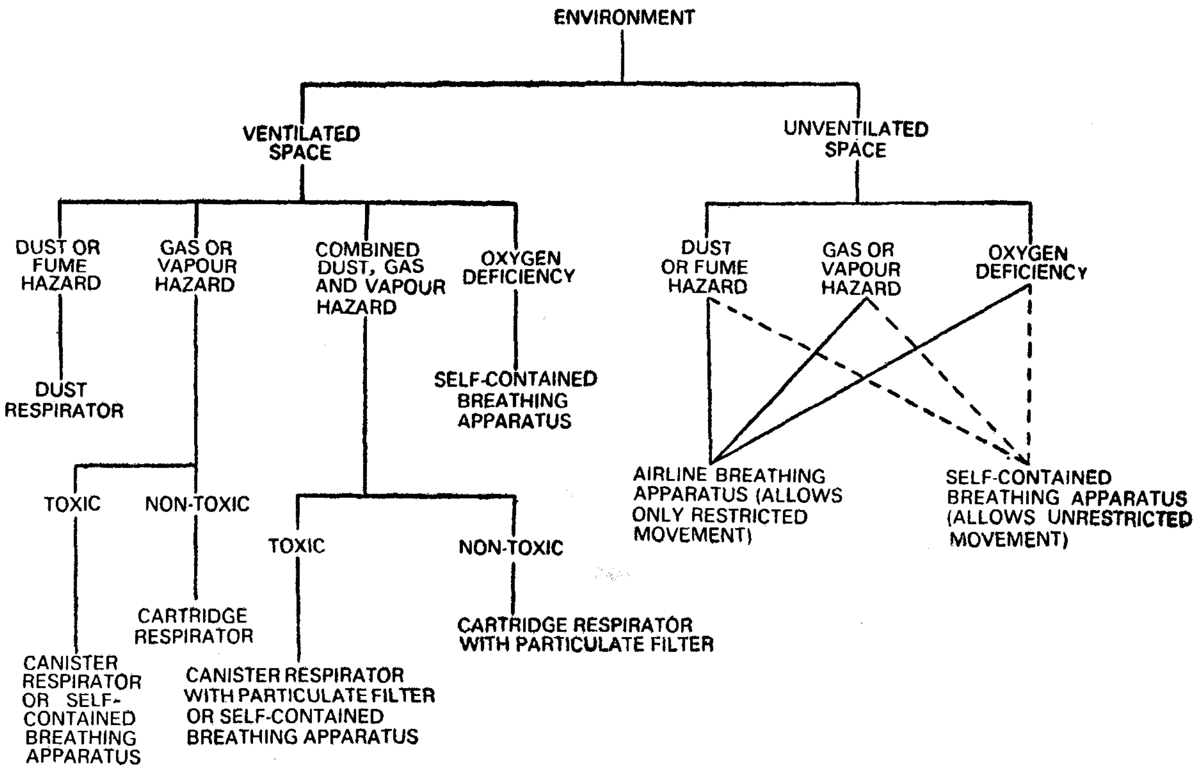

FIG. 2 ENVIRONMENT CLASSIFICATION FOR SELECTION OF RESPIRATORY PROTECTIVE DEVICES

(Normally, in a ventilated space oxygen deficiency would not occur, except due to an accident situation)

4.2.1.1 *Simple asphyxiants* — These are physiologically inert substances that dilute oxygen in the air, for example, nitrogen, hydrogen, helium, methane and carbon dioxide.

4.2.1.2 *Chemical asphyxiants* — In low concentrations, these interfere with the supply or utilisation of oxygen in the body by chemically reacting with blood, for example, carbon monoxide, hydrogen cyanide, cyanogen and nitriles.

4.2.2 *Irritants* — These are corrosive in action. They may cause irritation and inflammation of parts of the respiratory system (also skin and eyes) and pulmonary odema, for example, ammonia, hydrogen chloride, formaldehyde, sulphur dioxide, chlorine, ozone, nitrogen dioxide, phosgene and arsenic trichloride.

4.2.3 *Anaesthetics* — They cause loss of feeling and sensation and may lead to unconsciousness and death, for example, nitrous oxide, helogenated hydrocarbons and ethers. Some anaesthetics damage body organs, for example, carbon tetrachloride effects liver and kidneys, and chloroform affects liver and heart.

4.2.4 *Systemic Poisons* — These damage organs and systems in the body, for example, mercury (nervous system and various organs), phosphorus (bone), hydrogen sulphide (respiratory paralysis) and arsine (red blood cells and liver).

4.3 Particulate Contaminants

4.3.1 *Relatively Inert* — These cause discomfort and minor irritation, but generally there is no injury at reasonable concentrations. Examples are marble and gypsum.

4.3.2 *Pulmonary Fibrosis Producing* — They produce nodulation and fibrosis in the lungs, possibly leading to complications, for example, quartz, cristodalite, tridymite, and asbestos.

4.3.3 *Cancer Producing* — These produce cancer in some individuals after "latent" period of 20 to 40 years, for example, asbestos, chromates, and radioactive particulates.

4.3.4 *Chemical Irritants* — These produce irritation, inflammation, ulceration, etc, in upper respiratory tract, for example, acid mists and alkali mists.

4.3.5 *Systemic Poisons* — These produce pathologic reactions in various systems of the body, for example, lead, manganese and cadmium.

4.3.6 *Allergy Producing* — They produce reactions such as itching, sneezing and asthma, for example, pollens, isocyanates, gums and spices.

4.3.7 *Febrile Reaction Producing* — These produce chills followed by fever, for example, fumes of zinc and copper.

4.4 Combinations of Gas, Vapour and Particulate Contaminants — Combinations of contaminants may occur simultaneously in the atmosphere. Contaminants may be entirely different substances (dust or gases from blasting) or the particulate and vapour forms of the same substance. Synergistic effects may occur. Such effects may require extraordinary protective measures.

4.5 Conditions immediately dangerous to life or health may result from most of the above hazards with the probable exception of nuisance or low toxicity dusts.

5. RESPIRATORY HAZARDS

5.1 Gas and Vapour Contaminants

5.1.1 *Inert* — They do not react with other substances under most conditions and create a respiratory hazard by displacing air and producing oxygen deficiency, for example, helium, neon, argon and nitrogen.

5.1.2 *Acidic Substances* — These are acids or compounds which react with water to produce an acid. In water they produce positively charged hydrogen ions. These taste sour and are corrosive to mucous membranes and tissues, for example, hydrogen chloride, sulphur dioxide, fluorine, nitrogen dioxide, acetic acid, hydrogen sulphide, and hydrogen cyanide.

5.1.3 *Alkaline Substances* — They are alkalis or compounds which react with water to produce an alkali. When in aqueous solution, they produce negatively charged hydroxyl ions (OH^-). They taste bitter and are corrosive to tissues, for example, ammonia, amines and carbonates.

5.1.4 *Organic Substances* — These are carbon compounds. Examples are: saturated hydrocarbons (methane, ethane, butane); unsaturated hydrocarbons (ethylene, acetylene); alcohols (methyl alcohol, ethyl alcohol); ethers (methyl ether, ethyl ether); aldehydes (formaldehyde); ketones (acetone); organic acids (formic acid, acetic acid); halides (chloroform, carbon tetrachloride); amides (formamide, acetamide); nitriles (acetonitrile); isocyanates (toluene isocyanate); amines (methylamine); epoxy compounds (epoxyethane, propylene oxide); aromatics (benzene, toluene, xylene); and organometallic compounds (ethyl silicate, tetraethyl lead and organic phosphates).

5.1.5 *Hydrides* — Compounds in which hydrogen is chemically bonded to metals and certain other elements (for example, diborane and lithium hydride).

5.2 Particulate Contaminants — Particles are produced by mechanical means by disintegration processes of grinding, crushing, drilling, blasting, and spraying; or by physico-chemical reactions such as combustion, vaporization, distillation, sublimation, calcination, and condensation. Particulates are classified as dust, fume, fog, mist, smoke and spray.

6. CLASSIFICATION AND DESCRIPTION OF RESPIRATORS

6.1 Air Purifying Respirators

6.1.1 *Gas and Vapour Removing Respirators* — They are provided with packed sorbent beds (cartridge or canister) to remove single gases or vapours, or a single class of gases and vapours or a combination of two or more classes of gases and vapours by absorption, adsorption, chemical reaction or catalysis or by a combination of these methods.

6.1.1.1 Canisters are marked with bold letters for the contaminant against which they protect and are colour coded for quick identification. The maximum concentration against which a canister can be used is indicated on the label. Canisters for protection against carbon monoxide should have an indicator or timer that shows when the canister should be changed.

6.1.1.2 *Full facepiece respirator (gas mask)* — It is equipped with a single large chin canister or harness mounted canister with breathing tube and inhalation and exhalation valves. Canisters are available in different sizes and chin styles. The service life is proportional to the canister size for a given type of canister.

6.1.1.3 *Half-mask respirator (chemical cartridge respirator)* — It is equipped with one or more cartridges and exhalation and inhalation valves.

6.1.1.4 *Mouth-piece respirator* — It is a compact device designed for quick application when the atmosphere is suddenly contaminated with a hazardous material. It normally consists of a housing with a mouthpiece and a single cartridge, a nose clamp, exhalation and inhalation valves and a neck band.

6.1.2 *Particulate Removing Respirator* — In these devices, 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 particles or classes of particles. Filters may be replaceable or be a permanent part of the respirator. Some filters can be used only once, others are reusable and should be cleaned according to manufacturer's instructions.

6.1.2.1 *Full facepiece respirator* — It is normally equipped with a high efficiency filter canister designed to protect against hazardous particulates, and inhalation and exhalation valves.

6.1.2.2 *Half-mask respirator* — It is normally provided with one or two (dust, mist or fume) filters designed to protect against nuisance and low to moderate toxicity dusts, fumes and mists, and exhalation and inhalation valves. A knitted fabric cover is sometimes worn on dust respirators to decrease discomfort.

6.1.2.3 *Mouthpiece respirator* — This is infrequently used as a particulate respirator.

6.1.3 *Combination Gas, Vapour 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 prefilter.

6.2 Atmosphere-Supplying Respirators — With the help of such respirators, a respirable atmosphere independent of the ambient air is supplied to the wearer.

6.2.1 *Self Contained Breathing Apparatus* — In these respirators supply of air, oxygen or oxygen-generating material is carried by the wearer. They are normally equipped with full facepiece but some are provided with a mouthpiece for escape purposes.

6.2.1.1 *Closed circuit self contained breathing apparatus* — These are of two types:

a) *Compressed or liquid oxygen type* — High-pressure oxygen 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 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 oxygen enters the bag continuously or as the bag deflates to accentuate an admission valve sufficiently. A pressure relief system is provided and a manual bypass system and saliva trap may be provided depending upon the design.

b) *Oxygen-generating type* — Water vapour in the exhaled breath reacts with chemical in the cartridge to release oxygen 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 cartridge. The oxygen release rate is governed by the volume of exhaled air. Carbon dioxide is removed by the cartridge.

6.2.1.2 *Open circuit self contained breathing apparatus* — These make use of compressed air or compressed oxygen or liquid air or liquid oxygen. Where oxygen (liquid or compressed) is used, such apparatus should not be used for atmospheres not compatible with oxygen. These are of two types:

a) *Demand type* — These are equipped with a demand valve that is actuated 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.

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.

NOTE — Where compressed air breathing equipment do not have a bypass system, they are not necessary under the following conditions: (a) when pressure reducers are built in such a way that blockage of air supply is impossible; and (b) where it is ensured that the lung demand valve still operates and intolerable pressure increase is avoided by an over-pressure valve. Should the lung demand valve also break down, the lung demand can be operated by a little push button.

b) *Pressure demand type* — These are 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.

6.2.2 *Hose Mask and Air Line Respirator*

6.2.2.1 *Hose mask* — This is equipped with a full facepiece, non-kinking breathing tube, rugged safety harness and a large diameter heavy-duty non-kinking air supply hose. The breathing tube and air hose are securely attached to the harness. A check valve allows airflow only towards the facepiece. The facepiece is fitted with an exhalation valve. The harness has provision for attaching a safety line. These are of two types:

a) *Hose mask with blower* — Air is supplied by a motor-driven or hand-operated blower. The wearer can continue to inhale through the hose if the blower fails. Up to 100 m of hose length is permissible.

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 15 m of hose length is permissible.

6.2.2.2 *Air-line respirator* — Respirable air is supplied through a small-diameter air-line from a compressor or compressed air cylinder. 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 valve(s) or opening in the enclosure (facepiece, hood, suit). Up to 80 m of air-line is permissible. There are three types of air-line respirators.

a) *Continuous-flow class* — equipped with a half-mask or full facepiece, or a helmet (abrasive blasting) or hood covering the wearer's head and neck. At least 110×10 cm^3 of air per minute to tight-fitting facepieces and 170×10 cm^3 per minute to loose fitting hoods and helmets shall be required.

b) *Demand-type* — equipped with a half mask or full facepiece. The demand valve permits flow of air only during inhalation.

c) *Pressure-demand type* — equipped with a half mask or full facepiece. A positive pressure is maintained in the facepiece at all times.

6.2.2.3 *Supplied air suit* — This is a form of continuous air-line respirator. 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.

6.2.3 *Combination Self Contained and Air-Line Respirators* — Normally these constitute 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.

6.3 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 either an air-line respirator with an air-purifying 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.

7. CAPABILITY AND LIMITATIONS OF RESPIRATORS

7.1 In the selection of a respirator it is essential to know the limitations within which protection is provided. These limitations are described below.

7.1.1 *Air Purifying Respirators* — Air purifying respirators do not protect against (i) oxygen deficient atmospheres; (ii) skin irritation; and (iii) absorption through the skin of air borne 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 vapours 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 will not provide the maximum design protection specified unless the facepiece is carefully fitted to the wearer's face to prevent inward leakage. The period for which protection is afforded depends on (i) the type of canister, cartridge or filter; (ii) concentration of contaminant, and (iii) the wearer's respiratory rate.

A proper type of canister, cartridge or filter should be selected for the particular atmosphere and conditions. Air purifying respirators generally cause discomfort and objectionable resistance to breathing. Respirator facepieces present special problems to individuals required to wear prescription lenses. These devices at the same time do have the advantage of being compact, light weight and simple in operation.

7.1.1.1 *Gas and vapour-removing respirators* — The limitations mentioned in **7.1.1** are all applicable to these respirators. In addition, no protection is provided against particulate contaminants, unless specified on canister or cartridge label. A precaution should be observed in respect of temperature. Generally, a rise in canister or cartridge temperature indicates that a gas or vapour is being removed from the inspired air. But this is not a reliable indicator of canister performance. In fact, an uncomfortably high temperature should indicate a very high concentration of gas or vapour and requires an immediate return to fresh air.

a) *Full facepiece respirator* (*gas mask*) — Its use should be avoided in atmospheres immediately dangerous to life or health or if the contaminant (s) lacks sufficient warning properties, for example, odour, or irritation. The full face cover protects eyes.

b) *Half mask respirator* (*chemical cartridge respirator*) — It should not be used in atmospheres immediately dangerous to life or health. Its use should be limited to low concentrations of gases and vapours. A fabric covering shall not be worn on the facepiece since it will permit gases and vapours to pass. No protection is provided by these respirators to the eyes.

c) *Mouth-piece respirator* (*chemical cartridge*) — It shall not be used in atmospheres immediately dangerous to life or health. Mouth breathing prevents detection of contaminants by odour. The nose clip shall be securely fixed in place to prevent nasal breathing. No protection is provided to the eyes from irritating aerosals.

d) *Self-rescue mouthpiece respirator* — This is designed for self rescue from immediately dangerous atmosphere of gases and vapours. Mouth breathing prevents detection of contaminants by odour. The nose clip shall be securely fixed in place to prevent nasal breathing. No protection is provided to the eyes.

7.1.1.2 *Particulate-removing respirator* — The limitations given in **7.1.1** are all applicable to these respirators. In addition these respirators protect against non-volatile particles only. No protection against gases and vapours is afforded. The filter should be replaced or cleaned when breathing becomes difficult due to plugging by retained particles. These respirators should not be used during shot and sand blasting operations. Special abrasive-blasting respirators should be used.

a) *Full facepiece respirator* — Its use should be avoided in atmospheres immediately dangerous to life or health or if the contaminant lacks sufficient warning properties like odour or irritation. Full face cover protects the eyes elso.

b) *Half-mask respirator* — It should 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 from irritating aerosols.

c) *Mouthpiece respirator (filter)* — It should not be used in atmospheres immediately dangerous to life or health. Mouth breathing prevents detection of contaminants by odour. The nose clip shall be securely fixed in place to prevent nasal breathing. No protection is provided to the eyes from irritating aerosols.

d) *Self-rescue mouthpiece respirator (filter)* — It is designed for self-rescue from atmospheres having immediately dangerous concentrations of toxic particles. Mouth breathing prevents detection of contaminants by odour. The nose clip shall be securely fixed in place to prevent nasal breathing. No protection is provided to the eyes.

7.1.1.3 *Combination particulate and vapour-and-gas removing respirators* — The advantages and disadvantages of the component parts of the combination respirator as described above apply.

7.1.2 *Air Supplying Respirators* — Atmosphere-supplying respirators provide protection against oxygen deficiency and most toxic atmospheres. The breathing atmosphere is independent of ambient atmospheric conditions. Except for the supplied-air suit, no protection is provided against skin irritation by materials such as ammonia and hydrogen chloride, or against absorption of materials such as hydrogen cyanide, tritium, or organic phosphate pesticides through the skin. Facepieces present special problems to individuals required to wear prescription lenses.

7.1.2.1 *Self contained breathing apparatus* — The wearer carries his own breathing atmosphere. Use is permissible in atmospheres immediately dangerous to life or health. 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 apparatus have a short service life (few minutes) and are suitable only for escape (self rescue) from an irrespirable atmosphere. Main limitations of these respirators are their weight or bulk or both, limited service life, and the training required for their maintenance and safe use.

a) *Closed-circuit apparatus* — The closed circuit operation conserves oxygen and permits longer service life.

b) *Open-circuit apparatus* — 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.

NOTE — Self-contained breathing apparatus can only be used with full face masks or mouthpieces, since half masks or hoods do not have a sufficiently tight connection with the human air passage.

7.1.2.2 *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. The wearer is restricted in movement by the hose or air-line 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.

a) *Hose mask*

1) *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.

2) *Hose mask without blower* — It is limited to use in atmospheres from which the wearer can escape unharmed without aid of the respirator.

b) *Air-line respirators* — 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. Air-line respirators provide no protection if the air supply fails.

c) *Supplied air suit* — These suits protect against atmospheres that affect the skin or mucous membranes or that may be absorbed through unbroken skin. Some contaminants, such as tritium may penetrate the suit material and limit its effectiveness. Other contaminants, such as fluorine, may react chemically with the suit material and damage it. These suits are limited in use to atmospheres not immediately dangerous to life or health.

7.1.2.3 *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.

7.1.3 *Combination Atmosphere-Supplying and Air-Purifying Respirators* — 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 operation even though conditions would require such change.

8. COLOUR CODE FOR CANISTERS AND CARTRIDGES

8.1 The colour coding for identification of different types of canisters and cartridges shall be as prescribed in IS : 8318-1977*.

9. GUIDANCE ON USE OF RESPIRATORY PROTECTION DEVICES

9.0 Some broad guidelines are given below which should be followed.

9.1 The use and fit of a respiratory device requires careful control and where practicable it should be issued on a personal basis.

9.2 Standard procedures should be developed for respirator use. These should include all information and guidance necessary for their proper selection, use and care. Possible emergency and routine uses of respirators should be anticipated and planned.

9.3 Written procedures should be prepared covering safe use of respirators in dangerous atmospheres that might be encountered in normal operations. Personnel shall be familiar with these procedures and the available respirators.

9.4 In areas where the wearer could be overcome by a toxic or oxygen deficient atmosphere due to failure of the respirator, at least one additional man should be present. Communications (visual, voice or signal line) should be maintained between both or all individuals present. Planning should be such that at least one individual will be unaffected by any likely incident and have the proper rescue equipment to be able to assist the operator in case of emergency.

9.5 Fitting of the facepiece is most important and subjects should be properly instructed when first issued with equipment, making sure that all the inspired air is drawn through the device in the proper manner. A satisfactory fit of a full facepiece cannot be expected when spectacles are worn unless spectacles are specially made for the purpose.

9.5.1 To assure proper protection, the facepiece fit shall be checked by the wearer each time he puts on the respirator. This may be done by following the manufacturer's facepiece fitting instructions. The following two simple field tests may also be used.

9.5.1.1 *Positive pressure test* — Close the exhalation valve and exhale gently into the facepiece. The face fit is considered satisfactory if a slight positive pressure can be built up inside the facepiece without any evidence of outward leakage of the air at the seal. For most respirators, this method of leak testing requires that the wearer first removes the exhalation valve cover and then carefully replaces it after the test.

*Colour identification markings for air-purifying canisters and cartridges.

9.5.1.2 *Negative pressure test* — Close off the inlet opening of the canister or cartridge(s) by covering with the palm of the hand(s) or by replacing the seal(s), inhale gently so that the facepiece collapses slightly, and hold the breath for ten seconds. If the facepiece remains in its slightly collapsed condition and no inward leakage of air is detected, the tightness of the respirator is probably satisfactory.

9.6 Potential users of respirators should also be required to test their facepiece fit by wearing the respirator under realistic test conditions. A concentration of 100 parts per million isoamyl acetate vapour may be prepared in a man test chamber, a small plastic enclosure or in a vacant room. If the person wearing the respirator can enter and remain in this test atmosphere without detecting the odour of isoamyl acetate, he has a good fit. If he detects the odour, he should retreat to fresh air, readjust the facepiece, and repeat the test. If leakage is still noted, it can be concluded that the particular respirator will not protect the wearer. The wearer should not continue to tighten the head band straps until they are uncomfortably tight, simply to achieve a gas-tight face fit. If fitted too tightly for the above test, the wearer may not use the respirator when it is really needed or may wear it fitting comfortably loose and without a gas tight seal.

9.7 Particulate filter respirators can frequently be adopted for use with chemical cartridge and may also be tested for fit in isoamyl acetate atmosphere.

9.8 The fit of a respirator provided with a high efficiency particulate filter may be checked as follows. The smoke from a smoke tube is directed at the facepiece seal and leakage is indicated by irritation of the throat and lungs. (When testing half-mask facepiece, do not direct the smoke into the eyes; and instruct the wearer to keep his eyes closed during the test.) The glass tube containing stannic chloride on pumice is scored at each end for easy breaking. A squeeze bulb with a short rubber tube aspirates air through the tube. Visible smoke is immmediately formed by contact with moisture in the air. Freshly produced smoke particles from this tube range from less than 0·1 to 3 microns in diameter. The irritant is hydrochloric acid absorbed on the particulate. A similar smoke is produced with sulphur trioxide or titanium tetrachloride tube.

10. TRAINING AND EDUCATION IN PROPER USE OF RESPIRATORS

10.1 A wearer should be trained in the correct way to use and adjust respiratory protective devices. Instructions should also cover the following:

i) How to recognize the need to wear a device,

ii) The importance of wearing the device,

iii) Principle on which the device operates and its essential parts,

iv) The field of use and limitations of the device,

v) The probable time over which it will provide protection,

vi) How to recognize faulty functioning,

vii) What to do under emergency conditions which may be brought about by his work or by accident to his protective equipment, and

viii) The necessity for proper handling, maintenance and cleaning of the equipment.

11. MAINTENANCE AND CARE OF RESPIRATORS

11.1 Respirators should be properly maintained to retain their original effectiveness. A programme for maintenance and care of respirators should be adjusted to the type of plant, working conditions, and hazards involved, and should include the following basic services:

i) Inspection for defects (including leak check),

ii) Cleaning and disinfection,

iii) Repair, and

iv) Storage.

11.2 Inspection

11.2.1 All respirators should be inspected in routine before and after each use. A respirator that is not used in routine but is kept ready for emergency use should be inspected after each use and at least once a month to ensure that it is in satisfactory working condition.

11.2.2 Self-contained breathing apparatus should be inspected monthly. Air and oxygen cylinders should be fully charged according to manufacturer's instructions. It should be ensured that the regulator and warning device function properly.

11.2.3 Respirator inspection should include a check of the tightness of connections, and the condition of the facepiece, head harness, valves, connecting tube and canisters. Rubber parts should be inspected for pliability and signs of deterioration. Stretching and manipulating rubber parts with a massaging action will keep them pliable and flexible and prevent them from taking a set during storage.

11.2.4 A record should be kept of inspection dates and findings for respirators maintained for emergency use.

11.3 Cleaning and Disinfection

11.3.1 Routinely used respirators should be collected, cleaned and disinfected as frequently as necessary to ensure that proper protection is provided for the wearer. Each worker should be briefed on the cleaning procedure and it should be ensured that he will always receive a clean and disinfected respirator. Such assurances are of greatest significance when respirators are not individually issued. Respirators maintained for emergency use should be cleaned and disinfected after each use.

11.3.2 The following procedure is recommended for cleaning and disinfecting respirators:

i) Remove any filters, cartridges or canisters.

ii) Wash facepiece and breathing tube in cleaner-disinfectant or detergent solution. Use a hand brush to facilitate removal of dirt.

iii) Rinse completely in clean, warm water.

iv) Air dry in a clean area.

v) Clean other respirator parts as recommended by the manufacturer.

vi) Inspect valves, head harness and other parts, and replace with new parts, if defective.

vii) Insert filters cartridges, and canisters, new if necessary; make sure that the seal is tight.

viii) Place in plastics bag or container for storage.

11.3.2.1 Strong cleaning and disinfecting agents can damage respirator parts. Temperatures above 85°C and vigorous mechanical agitation should not be used. Solvents which affect rubber parts should be used with caution.

11.4 Repair — Replacement or repairs should be done by experienced persons with parts designed for the respirator. No attempt should be made to replace components or to make adjustment or repairs beyond the manufacturers recommendations. Reducing or admission valves or regulators should be returned to the manufacturer or to a trained technician for adjustment or repair.

11.5 Storage

11.5.1 After inspection, cleaning and necessary repair, respirators should be stored to protect against dust, sunlight, heat, extreme cold, excessive moisture or damaging chemicals. Respirators placed at stations and work areas for emergency use should be stored in compartment built for the purpose, be quickly accessible at all times and be clearly marked. Routinely used respirators, such as dust respirators, may be placed in plastics bags. Respirators should not be stored in such places as lockers or tool boxes unless they are in carrying cases or cartons.

11.5.2 Respirators should be packed or stored so that the facepiece and exhalation valve will rest in a normal position and function will not be impaired by the rubber parts setting in an abnormal position.

11.5.3 Instructions for proper storage of emergency respirators, such as gas masks and self-contained breathing apparatus are found in the " use and care " instructions usually mounted inside the carrying case lid.

12. SPECIAL PROBLEMS IN USE OF RESPIRATORS

12.0 There are some special problems in the use of respirators which need careful consideration and these are mentioned below.

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 should not be allowed.

12.2 Eyewear with Half Mask Facepiece — If corrective spectacles or goggles are required, they should be worn so as not to affect the fit of the facepiece. Proper selection of equipment will minimize or avoid this problem.

12.3 Respirator Use in Low Temperatures — Major problems in the use of the full facepiece at low temperatures are poor visibility and freezing of exhalation valve. All full facepieces are designed so that the incoming fresh air sweeps over the inside of the lenses to reduce fogging. Otherwise, it would be impossible to wear a full facepiece in ordinary room temperatures without severe fogging. Antifog compounds can be used to coat the inside of the lense to prevent fogging at room temperatures and down to temperatures approaching 0°C. However, below 20°C antifog compounds will not prevent severe fogging.

12.3.1 Full facepieces are available with nose cups that direct moist exhaled air through the exhalation valve. A properly fitted nose cup should provide satisfactory or adequate visibility at temperatures down to 0°C.

12.3.2 At very low temperatures, the exhalation valve may collect moisture and freeze open, allowing the wearer to breathe contaminated air, or freeze closed, preventing normal exhalation. Dry respirable air should be used with contained breathing apparatus or air line respirators at low temperatures. The dew point of the breathing gas should be appropriate to the ambient temperatures.

12.3.3 High pressure connections on self-contained breathing apparatus may leak because of metal contraction at low temperatures. The connections should not be overtightened since they may break when temperature returns to normal.

12.4 Respirator Use in High Temperatures — A man working in areas of high ambient temperature is under stress. Any additional stress resulting from the use of respirators should, therefore, be minimized. This can be done by selecting and using respirators having minimum weight and breathing resistance. Supplied-air respirators and hood and suits having an adequate supply of cool breathing air are recommended.

12.5 *Communications*

12.5.1 Although conventional respirators distort the human voice to some extent, the respirator exhalation valve usually provides a pathway for some speech transmission over short distance in relatively quiet areas. Talking can induce facepiece or component leakage and therefore, should be limited while wearing a respirator, especially those with half-mask facepiece.

12.5.2 Mechanical speech transmission devices called speaking diaphragms are available as an integral part of some respirators. These consist of a resonant cavity and diaphragm which amplify sound in the frequency range most important to speech intelligibility. The diaphragm acts as a barrier to the ambient atmosphere. It should be carefully handled and protected by a cover to prevent puncture.

12.5.3 Various methods of electronically transmitting speech from the respirator are available. Respirators with electric or electronic speech transmission devices having an integral or body attached battery power supply should be used with caution in explosive atmospheres. Sealed power sources should be checked for integrity of seals. Connecting cables from microphones inside the facepiece should have gas tight seals where they emerge from the facepiece. When the loudspeaker diaphragm is part of the barrier between the respirator wearer and the ambient atmosphere it should be frequently inspected for leakage and should be adequately protected from puncture or rupture. The assembly of an electronic or electrical speech transmission device into a respirator should be avoided if it results in a centre of gravity and moment of inertia such that the mask may be dislodged from the face during wearer's activity in a toxic environment. Removal of speech transmission devices may allow contaminant leakage into the facepiece.

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Panel for Respiratory Protective Equipment, ISAC/S-2 : P1

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INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

Quantity	*Unit*	*Symbol*
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

Quantity	*Unit*	*Symbol*
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	*Unit*	*Symbol*	*Definition*
Force	newton	N	1 N = 1 kg. m/s^2
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2