

Results.						Volume of Gas leaking, in Litres, per Minute. Orifice-size, .07 in. dia.	
Pressure, in Inches, of Water.							
1	..	..	..	..	..	..	.8
2	..	..	..	..	..	..	1.3
4	..	..	..	..	..	..	1.6
5	..	..	..	..	..	..	2.2

During the life of any apparatus permitting a negative pressure to exist in the circulating-tubes, leakage of a dangerous character, either due to accident or wear-and-tear, may occur; and, as has just been demonstrated, a very small aperture will permit volumes of considerable extent to be sucked into such an apparatus.

It is interesting to note how far such leakages may become dangerous. In ordinary practice in galleries where smoke is employed leakage may produce no symptoms of discomfort, because the solid matter in the smoke—the CO₂ and sulphur-fumes—may all be absorbed by the absorbent cartridge, and there remains sufficient oxygen in the pungent atmosphere to produce no ill effect. Further, the atmosphere in the practice gallery does not, as a rule, contain any carbon-monoxide. An apparatus, then, possessing a serious leak may be passed as perfectly sound in the practice gallery as usually employed for training.

Let me direct your attention now to the behaviour of an apparatus possessing a leak in the negative-pressure zone when used underground in atmospheres containing carbon-monoxide, or devoid of oxygen.

A man absorbs, if moving quietly about (at the rate of three miles per hour), 1,000 c.c. of oxygen per minute, and with violent exertion as much as 3,000 c.c. (Some definite data on this subject is available in a paper written by Drs. Gordon Douglas and Haldane.*) Take a case in which an apparatus possesses a leak of 1 litre per minute, which is employed in atmospheres containing different percentages of carbon-monoxide. Assuming, as is probable, that about three-fourths of the CO leaking into the apparatus is absorbed by the blood, the following is the approximate period which a man could remain in such an atmosphere before becoming incapacitated (according to Dr. Haldane). When 450 c.c. of carbon-monoxide have been absorbed a man would be stumbling about quite helpless and stupid, as his blood would be at least 50 per cent. saturated.

Percentage of CO in Atmosphere.						Time to produce Incapacitation. (450 cc. absorbed — Incapacitation.)	
1/2	..	..	..	..	..	..	2 hours.
1	..	..	..	..	..	..	1 hour
2	..	..	..	..	..	..	1/2 hour.
3	..	..	..	..	..	..	20 minutes.
4	..	..	..	..	..	..	15 minutes.
5	..	..	..	..	..	..	12 minutes.

On the other hand, if the atmosphere contains no carbon-monoxide, but is devoid of oxygen, as in an atmosphere of firedamp or black-damp, with the supply of oxygen 2 litres per minute, as is usual in rescue apparatus of this type, the man would still be in great danger of falling down unconscious during any considerable exertion, and this would be so even if the leakage were much less than 1 litre per minute. For as soon as the oxygen consumption equalled 2 litres per minute, the apparatus would rapidly fill with firedamp or nitrogen, and, instead of the man being checked in his work by the bag becoming too empty for comfortable breathing, he would very soon be breathing freely an atmosphere containing a dangerously low percentage of oxygen. The result of this would be that he would fall down unconscious before he was aware of his danger. The larger the leak, the more rapidly and certainly would this occur, although during rest or slight exertion there would be no danger except from enormous leakage.

In the case of an apparatus possessing positive pressures throughout, small leakages are harmless, and can be easily detected. The breathing-bag becomes deflated, and a man wearing the apparatus finds it difficult to breathe. In this manner the wearer's attention is drawn to the defect, and in the case of a small leak, such as would prove fatal in a negative-pressure apparatus, ample opportunity is afforded the wearer to quietly withdraw to a place of safety.

It appears quite clear that any apparatus which will permit of leakage from the outside to the inside may become a source of considerable danger, and, as it is extremely difficult to detect or guard against such leaks, any apparatus of this character should be avoided; indeed, in no circumstances should an apparatus possessing an injector be used for mine-rescue work.

A large number of such apparatus (Meco and Draeger) are already being used in mines in this country, and immediate steps should be taken to convert them to positive-pressure apparatus; otherwise calamities must inevitably occur.

FIREMEN'S CERTIFICATES.

The following memorandum has been issued by the Home Office (United Kingdom) :—

1. After the 1st January, 1913, no person can be appointed to act as fireman, examiner, or deputy, and no person already employed as a fireman, examiner, or deputy can continue to be so employed, unless he has obtained a fireman's certificate as required by the Coal-mines Act, 1911, section 15. This requirement applies to all firemen, examiners, or deputies. No exception is made for persons holding managers' or under-managers' certificates.

A full certificate for a fireman, examiner, or deputy certifies three things—(1) that he can test for gas with a safety-lamp, (2) that he can measure an air-current, (3) that his hearing is good.

* "The Capacity of Air-passages under Varying Physiological Conditions," by C. G. Douglas and J. S. Haldane. *Journal of Physiology*, vol. 45, 1912.