Ozone: health hazards and precautionary measures

Guidance Note EH38

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This guidance is primarily aimed at employers and managers of people exposed to ozone in the course of their work.

It draws attention to the potential ill health which exposure to ozone can cause and indicates potential sources of ozone at work as well as offering advice on the precautions you may need to take to prevent or control exposure.

Other groups, such as employees and health and safety professionals, will also find the guidance useful.

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This guidance is issued by the Health and Safety Executive. Following the guidance is not compulsory and you are free to take other action. But if you do follow the guidance you will normally be doing enough to comply with the law. Health and safety inspectors seek to secure compliance with the law and may refer to this guidance as illustrating good practice.

Contents

Introduction

1 This Guidance Note is particularly aimed at employers and managers of people exposed to ozone in the course of their work. Other groups, such as employees and health and safety professionals, will find this guidance useful. It draws attention to the potential ill health which exposure to ozone could cause and indicates potential sources of exposure at work. It gives advice on the precautions which you may need to take to prevent or control exposure as required by the *Control of Substances Hazardous to Health Regulations 1994* [1] (COSHH). It does not discuss environmental exposure to ozone or atmospheric ozone-depleting substances.

2 This guidance should be read in conjunction with the Approved Code of Practice, *Control of Substances Hazardous to Health* (the COSHH general ACOP) [2].

Occurrence and properties

3 Ozone, 0_3, is a form of oxygen. It is a colourless gas with a distinctive odour and is a normal constituent of the earth's atmosphere. It is about 1.6 times heavier than air (density 2.144 g/l).

4 Ozone is produced naturally from oxygen whenever sufficient ultraviolet (UV) radiation or electrical discharges occur, for example at high altitudes or by the action of lightning. Such natural occurrences are unlikely to produce hazardous concentrations at ground level. The majority of ozone found near ground level is formed by photochemical reactions involving oxides of nitrogen and hydrocarbons.

5 Ozone is an unstable substance, but its rate of decomposition varies widely depending on temperature and humidity. A given ozone output which yields a faint trace of ozone in a workroom atmosphere on a humid day may create an undesirable concentration on a dry day. These factors are important when considering occupational exposure to ozone.

6 Ozone is a powerful oxidising agent and can react explosively with oil and grease. Low concentrations of ozone have a significant effect upon textiles, fabrics, organic dyes, metals, plastics and paints and cause the characteristic cracking of stressed rubber, commonly called 'weathering'. A few substances, such as glass and some grades of stainless steel are, however, resistant to the oxidising effects of ozone.

7 Ozone is not classified under the Chemicals (Hazard Information and Packaging for Supply) Regulations 1994 (the 'CHIP 2' regulations). Ozone cannot be stored or transported in vessels because it decomposes spontaneously in the presence of oxidisable impurities, humidity and solid surfaces. It is always generated *in situ*, for immediate use, and is extremely unlikely to be supplied as a commodity. Labelling phrases are therefore inappropriate.

Effects on health

8 Since ozone is a highly reactive substance, any adverse health effects will be found essentially at the sites of initial contact: the respiratory tract (nose, throat and airways), the lungs, and at higher concentrations, the eyes. The principal health effects are produced by irritation of and damage to the small airways of the lung.

However, people have considerable variation in sensitivity. Uncontrolled exposure to relatively high levels of ozone could lead to more severe health effects, including lung damage. At the levels of exposure likely to be normally found in the workplace the main concern is irritation of the (upper) airways, characterised by coughing and a feeling of tightness in the chest. This guidance on establishing effective risk management measures for controlling exposure to ozone, focuses on the control of exposure to levels at which any health effects, if they did occur, would not be significant (see paragraph 25).

Ozone in the workplace

9 Ozone is produced industrially by bombarding oxygen with UV radiation or by passing air through a high voltage AC electrical discharge. It is used for a wide variety of industrial purposes including the following:

- to improve air quality in offices and as an odour suppresser in hotel bedrooms, commercial kitchens and cafeterias, food and fish processing plants, rubber compounding plants, chemical plants, sewage treatment works and cold stores;
- as a disinfectant in the production of drinking water;
- to overcome taste, odour and peaty colour problems in drinking water;
- as part of the water treatment process in the removal of pesticides;
- as a disinfectant in swimming pools;
- for pre-treatment in coating applications - including inks, wood finishing, metal decorating and general industrial finishing;
- for pre-treatment of plastic surfaces immediately before printing;
- as a bleaching agent in both the textile and foodstuff industries;
- as a reaction initiator in the chemical industry.

Ozone is also produced as an incidental by-product of many industrial activities, some of which are described below.

Ultraviolet radiation

10 During high quality precision welding (including TIG and MIG techniques), metals are arc welded in the presence of a shielding gas. The ultraviolet radiation from the arc produces significant quantities of ozone, the risks of exposure being particularly significant during the welding of aluminium and stainless steel. Titanium is highly reactive and generally welded inside a sealed and inert enclosure.

11 Ozone is also produced near many types of lamp which emit ultraviolet radiation. Such lamps are used in a variety of processes, for example:

- ink curing: some printing inks, varnishes and lacquers are composed of chemicals formulated to polymerise rapidly into hard resins upon exposure to UV radiation;
- projection lamps: high pressure xenon lamps used in cinema projectors emit some UV radiation and also produce ozone.

High voltage electrical equipment

12 Ozone is also produced around high voltage equipment and by electrical discharges in specific processes. Some examples are given below:

- electrostatic precipitators: these are used to remove dust and some airborne contaminants from the air where ozone is produced incidentally;
- static eliminators: these are used in industry to remove static electricity from recently moulded plastic articles. The main factor which determines the amount of ozone generated is the voltage across the collector plates; the higher the voltage the more ozone is produced;
- X-ray machines.

Advice on complying with the COSHH regulations

Control of exposure to the occupational exposure standard (OES)

13 The current OES for ozone is 0.2 ppm in air averaged over a 15-minute reference period. If exposure to ozone cannot be prevented then the exposure by inhalation should be reduced to this standard (0.2 ppm). If exposure by inhalation does exceed the OES, this can still be considered as adequate control provided the reasons have been identified and you are taking appropriate steps to reduce exposure to the OES as soon as is reasonably practicable.

Assessment

14 Regulation 6 of COSHH requires that employers shall not carry out any work which is liable to expose any employees to any substance hazardous to health unless they have made suitable and sufficient assessment of the risks created by that work to the health of those employees and of the steps that need to be taken to meet the requirements of the COSHH Regulations. You will need to carry out a 'suitable and sufficient' risk assessment wherever exposure to ozone is likely to occur.

15 The HSE booklet *A step by step guide to COSHH assessment* [3] describes in general terms how to make an assessment. Guidance is also given in the COSHH general ACOP. An action plan/check list for assessment would involve:

- where is ozone likely to be generated?
- is exposure likely?
- who is likely to be exposed?
- can the exposure be prevented?
- if the exposure cannot be prevented estimate the potential level of exposures (in some cases this may involve personal exposure monitoring). If you can demonstrate that your estimate of exposure is unlikely to exceed the OES, you do not need to take any further action;
- if exposures exceed or are likely to exceed the OES, decide what control measures are needed and take appropriate action. The assessment must be reviewed regularly.

Low risk work activities

16 With some work activities, there may be exposure to small amounts of ozone that is without any significant risk to health. These low risk work activities are mainly encountered in office type environments. They include working with most types

of photocopiers, printers, projectors, X-ray machines (all types: medical, dental, industrial), and some types of room deodoriser.

17 The risks to health are slight - and in general any symptoms shown will be irritation of the respiratory tract. However, employers should be aware that it is possible in certain cases to build up levels of ozone in excess of the occupational exposure standard (OES) in inadequately ventilated rooms (see paragraph 13).

18 Manufacturers and suppliers should provide recommendations on the siting and use of such equipment, and in normal use it is unlikely that you would need do more than comply with the recommendations to ensure the OES is not exceeded. The preferred option is to put the equipment in a dedicated room. Where this is not practicable, it may be necessary to site the equipment in a well ventilated area. However, if the siting is not in accordance with the manufacturers recommendations you should make a more detailed assessment of the potential risks.

19 Ozone oxidises airborne organic matter and inhibits the growth of bacteria (although it does not kill them). To use this effect, slow output ozone generators are often used to improve air quality in offices or to act as a commercial odour suppressor. These generators emit small quantities of ozone: assessment of the most appropriate siting and ventilation should be carried out in the same way as for printers and copiers.

20 Employers need to ensure that, where appropriate, their employees are aware of the precautions required to reduce the risks from exposure to ozone, and the control measures that are used. Employees should be told to report any obvious problems - such as a closed ventilation window in a copier room - to their supervisor or employer.

21 If your risk assessment shows that these are the only sources of ozone in your workplace, and you have followed the above guidance, then you need only keep these measures under review to comply with COSHH.

Higher risk work activities

22 COSHH requires that precautions should be taken for the protection of every employee who may be exposed to hazardous substances. In the case of ozone, experience shows that certain work activities described in paragraphs 9 to 12 will present a significant potential for exposure. Such exposures to higher levels of ozone can cause serious health effects and present a *higher risk to people*. The control measures employers need to take are explained in detail in the rest of this guidance.

Prevention and control of exposure

23 The COSHH Regulations require employers to ensure that the exposure of their employees to substances hazardous to health is either prevented or, where this is not reasonably practicable, adequately controlled.

24 The advice in the following paragraphs should help you when considering prevention and/or control procedures. These should be adapted to suit local

conditions. Arrangements should be made to review the adequacy of precautions taken, particularly if the circumstances of use change or in the light of new technical developments. For instance, the continued use of static eliminators in poorly ventilated rooms can cause a build up of ozone above the occupational exposure limit (OEL).

Prevention of exposure

25 Prevention of exposure to ozone should be the preferred approach. For many processes, the release of ozone into the workplace can be prevented or substantially reduced by its destruction at source.

Control measures

26 Adequate control should be achieved, as far as reasonably practicable, by the use of process or engineering controls. Where these measures are not adequate, you should consider further controls, such as improved systems of work and the use of respiratory protective equipment. Whatever system is chosen, there is a need to check that it is effective and remains effective.

Engineering control

27 Engineering control measures needed will vary depending on the requirements of each workplace. The following methods will adequately encompass most situations:

- Where the source of ozone emission can be defined, for instance the use of ultraviolet lamps in ink curing, it may be reasonably practicable to use local exhaust ventilation close to the source of the emission (with UV lamps this is the lamp enclosure). This prevents or significantly reduces the amount of ozone entering the workroom air. Extracted air may need to be passed through an appropriate filter to remove the ozone before discharge.
- Where the source of ozone is less well defined, or the use of local exhaust ventilation is not reasonably practicable, the workroom should be equipped with adequate general ventilation.
- In plant rooms, where ozone is generated, it is recommended that there is sufficient ventilation to allow potentially dangerous accumulations of gas to be rapidly dispersed.
- During welding operations, it may be possible to reduce the quantity of ozone produced (as an incidental by-product) by shrouding the workpiece to prevent the escape of UV light.

Respiratory protective equipment (RPE)

28 There will be situations where other control measures are either not reasonably practicable or fail to achieve adequate control. In these circumstances the use of RPE is a valid control strategy. For instance, it may be necessary to use RPE when dealing with an ozone leak from a generator, or when undertaking inert gas shrouded welding operations on production plant.

29 The RPE selected should be suitable and manufactured to an appropriate standard. Employees should be properly trained in their use and supervised. The equipment should be regularly cleaned and checked to ensure that it remains effective. Further guidance on the selection and use of RPE is contained in the HSE booklet *Respiratory protective equipment - a practical guide for users* [11] .

Maintenance, examination and testing of control measures

30 Regulation 9 of COSHH requires that every employer who provides any control measure to meet the requirements of Regulation 7 shall ensure that it is maintained in an effective state, in an efficient working order and in good repair.

31 In order to comply with regulation 9 you should ensure that:

- all measures used to control exposure to ozone are maintained in good working order and in good repair (the manufacturer/supplier of the plant should be able to help you with appropriate information);
- competent persons undertake frequent visual checks and periodically carry out thorough examinations of the equipment to ensure they are being maintained adequately;
- all local exhaust ventilation plant is examined and tested at least every 14 months (a record of such tests must be kept for at least 5 years after the date on which they were made).

32 Further general information about LEV is contained in the HSE booklets *The Maintenance, examination and testing of local exhaust ventilation* [10], *An introduction to local exhaust ventilation* [9], and in the COSHH general ACOP [2].

Monitoring exposure

33 The result of a COSHH assessment will help you decide whether there is a need to carry out monitoring. When the COSHH assessment indicates that there might be wide variations of exposure at certain times and in certain operations, then measurement of exposure to ozone might be necessary to confirm that adequate engineering control is being maintained to control the exposure at or below the OES. Any monitoring regime should be planned carefully, and the advice of an occupational hygienist could prove to be useful. General guidance on monitoring and its frequency, and the record-keeping required, is given in the COSHH general ACOP [2]. Detailed advice on monitoring strategies can be found in Guidance Note EH42 *Monitoring strategies for toxic substances* [5] .

Detector tubes

34 Short-term detector tubes capable of measuring ozone are available from a number of manufacturers. They provide an inexpensive and simple method for estimating the concentration of ozone in workplace air over a short time period, and can therefore be useful for making screening measurements to identify peak exposures or potential leaks from machines or control equipment. However, it is generally not valid to use detector tube measurements to calculate time-weighted average exposures for comparison with the OES. Also, ozone measurements made with detector tubes can be relatively imprecise and are susceptible to positive interference from other oxidising agents, for example chlorine and nitrogen dioxide.

35 For personal monitoring the use of a direct-reading instrument or an indirect method is recommended when assessing the pattern and duration of exposure.

Direct reading instruments

36 A wide range of direct reading instruments for measuring ozone are available commercially. Most are fixed-site or transportable instruments that are only suitable for making screening measurements. However, there are some portable instruments available that are suitable for measuring personal exposure. Since direct reading instruments are continuously reading, they can be used for making measurements of time-weighted average exposure over short-term (15 minutes) or long-term (8 hour) reference periods for comparison with the OES.

Indirect method

37 The US Occupational and Health Administration (OSHA) has published an indirect method for measuring personal exposure to ozone for comparison with limit values. OSHA Method 10-214 [7] describes a procedure which involves drawing air through a glass fibre filter impregnated with nitrite. Ozone present in the sampled air oxidises nitrite to nitrate, which is determined by ion chromatography. Precautions should be taken to avoid positive interference by sulphur dioxide or particulate nitrate, which may be present in the test atmosphere.

Health surveillance

38 In general, routine health surveillance is unlikely to be necessary, but employees should be made aware of the possibility of exposure to ozone, and should be encouraged to inform their employer and their doctor if they develop any respiratory problems. People with allergic conditions such as asthma or hay fever might form a sensitive group in which exposure to ozone could worsen their condition.

First aid

39 If a person is overcome by ozone, the following precautions should be adopted:

(a) Remove the person to a warm uncontaminated atmosphere and loosen tight clothing at the neck and waist.
(b) Keep the person at rest.
(c) If the person has difficulty in breathing, oxygen may be given provided that a suitable apparatus and a trained operator are available.
(d) If breathing is weak or has ceased, artificial respiration should be started. Mouth-to-mouth or mouth-to-nose methods should be used.
(e) Seek medical help.

Ozone poisoning should be treated symptomatically. A period of medical observation may be necessary because of the risk of delayed lung damage.

Information, instruction and training

40 To comply with Regulation 12 of COSHH, employers should give all their employees who may be exposed to ozone at work sufficient information, instruction and training to understand the risks to their health caused by exposure to ozone and the precautions which should be taken to avoid or minimise exposure. For example welders may be unaware that the UV radiation from the arc generates ozone and that they could be exposed to it. Employers should provide adequate supervision, particularly to new and inexperienced workers. The training should include details on how control measures are to be used. Employees should be told to report any obvious defects in the control measures to their supervisor. Where RPE is used employees should be trained to check that it fits properly, and given clear instructions about when it should be used, serviced or, if it is disposable, thrown away.

Emergency procedures

41 Emergency action plans should be prepared for all sites where ozone is generated in potentially hazardous quantities. Where leaks from pipes or equipment are detected, ozonators should be capable of being shut down if abnormal operating conditions prevail (for example air drier failure, cooling water failure, excess system pressure). In the event of an ozone leak do not attempt a plant restart until the source of leakage has been identified and rectified. Leak detection by nose is not satisfactory because even slight leaks cause the sensation of smell to be numbed and lead to the false conclusion that a leak no longer exists.

42 Appropriate warning signs indicating the presence of a potential toxic gas hazard should be displayed on ozone plant access doors or in passageways leading to the plant room.

Safety representatives

43 Where trade union safety representatives are appointed under the Safety Representatives and Safety Committees Regulations 1977, they should be consulted by the employer. Such consultations allow the safety representatives to assist employers to develop control measures.

Appendix: references and sources of further information

COSHH Regulations and ACOPs

1 *The Control of Substances Hazardous to Health Regulations* 1994 SI 1994 NO 3246 HMSO ISBN 0 11 043721 7

2 *Approved Code of Practice, Control of Substances Hazardous to Health 5th Edition* 1994 HSE Books ISBN 0717608190

Other COSHH guidance

3 *A step by step guide to COSHH assessment* HSG97 1993 HSE Books ISBN 0 11 886379 7

HSE Guidance Notes, Environmental Hygiene (EH) Series

4 *Occupational Exposure Limits* EH40 1996 HSE Books (revised annually) ISBN 071760876 X

5 *Monitoring strategies for toxic substances* EH42 1989 HSE Books ISBN 0 11 885412 87

6 *Occupational Exposure Limits: criteria document summaries* EH64 1995 supplement HSE Books ISBN 0717608832

Measurement methods

7 US Occupational Safety and Health Administration OSHA Analytical Methods Manual 2nd Edition *Method 10-214: Ozone in workplace atmospheres (impregnated glass fiber filter)* USDOUOSHA Salt Lake City 1995

Health surveillance

8 *Health surveillance under COSHH: guidance for employers* 1990 HSE Books ISBN 0 7176 0491 8

Exhaust ventilation

9 *An introduction to local exhaust ventilation* HSG37 1993 HSE Books ISBN 0 11 8821342

10 *The maintenance, examination and testing of local exhaust ventilation* HSG54 1990 HSE Books ISBN 0 11 8854380

11 *Respiratory protective equipment - a practical guide for users* HSG53

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