OXY-FUEL GAS CUTTING: CONTROL OF FUME, GASES AND NOISE

Paragraph **Contents**

INTRODUCTION

1 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.

2 The objective of producing this document is to increase awareness of the health risks associated with oxy-fuel gas cutting and to offer advice on how these risks may be controlled. All publications referred to are published by HSE unless otherwise stated and can be obtained from HSE Books, PO Box 1999, Sudbury, Suffolk CO10 2WA tel 01787 881165 or via their website http://www.hsebooks.co.uk.

3 Oxy-fuel gas cutting is widely used in the scrap metal industry. While this document contains advice on the associated health risks, for more in-depth guidance *The British Metals Federation Health and Safety Manual* should also be consulted. This however, is available only to members of the British Metals Federation which can be contacted at 16 High Street, Brampton, Huntingdon, Cambs PE18 8TU telephone 01480 455249.

4 This document does not contain advice on the fire and explosion hazards associated with the process. However, it is essential that precautions are taken to safeguard against these hazards. For guidance on this see HSG 139 *The safe use of compressed gases in welding, flame cutting and allied processes* ISBN *0 7176 0680 5* and the free leaflets INDG297 *Safety in gas welding, cutting and similar processes*, INDG327 *Take care with acetylene* and INDG314 *Hot work on small tanks and drums.*

HEALTH HAZARDS

5 Oxy-fuel gas cutting generates fume, gases, noise and infra-red radiation (IR) hazards. This document does not deal with IR hazards.

Fume

6 Oxy-fuel gas cutting produces particulate fume. The nature of the fume depends upon:

(1) the metal being cut;

(2) any coatings that have been applied; and

(3) the presence of contaminates.

Metals

7 The composition of the particulates released is broadly similar to that of the parent metal. Consequently the contribution of the parent metal to the fume varies from metal to metal. For example:

(1) Carbon steel - iron oxide forms the main component of the fume. Chronic exposure to high levels of iron oxide can result in siderosis, a permanent but relatively benign condition which affects the lungs.

(2) Galvanised steel - generates zinc oxide fumes which can cause metal fume fever if exposure is not properly controlled. This is an acute illness of short duration characterised by a dry cough, difficulty breathing, shaking and cramps. Other metals including iron, aluminium and tin can also cause this condition.

(3) Metal alloys containing cadmium - release cadmium fumes. High, short-term exposure to the fumes can cause kidney damage, and inflammation of the lung tissue which can prove fatal.

(4) Stainless steel - is typically cut using an alternative cutting process such as plasma cutting due to the high melting point of the metal oxide. However, should stainless steel be cut using the oxy-fuel gas process chromium (VI) and nickel will be present in the fume. Both substances are associated with the risk of occupational asthma and lung cancer. Asthma is characterised by attacks of breathlessness, wheezing and coughing. There may also be rhinitis (runny nose) and eye irritation.

Coatings

8 Metals can be coated with a wide range of substances which release fume during oxy-fuel gas cutting. The effect of a number of these is summarised below.

Coating	**Possible constituents**	**Health hazards**
Paints	Chromium	Hexavalent chromium can cause ulceration, skin sensitisation, occupational asthma and cancer.
	Lead	Prolonged exposure can result in adverse effects on the blood, kidneys, central nervous system and reproduction.
	Mercury	Effects on the central nervous system and kidney damage.
Plastic	Zinc	Metal fume fever causing flu-like symptoms.
Polyurethane foam	Isocyanates	Occupational asthma.
Oils/greases	Various toxic products	Various long-term effects on the lungs and the body

9 Steel used in metal fabrication is often coated with a primer to minimise corrosion. During oxy-fuel gas cutting the heat generated can cause the primer to thermally degrade resulting in the release of a wide range of pollutants. However, evidence is available which suggests that the compounds involved are of relatively low concentration. The measured concentrations of those compounds which have occupational exposure limits (see paragraph 29-30), appearing to fall within these limits. This therefore suggests that the pollutants released play an insignificant role compared to fume from the parent metal and the formation of gases (see paragraphs 12-16).

Contaminants

10 Where a metal fabrication is contaminated, the high temperatures associated with the process can cause the contaminant to release fumes as it breaks down. Sources of possible contamination include residues of process materials and components used in the manufacture of the fabrication such as rubber seals, electrical wiring and insulation. The range of potential contaminates is therefore extremely wide and varied, as is the fume that may be released.

Fume levels

11 Factors affecting fume levels include:

(1) plate thickness - fume levels increase as the plate thickness increases.

(2) cutting speed - faster the cutting speed greater the rate of fume generation. However, as the job is completed quicker exposure to the fume may be similar to when using a slower cutting speed. A faster cutting speed can also reduce the kerf width resulting in lower dust levels.

(3) process used, ie mechanised or manual cutting - mechanised cutting generates greater levels of fume particularly where multiple cutting torches are fitted.

(4) ventilation available - oxy-fuel gas cutting in a semi-confined or confined space can generate high levels of fume if additional ventilation is not provided.

(5) presence of coatings or contaminants - this is a particular problem in scrap metal, demolition and ship repair industries. High levels of fume can be experienced even when cutting by hand in the open air.

(6) the use of additional cutting materials such as an accelerator - affects both fume levels and composition. Using iron powder will for example result in a slight increase in iron oxide levels due to oxidation of the powder.

Gases

12 The main gases formed during oxy-fuel gas cutting are oxides of nitrogen and carbon. Emissions of these gases are unaffected by whether or not the metal has been coated. However, where the workpiece is contaminated a variety of other gases may also be released (see paragraph 16).

Nitrogen oxides

13 The high process temperature causes oxygen and nitrogen in the air to combine, forming nitric oxide (NO). Where NO levels are high the gas rapidly oxidises into nitrogen dioxide (NO_2). Conversely, if NO levels are low oxidation takes place very slowly resulting in the formation of only low levels of NO_2.

14 Nitric oxide is a severe eye, skin and mucous membrane irritant. Nitrogen dioxide is a highly toxic, irritating gas. There has been some reports of exposure to high levels of nitrogen dioxide (as generated by oxy-fuel gas cutting in confined spaces) resulting in severe ill health and even death. Initial exposure to high concentrations of the gas can however result in only mild irritation followed by a symptom free period of several hours. However, this can develop into a build up of fluid on the lungs which in severe cases can sometimes be fatal. Both nitrogen dioxide and nitric oxide have been shown to have mutagenic potential, which raises possible concerns for lung cancer.

Carbon oxides

15 A large proportion of the oxygen needed for combustion is drawn by the flame from the air. A by-product of the combustion process is carbon dioxide (CO_2). When combustion is incomplete, as when using a reducing flame or when cutting in a confined or semi-confined space, carbon monoxide (CO) may also form. Of the two, carbon monoxide is by far the more hazardous, causing a reduction in the blood's oxygen carrying capacity which can be fatal.

Contaminant gases

16 These gases can be broken down to 2 broad categories:

(1) gases released from the work piece - eg oxy-fuel gas cutting of refrigeration pipe work can result in the release of ammonia gas if the pipe work has not been adequately drained.

(2) gases released by the thermal degradation of surface contamination - oxy-fuel gas cutting of scrap metal containing remnants of diesel fuel or fuel oil may for example, result in the release of sulphur dioxide.

Gas levels

17 A number of the factors affecting fume levels such as cutting speed and available ventilation, have a similar impact on gas levels. Additional factors include

(1) the grade of steel - CO levels increase as the carbon content of the steel increases.

(2) cutting process - unlike manual cutting, mechanised cutting reduces CO levels as the higher pressure and increased oxygen consumption transform it into CO_2. In contrast, fume levels are generally higher with mechanised cutting. The risk from fumes and gases is however greater during manual cutting due to the worker's closer proximity to the torch.

(3) flame length and usage - NO levels increase as the length of the flame increases. The longer the flame remains idle, greater is the rate of NO fume generation.

(4) nozzle size - an increase in the nozzle size can result in an increase in NO levels.

(5) fuel gases - the comparable amount of NO produced by propane is less than that produced by acetylene and natural gas.

Noise

18 Noise is generally only a problem when cutting plate thicknesses above 40-50 mm or when a large number of cutting torches are used simultaneously as in mechanised cutting. In such cases noise levels in excess of 90 dB(A) may result.

LEGAL CONSIDERATIONS

19 The Control of Substances Hazardous to Health Regulations 1999 (COSHH) require a suitable and sufficient assessment to be made of the risks to health generated by oxy-fuel gas cutting. The assessment has to consider the risks to health and how exposure may be prevented or controlled. This should include both fume and gas hazards and take into account the possible impact of the above factors on exposure levels.

20 In reducing the risk to health a hierarchy of measures has to be followed consisting of elimination, substitution, control using engineering means and personal protective equipment (PPE) including respiratory protective equipment (RPE). A combination of these measures may be used however, RPE should only be used as a final measure and then only in addition to other controls.

21 Employers have also to provide their employees with information, instruction and training on the health hazards they are exposed to whilst at work. For oxy-fuel gas cutting this involves making all relevant employees aware of the risks from fumes and gases and the control measures needed. For further guidance on the COSHH Regulations see *General COSHH Approved Code of Practice* (L5) ISBN 0717616703 and free leaflet INDG 136 (rev1) *COSHH - a brief guide to the regulations*. Advice on the COSHH Regulations relating specifically to welding is contained in *Guidance Note EH 54 Assessment of exposure to fume from welding and allied processes* ISBN 0118854291.

22 The Control of Lead at Work Regulations 1998 have similar requirements to those of the COSHH Regulations except they relate exclusively to exposure to lead. In addition, where exposure to lead is likely to be significant they require lead in air and blood-lead concentrations to be monitored. Workers may be suspended if their blood-lead levels rise too high. There are also specific requirements to avoid eating, drinking and smoking in the work area. Further details on these regulations is contained in *Control of lead at work: Control of Lead at Work Regulations 1998, Approved Code of Practice (ACoP), Regulations and Guidance* (COP2) ISBN 0717615065.

23 The Personal Protective Equipment at Work Regulations 1992 require employers to undertake an assessment of risks of injury not controlled by other means. For any such risks, suitable PPE has to be provided free of charge. Additional guidance is contained in *Personal protective equipment at work: Personal Protective Equipment at Work Regulations 1992* (L25) ISBN 0 717604152, and Information Document HSE 668/25 *Personal protective equipment for welding and allied processes: Practical guidance on assessment and selection* obtainable from HSE offices.

24 The Confined Spaces Regulations 1997 (CS Regulations) apply to oxy-fuel gas cutting in a confined space such as a tank or similar fabrication. The CS Regulations in particular require:

(1) the need to avoid entry to confined spaces, where reasonably practicable;

(2) if entry into a confined space cannot be avoided, a safe system of work must be followed; and

(3) adequate emergency (rescue) arrangements must be in place before work starts.

25 For further guidance see *Safe work in confined spaces: Confined Spaces Regulations 1997: Approved Code of Practice (ACoP), Regulations and Guidance* (L101) ISBN 0717614050 and the free leaflet INDG258 *Safe work in confined spaces.*

26 The Noise at Work Regulations 1989 establish 2 action levels:

(1) the first action level - a daily personal noise exposure of 85 dB(A); and

(2) the second action level - a daily personal noise exposure of 90 dB(A).

27 Where employees are exposed at or above the first action level, employers are required to conduct a noise assessment, provide hearing protection and provide training on using the hearing protection correctly. If employees' daily personal exposure exceeds the second action level, in addition to the above the employer has also to take steps to try and reduce the level of this exposure other than by the means of hearing protection.

28 As noise levels are likely to vary, assessment of noise exposures from oxy-fuel cutting needs to be based on the maximum plate thickness that may be cut, the maximum number of cutting heads in use at any one time and the likely daily duration of exposure. Any other contributions to the noise exposure of each employee should be included in establishing their total daily exposure. Further guidance is contained in *Reducing Noise at Work: Guidance on the Noise at Work Regulations 1989* (L108) ISBN 0717615111.

EXPOSURE LIMITS

29 Under the COSHH Regulations specific occupational exposure limits (OELs) are set for certain substances. *Guidance Note EH 40 Occupational Expos*ure *Limits* (ISBN 071761977X (for EH 40/2001)) gives details of the statutory limits, and is revised annually. Substances may have one of 2 types of OEL:

(1) a maximum exposure limit (MEL) - is the maximum concentration of an airborne substance, averaged over a reference period, to which employees may be exposed by inhalation. In addition, employers also have a duty to take all reasonable precautions and to exercise all due diligence to ensure exposure is kept as far below the MEL as is reasonably practicable. Thus, even if exposure is below the MEL additional steps must be taken to reduce it even further, if it would be reasonably practicable to do so.

(2) an occupational exposure standard (OES) - is the concentration of an airborne substance, averaged over a reference period, at which, according to current scientific knowledge there is no evidence it is likely to damage the

health of people exposed to it by inhalation day after day. Control is thought adequate if exposure is reduced to or below the OES.

30 Amongst the OELs listed in EH40 are MELs for exposure to cadmium, nickel and hexavalent chromium and OESs for carbon and nitrogen oxides and welding fume (which by definition includes fume released by gas cutting). By comparing the level of personal exposures with the relevant OEL it is possible to see whether exposure to a substance and hence the risk to health, needs to be reduced further.

CONTROL

Elimination

31 Opportunities to avoid cutting metal are limited, particularly in the scrap metal and demolition industries. In metal fabrication the best preventative measure is likely to be planning the work so that corrections after completion of the work are minimised, eg by cutting steel plate as accurately as possible and by not leaving ‘green’ to be cut off at a later date.

Substitution

32 Alternative methods of cutting metal fall into 2 broad categories; thermal cutting and non-thermal cutting. Before using oxy-fuel gas cutting consideration should be given to whether any of these methods could be used as a means of reducing exposure to noise, fume and gases.

Thermal cutting

33 Alternative methods of thermal cutting include:

(1) plasma arc cutting - gives clean cuts at fast cutting speeds and can be used to cut any metal. Hand-held cutting units are also available. However, the potential levels of fume, noise and radiation are greater than with oxy-fuel gas cutting. Fume levels do though depend on many factors such as arc current, cutting speed, the material being cut and the plasma gas used. For further guidance see Information Document HSE 668/22 *Plasma cutting: Control of fume, gases and noise.*

(2) laser cutting - as the cut itself is fine, gas and fume levels encountered are likely to be lower than with oxy-fuel gas cutting and plasma arc cutting. Noise levels are also relatively low. A high degree of accuracy can be achieved over a wide range of materials. Steel plate up to 20 mm thick can be cut, although for thicknesses over 5-6 mm the process is extremely slow. However, less reprocessing due to more precise cutting and the elimination of thermal distortion compensates for this. The initial capital costs are comparatively high and the process is designed for mechanised use only. Additional risks from using, setting and maintaining the laser and the associated equipment will be introduced and will need to be controlled.

Non-thermal cutting

34 Non-thermal methods of cutting include:

(1) abrasive water jetting - is fume free and capable of cutting a wide range of materials including steel up to 100 mm thick. It produces high quality cut edges which require no subsequent edge finishing. However, as it is a very slow process this advantage is lost when steel plate thicker than 5 mm is cut. The forces generated by the process also make it generally inappropriate for manual use. Portable mechanised units are available so it can still be used for site work. Noise levels greater than 90 dBA are generated. The capital and running costs are also high. Additional risks from the water jet cutter and associated equipment and from any automated equipment for directing the water-jet (robots are sometimes used) will be introduced and will also need to be controlled

(2) mechanical cutting - ie crocodile shears, abrasive cutting discs, pneumatic breakers etc generate less fume but produce high levels of noise and can also expose the operator to dangerous parts of machinery or hand-arm vibration. They have limited application in terms of the thickness of metal they can cut, their degree of accuracy and their inability to cut complex profiles. Their main use is therefore in the scrap metal and demolition industries.

General precautions

35 Before commencing any work with oxy-fuel gas cutting it is essential the associated risks to health are properly assessed. This should include identifying any coatings or contamination that are present and their potential to release harmful fumes or gases. The level of available ventilation should also be assessed along with its impact on fume and gas levels. How the planned work may be completed safely can only be identified once a thorough assessment has been made of the associated risks to health.

36 Employees involved in the process and their supervisors should be made fully aware of the associated risks to health and the required precautions. Where necessary these precautions should be laid down in a documented safe system of work. The work should also be supervised to ensure it is conducted as instructed.

Noise

37 There is little opportunity to reduce noise emissions other than by using proprietary nozzles where the fuel gas and the cutting oxygen ducts have been modified to reduce noise levels. A hood incorporating an acoustic lining can also be fitted above the cutting torch. A window in the hood can allow the operator to observe the cutting process. The hood may be combined with a suction device to provide localised extraction. Where the cutting table is not fitted with an extraction system (see paragraph 45) a honeycomb structure comprising square or rectangular cells may be fitted below the table. The noise generated below the workpiece is radiated into a single honeycomb cell and, provided the workpiece covers the cell completely, is deadened by multiple reflections at the side walls.

Fume and gases

38 Ways to reduce exposure to fume and gases include:

(1) using the correct nozzle;

(2) ensure the flame does not burn at its maximum length, instead try to keep it as short as possible;

(3) extinguish the torch during short working pauses, this may be made easier by using gas economisers with a pilot flame to avoid the need to reset the mixture when relighting the torch;

(4) where there is a choice of possible coatings, select one with lower fume emissions using the coatings' health and safety data sheets;

(5) cover the parts to be cut with tape or plastic film before painting or schedule the painting so that as much of it as possible is conducted after cutting has been completed;

(6) where possible remove any coatings or contaminants from the cutting point prior to commencing the cut (as far as possible use mechanical means, eg scraper, emery paper or, for larger areas, vacuum blasting, although the dust that is released will need to be controlled);

(7) establish what action should be taken if an unknown coating cannot be removed from a work piece (this should include requirements for both LEV and RPE);

(8) increase the length of the cutting torch; and

(9) working with the head outside the plume of fumes and, if working outside, work up wind from where the cut is made.

39 In most situations involving either mechanised cutting, cutting in a confined space or cutting of heavily contaminated materials unacceptable levels of fume and gas are likely to remain, and additional control measures will be needed. However, this can only be decided once the health risks associated with the process have been properly assessed including an assessment of likely exposure levels. Where any relevant OELs are exceeded further control will be required.

40 The 2 main methods of capturing fume and gases are water baths and LEV. Personal protective equipment will be required for any remaining residual risk.

Water baths

41 Water baths can be used to control fumes and gases during mechanised cutting. The jet of combustion products is projected down into the water where most of the fume is captured. The plate can be cut resting either above the surface of the water or partially submerged (the cutting torch however remaining above the water). If hole punching is required the plate needs to be removed from the water. The water level can be readily adjusted to facilitate this. Additional advantages of using a water bath include:

(1) heat stored in the water minimises heat loss, partial vacuums are also avoided, unlike when using LEV;

(2) no filter equipment is required;

(3) any slag on the underside of the plate comes away more easily and the slag can be removed using a slurry exhauster without releasing dust.

42 A more traditional method of trapping the dust is to use air water sprays or water sprays beneath the cutting table. This method is however increasingly being replaced by the use of water baths and LEV.

43 Using either a water bath or a water spray system is associated with the risk of legionnaires' disease. However, there have been no reported incidents. The risk primarily arises where water temperatures are between 20 and 45^{o}C, the water is dirty and agitation of the water during cutting creates aerosols of water droplets. The risk of legionella should be considered in the COSHH assessment. Where such a risk is identified the measures detailed in *Legionnaires' disease: The control of legionella bacteria in water systems: Approved Code of Practice and Guidance* (L8) ISBN 0717617726 should be followed.

44 A disadvantage of water baths and water spray systems is that it can be costly to dispose of the contaminated water. Mild steel plate can also become rusty following contact with water although this can partially be avoided by using an inhibitor in the water.

Local exhaust ventilation

45 In the case of mechanised cutting another method of controlling exposure is to build LEV into the table supporting the cutting grid or bed. The majority of the fume forms below the plate where it is projected by the jet of combustion products. The minimum air velocity at the face of the table should be 0.6 metres/second (measured downwards into the open table at the position where the plate is supported). Such systems can be combined with exhaust hoods fitted around the cutting torch to provide an enhanced level of control over fume and gases.

46 Modular extraction tables are available designed to avoid extracting excessive quantities of air from the workplace. The tables work in sections, each section covering only a limited area. Regulators fitted to each section open and close according to the position of the cutting torch. Air is therefore only extracted from the section immediately below where the cut actually takes place. This type of extraction can be retrofitted to existing cutting machines. An alternative design connects the sections to the exhaust duct via a section of duct which moves in sequence with the torch along a fixed duct with a slotted rubber cover. Systems of this type will require increased maintenance in order to ensure effective operation.

47 The extracted air should not be returned to the workplace as it is not possible to filter out the gases that are also generated. The air should instead be exhausted outside although heat exchangers can be used to capture some of the energy that would otherwise be lost.

48 A similar type of extraction system can be used for hand-held cutting where this takes place in a fixed location such as in a scrap yard. Either an extraction table can be used or the extraction can be located in a pit covered by grating. Air can again be extracted either from the entire area or from the individual sections where cutting is taking place.

49 An alternative method of controlling exposure to fume and gases is to use proprietary LEV systems similar to those designed for use when welding. It is essential however that as the cut progresses the LEV is adjusted to keep the inlet close to where the fumes and gases generate. Further advice on LEV is contained in Guidance Note EH 55 *The control of exposure to fume from welding and allied processes* ISBN 0118854399. It is vital the LEV is properly maintained and undergoes a thorough examination and test at least once in every period of 14 months, for further details see HSG54 *Maintenance, examination and testing of local exhaust ventilation* ISBN 0717614859.

50 Local exhaust ventilation should always be used in preference to RPE which should only be used as an additional control measure and not as a substitute.

Respiratory protective equipment

51 Respiratory protective equipment should be worn where the COSHH assessment identifies a continuing risk to health which cannot be further reduced by alternative means. The RPE should be CE marked, or HSE approved if supplied before I July 1995. It is essential that the RPE:

(1) protects against all the substances identified by the assessment as a risk. In particular it should be determined whether protection is required against gases, fumes or both. Respiratory protective equipment designed solely to protect against particulate fume will not protect against gases (for which air-fed equipment may be necessary);

(2) provides protection against all levels of exposure encountered;

(3) is suitable for the worker, eg provides a good face seal (may be assessed by carrying out a quantitative face fit test) and is compatible with any other equipment which is worn at the same time;

(4) is suitable for the work; and

(5) is properly maintained.

52 Training should be provided in the correct use of the RPE and its limitations.

53 Where work takes place within a confined space and the risk assessment identifies that RPE is necessary, in most cases breathing apparatus will be required. This will be the case for entry into the confined space and for emergency rescue. Further details are available in HSG 53 *The selection, use and maintenance of respiratory protective equipment, a practical guide* ISBN 0717615375.

Personal hygiene

54 The presence of coatings requires a good standard of personal hygiene particularly if they contain lead. Amongst other things this should include:

(1) wearing suitable coveralls and protective gloves which should be stored separately from personal clothing and laundered by special arrangement;

(2) washing hands and face prior to taking breaks and at the end of the shift; and

(3) eating, drinking and smoking in the workplace only in designated areas which are free from contamination.

July 2001