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Serial No. 2489

June, 1923.

REPORTS OF INVESTIGATIONSDEPARTMENT OF THE INTERIOR - BUREAU OF MINESCOMPARISON OF GAS MASKS, HOSE MASKS, AND OXYGEN-
BREATHING APPARATUS

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Three types of respiratory apparatus - namely, gas masks, hose masks, and self-contained oxygen-breathing apparatus - are now commonly used for protection from noxious gases, vapors, and smokes or mists, but no particular type can be selected as best for all conditions. Many factors must be considered in connection with each situation, so that each must be considered as a problem in itself. Following are concise statements for comparing the types:

1. Gas masks are the simplest and easiest to wear, also the least cumbersome; but they protect only in comparatively low concentrations of noxious gases and should never be used where the air contains less than 16 per cent of oxygen. Special masks give protection from one gas or class of gases, but may give no protection against another gas or class of gases.

2. Hose masks protect in any irrespirable atmosphere, but are somewhat cumbersome, the length of hose limiting the distance a wearer may go from fresh air. They are serviceable also where a supply of pure air moves with the wearer, as where a locomotive engineer in a smoky tunnel is using a hose mask supplied with air from the compressed air line of the locomotive. Hose masks consume no chemicals or materials and so are not limited in the time they may be used.

3. Self-contained oxygen-breathing apparatus protect in any irrespirable atmosphere, but their weight is cumbersome, they can be used only by trained men, and frequent attention must be given them to maintain good working condition. On the other hand they are the only safe means for exploring mines and other places filled with irrespirable gases in high concentrations.

More complete statements concerning the properties of each apparatus in the light of various considerations are listed for easy comparison in the table herewith. It will be noted that gas masks are divided there into four classes - namely, (1) for organic vapors; (2) for acid gases; (3) for ammonia; and (4) for carbon monoxide. In general, masks for any one type of gas can not be substituted for those of another

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type, therefore care must be exercised in using the proper canister and men likely to be called upon to wear masks should be informed of these facts. Exact information concerning the purpose of a mask and the use to which it may be put are necessary in all cases to ensure safety. This table will aid in selecting the type of apparatus best suited for the condition to be met.

The Department of the Interior advises that two or more men similarly equipped should always be present when a man enters an irrespirable atmosphere, regardless of the type of apparatus worn. Life lines should be attached to persons entering tanks and similar places and held, when it is possible to do so, by two or more observers to guard against accident.--Reports of Investigations, Department of the Interior, Bureau of mines.

Comparison of advantages and limitations of gas masks, hose masks, and oxygen-breathing apparatus.

<u>Conditions</u>	<u>Gas masks</u>	<u>Hose masks</u>	<u>Oxygen-breathing apparatus</u>
Protection in atmospheres deficient in oxygen (less than 16% oxygen).	Gas masks do not protect against atmospheres deficient in oxygen and should not be used therein. They serve only as filters for removing comparatively small amounts of irrespirable gas from air that is otherwise normal.	Hose masks protect against all deficiencies of oxygen, since they are not dependent on the air surrounding the wearer.	Oxygen-breathing apparatus protect against all deficiencies of oxygen, they are not dependent on surrounding air, hence they are vitally important in exploring and rescue operations in mines after explosions and fires.
Protection in low concentrations of organic vapors, such as aniline, benzene, ether, toluene, gasoline, and the like (average 2% in air).	Gas masks with canisters containing 600 cubic centimeters or more of activated charcoal protect. The time of protection decreases rapidly as the concentration increases. Canisters containing gas absorbents other than activated charcoal are useless.	Protect against any concentrations.	Protect against any concentration.
Protection in high concentrations of organic vapors (exceeding 5% in air).	Gas masks do not protect sufficiently well to assure safety. They should not be used.	do.	do.
Protection in low concentrations of acid gases such as chlorine, formic acid, hydrogen chloride, hydrogen sulphide, nitrogen peroxide, sulphur dioxide, and the like (average 1% in air).	Gas masks with canisters containing 600 cubic centimeters or more of soda-lime or caustic soda fused on pumice granules protect. The time of protection decreases rapidly as the concentration increases. Canisters of dry activated charcoal last only about 1/5 as long as soda-lime.	do.	do.
Protection in high concentrations of acid gases (exceeding 2% in air).	Gas masks do not protect sufficiently well to assure safety. They should not be used.	do.	do.
Protection against ammonia gas (not exceeding 3% in air).	The above mentioned gas masks containing lime, soda, and charcoal absorbents do not protect against ammonia. Special gas masks for the purpose are required. The 3% maximum can not be long endured by the wearer of the mask because of the severe skin irritation from ammonia gas.	Protect against any concentration that the skin will bear.	Protect against any concentration that the skin will bear.
Protection against carbon monoxide (not exceeding 3% in air).	Special gas masks containing Hopcalite which catalyzes the action of carbon monoxide with oxygen of the air to produce relatively harmless carbon dioxide, protect against carbon monoxide. They have some action on hydrogen sulphide and some other gases but can be considered safe for use only in carbon monoxide. The masks protect against concentrations exceeding 3% but the intense heat produced can not be long endured.	Protect against any concentration.	Protect against any concentration.

Comparison of advantages and limitations of gas masks, hose masks, and oxygen-breathing apparatus. (Cont'd)

<u>Conditions</u>	<u>Gas masks</u>	<u>Hose masks</u>	<u>Oxygen-breathing apparatus</u>
Protection against mixtures of the above gases in air.	Canisters containing two or more of the above mentioned adsorbents protect against more than one gas or class of gases, but the total concentration of mixed irrespirable gases in air should not exceed that allowed by the lowest maximum figure for any of the classes included. When more than one adsorbent is contained in a canister the action of each is usually independent of the others and its capacity dependent upon its volume. Thus the capacity of the canister containing a mixture of adsorbents is less for a single gas than that of the canister filled only with the suitable adsorbent.	Protect against any concentration.	Protect against any concentration.
Protection against dusts, smokes and mists.	Canisters containing cotton-wool filters protect.	do.	do.
Is knowledge of concentrations necessary to assure safety?	A knowledge of the concentrations of gas and vapors is necessary to assure that the wearer does not exceed the capacity of his gas mask to protect.	Not necessary.	Not necessary.
Instruction in use of apparatus needed by wearer to assure his safety.	Very little instruction is needed, since the gas mask is relatively simple. Care must be exercised that the right type of container is used.	Very little instruction is needed	A thorough course of instruction is needed, combined with training. It should cover a period of several days under an experienced and competent instructor. The Bureau of Mines is prepared to give instruction without cost to qualified persons.
Training needed to assure safety.	Very little training is needed. A few trials at adjusting the mask and noting its tightness by closing the canister inlet with the hand and inhaling to test for leakage, suffices. No air should enter under these circumstances. Similar tests should always precede entrance to irrespirable gases and they should be cautiously entered while making sure that the mask works properly.	The statement under gas masks also applies to hose masks. If a blower is used to force air to the wearer the effects of leaks are minimized, because they are then outward.	Thorough training in the use of oxygen breathing apparatus combined with instruction is needed at the hands of experienced and competent men.

Comparison of advantages and limitations of gas masks, hose masks, and oxygen-breathing apparatus. (Cont.)

<u>Conditions</u>	<u>Gas masks</u>	<u>Hose masks</u>	<u>Oxygen-breathing apparatus</u>
Mechanical attention required to maintain good condition.	Very little attention is needed. Care should be exercised that no leakage exists, since negative pressure occurs during inhalation.	Very little attention is required.	Apparatus should be examined, tested and overhauled as needed, at intervals of about one month by a skilled mechanic or other competent person who understands thoroughly the action and function of each part. Failure to keep an apparatus in perfect adjustment may jeopardize the wearer.
Weight of apparatus	About 4 to 8 pounds, according to size of canister and style of support.	Depends upon length and type of hose. The wearer, however, supports only about 5 pounds.	30 to 45 pounds for various types of two-hour apparatus, half-hour apparatus weigh 15 to 17 pounds.
Encumbrance to wearer.	Interferes relatively little with movements.	The hose is an impediment in some situations, especially when space is cramped or beams, pipes, or corners are numerous.	Encumbrance is considerable; in the heaviest types, especially, the weight becomes tiresome after a time.
First cost of apparatus.	\$15 to \$50 according to manufacture and special features.	About \$75.	About \$160 to \$225 for two-hour types, about \$125 for half-hour types. Accessories such as oxygen tanks and pumps may add to the expense.
Cost of adsorbents and oxygen.	New canisters cost about \$2 to \$10 according to size and kind of adsorbent.	No cost.	Oxygen costs about 2 cents per cubic foot of gas at atmospheric pressure, soda-lime costs about 35 cents per pound or \$1.40 per charge
Cost of upkeep.	Practically no cost until worn out by use or rubber becomes useless through age.	Practically no cost until worn out by use or rubber deteriorates through age.	Periodic attention and adjustment create some cost of upkeep. Rubber parts deteriorate with age and require replacement when leaks appear.
Safe period of continuous service.	The safe period may range from about $\frac{1}{4}$ to several hours or even days, being inversely proportional to the concentrations of gases encountered for all masks except carbon monoxide masks. The latter are useful for only 2 to 6 hours, according to size of canister, regardless of any or no concentrations of carbon monoxide encountered.	There is no limit to the safe period.	Oxygen breathing apparatus are made in two sizes, rated for $\frac{1}{2}$ and 2 hours minimum continuous supply of oxygen. When discharged they require renewal of oxygen and chemical charges.