THE USE OF WATER GAS AND OTHER GASES IN FACTORIES—CARBONIC OXIDE POISONING.*

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In recent years there has been great extension of the manufacture and use of water gas and other gases of a similar nature (Dowson gas, Mond gas, Power gas, Producer gas, Blast furnace gas, etc.) for heating furnaces and boilers in factories, driving gas engines, welding, and many other industrial purposes. The particular danger associated with all these gases is that of poisoning by carbonic oxide (carbon monoxide, CO), which is also a constituent of ordinary coal gas. But whereas the proportion in coal gas varies from 4 to 12 per cent, in carburetted water gas it reaches 30 per cent, and in uncarburetted water gas 50 per cent. The other gases named above usually contain from 10 to 25 per cent.

The use of these gases was the subject of an enquiry in 1899 by a Departmental Committee (C. 9164), who recommended in their Report that the manufacture and distribution for heating and lighting purposes of any poisonous gas which does not contain a distinct and pungent smell should be prohibited, and that regulations should be made limiting the proportion of carbonic oxide. In recent Acts authorizing companies and local authorities to manufacture and supply Mond or similar gas for motive or heating purposes it is required that (1) the quantity of carbonic oxide in the gas shall be limited to 14 per cent; and (2) the gas shall be strongly scented. It is made the duty of H.M. Inspectors of Factories to enforce these provisions as regards factories and workshops to which the gas is distributed.

The Annual Reports of the Factory Department during the five years 1899 to 1903 contain references to at least 51 cases, including 17 deaths, of poisoning by carbonic oxide on manufacturing premises; 43 were due to one or other of the gases named above. These casualties were traced to several causes, among which may be mentioned:—(1) Leakage from joints or taps in pipes or flues conveying gas; (2) Gradual escape of the gas into a confined atmosphere, as into a small engine-room or the syphon-pit of the Dowson apparatus; (3) Cleaning of tanks or flues before a sufficient time has been allowed for the gas to escape; (4) Underground situation of flues; (5) Inodorous nature of the gas; (6) Ignorance of the danger from the gas and of the earliest symptoms produced by it; (7) Working alone; (8) Lack of rescue appliances; (9) Incomplete combustion of gas in defective gas ironing machines.

Carbonic oxide poisoning may occur in other ways without inhalation of the particular gases named. Thus danger of this kind may arise in laundries from the use of gas irons, and in workrooms from defective gas fittings and from gas stoves, especially when no provision is made for the products of combustion to be carried away by a flue or chimney. The absence of a chimney in a room greatly increases the risk. Carbonic oxide is found also in lime kilns, cement works (see form of notice *below*), and where braziers and coke fires are used in confined spaces.

Symptoms of Carbonic Oxide Poisoning begin with throbbing of the

* Home Office Memorandum, Form 827, Sept. 1904.

blood vessels of the head, giddiness, palpitation of the heart, and weakness of the limbs. These become greatly aggravated after any exertion. Owing to their insidious onset and the cumulative effect of the gas, the weakness of the limbs may come on without attracting notice, so that the person affected is unable to make good his escape from the poisonous atmosphere.

Headache, anæmia, and defective nutrition may result from the long continued breathing of the gas in amount too small to produce immediate effects, such as might occur from defective gas fittings in work rooms.

The appropriate remedies for poisoning by carbonic oxide are—fresh air, artificial respiration, administration of oxygen, and the application of warmth.

Preventive Measures.—The precautionary measures to be considered must vary somewhat according to the different manner in which the gas is manufactured and used in one and another factory, but the following are of general application :—

1. Notices should be posted up stating the deadly nature of the gas, the symptoms produced by its inhalation, and the best means of rendering aid to those who are "gassed."
2. Persons in charge of any engine worked by gas, or of any apparatus in which it is stored, or otherwise exposed to risk of inhaling carbonic oxide, should be free from any disease of the heart or lungs. Employers would do well to cause such persons to be examined and certified by a medical man.
3. No engine in which the gas is used should be in a confined space.
4. A competent and responsible person should, at stated short intervals inspect all valves and connections, to see that there is no escape of gas; and a signed record with the dates of such inspections should be kept.
5. The openings giving access to any part of the gas circuit should be few, and in positions as safe as possible, and opened only in cases of real need and by responsible persons.
6. No workman should enter, or approach when opened, the holder or other part of the gas circuit until the gas has been well flushed out by fresh air.
7. A cylinder of compressed oxygen, fitted with a piece of rubber gas-tubing and a mouthpiece, should be kept in constant readiness. Such cylinders can be obtained fitted also with a reducing valve.
8. Medical aid should be summoned immediately, but in view of the importance of losing no time in commencing treatment, the workmen employed should be instructed by a medical man in the manner of administering the oxygen and of performing artificial respiration. They should be especially warned of the danger of exposing the patient to cold.

Respirators are of no avail as a protection against carbonic oxide poisoning.

When, for purposes of rescue, it becomes necessary to enter an atmosphere charged with the gas, the rescuer must protect himself by tying a rope securely round his waist, the free end being held by persons outside, or, preferably, by the use of one or other of the special rescue appliances designed for such work. The principle underlying them is that the rescuer is made to breathe air, or a mixture of air and oxygen, which renders him independent of the poisonous atmosphere immediately surrounding him. Reference to such appliances, which are now kept in many chemical

works, &c., will be found in the Annual Report of the Chief Inspector of Factories for the year 1895, p. 47, and for the year 1896, p. 31.

In towns where the public gas supply is largely charged with water gas, attention to gas fittings in factories and workshops becomes a matter of increased moment.

The following notice, which has been drawn up by the Power Gas Corporation, Ltd., in consultation with the Medical Inspector of Factories to be posted up near the place where danger arises, may serve as a model:—

Danger of Gassing.

Breathing of Producer Gas should be avoided. It is dangerous when breathed in quantity.

The first symptoms produced by breathing the gas are giddiness, weakness in the legs, and palpitation of the heart.

If a man feels these symptoms, he should at once move into fresh warm air, when in slight cases they will quickly disappear.

Exposure to cold should be avoided, as it aggravates the symptoms.

A man should not walk home too soon after recovery, as muscular exertion, when affected by the gas, is to be avoided.

If a man should be found insensible or seriously ill from the gas, he should at once be removed into fresh warm air, and immediate information be sent to the oxygen administrator, a medical man being sent for at the same time.

No man should work alone on any work which would be likely to involve exposure to the gas. Should the nature of the work cause the man to enter a culvert or hole, he should have a rope tied securely round his waist, held at the other end by his mate standing outside.

Use of the Oxygen Cylinder.

The cylinder should be provided with a lever key, nipple and union, together with a rubber tube at the end of which is a mouthpiece. It is also advisable to have a small pressure gauge attached to the cylinder, so that loss of oxygen may be observed and the cylinder kept in working order.

Open the valve gradually by tapping the lever key (fully extended) with the wrist until the oxygen flows in a gentle stream from the mouthpiece in the patient's mouth, and allow the oxygen to be breathed until relief is obtained. The lips should not be closed round the mouthpiece, as it is important to allow free egress for surplus oxygen. The nostrils should be closed during inspiration or inflation of the lungs, and opened during expiration or deflation of the lungs, so that the oxygen may be inhaled as pure as possible through the mouth.

If the teeth are set, close the lips and one nostril. Let the conical end of the mouthpiece slightly enter the other nostril during inspiration, and remove it for expiration.

Artificial respiration is sometimes necessary in addition to the oxygen inhalation if the oxygen does not appear to act quickly.

Place the patient on his back, slightly raising the shoulders with a folded coat; remove everything tight about the chest and neck; draw the tongue forward and maintain it in that position. Grasp the arms just above the elbows, and draw them steadily above the head, keeping them on the stretch for two seconds and then folding them and pressing them against the chest for the same length of time. Repeat these movements about 15 times a minute for at least half an hour, or until natural breathing has been initiated, when the oxygen inhalation alone will suffice.

After recovery, oxygen inhalation at intervals should be continued as desired.

Further detail may be needed in connection with particular branches of industry. Thus, in consequence of the constant danger of carbonic oxide poisoning in cement works, the Associated Portland Cement Manufacturers (1900), Ltd., have adopted the following Notice, in addition to somewhat similar instructions to those given above :—

Regular inspection of kilns must be made on opening after being burnt off to see that they are safe for men to work in.

Under normal conditions the kiln is partly and sometimes entirely drawn before the chamber is cool enough to enter to clear for re-loading, and inspection must cover safety, not only as to heat but as to gases. The eye in front of kiln and back eye of chamber must be opened when drawing is commenced, and entrance to chamber must be made cautiously. Should there be the slightest indication of gas, a paper torch must be thrown into the kiln and seen to burn out properly before work therein is commenced. If after several attempts it is clearly shown that a paper torch will not burn freely, the men must not be allowed to enter, and the matter must be at once reported to the manager. This applies more particularly where there is a kiln burning next to the one that is being drawn, but in any case the dampers of the kiln being drawn must be down tight, and precautions taken generally to see that fumes from a burning kiln on the same flue cannot get back into a kiln in which men are at work, and this applies not only to the work of clearing or drawing, but to repair or any kind of work done in or about kilns.

In case of a kiln which has lain cold for a long period, all the above-named precautions must be observed, and, in addition, before men enter the pan or chamber, the drawing eye of the kiln must be opened, and thoroughly freed below so that the air may pass into the charge. Employées are especially warned against adopting the means employed by many persons ignorant of the first principles of resuscitation, *viz.*, placing men on their faces with mouth over a hole in the ground. All such means are strictly forbidden. The administration of stimulants in any form is most dangerous, and is also strictly forbidden.

A POSSIBLE SOURCE OF ERROR IN FAT DETERMINATIONS BY EXTRACTION METHODS.—C. Barthel (*Nord. Mejeri Tidn.*, 18, 1903, No. 35, *Exp. Stat. Rec.*) finds that vigorous stirring of skim milk, as occurs in the Pasteurization of the milk in some Pasteurizing machines provided with stirrers, causes a subdivision of the fat globules ; and that on drying the milk on paper, kaolin, sand, etc., the numerous minute globules thus formed cannot be dissolved out by the ether, presumably because the surface attraction of the absorbing medium cannot be overcome.

The Gottlieb method, on the other hand, gives correct results in the case of such milks, the percentages being from about one-tenth to four-tenths above those obtained by the Adams method, depending upon the fat content of the milk. The greater differences were observed in case of milk containing considerable quantities of fat. When samples of new milk were churned for 5 to 15 minutes at about 48° C., the results obtained with the separator skim milk by the extraction method were 0·18 to 0·44 per cent too low, while the results obtained by the two methods of analysis agreed within 0·01 to 0·04 of 1 per cent when the milk was not subjected to vigorous agitation.