PLASMA CUTTING: CONTROL OF FUME, GASES AND NOISE

INTRODUCTION

1 This document contains internal guidance which has been made available to the public. The guidance is considered good practice but is not compulsory. You may find it useful in deciding what you need to do to comply with the law. However, the guidance may not be applicable in all circumstances and any queries should be directed to the appropriate enforcing authority.

2 The guidance sets out precautions which can be adopted in practice by equipment users to reduce or eliminate the hazards of fumes, gases and noise during plasma cutting.

THE PROCESS AND ITS USE

3 A plasma arc produces a high temperature stream of ionised gas which is capable of cutting a wide range of types and thickness of metal. Cost and performance comparisons to other methods of cutting usually mean that plasma is mostly employed for cutting stainless steel, non-ferrous metals (such as aluminium and copper) and thinner mild steel.

4 A plasma torch may either be hand held or machine directed, most usually in a mechanised profile cutting machine. Hand-held systems are usually only employed for a maximum cutting thickness of about 25mm. Profile machine mounted torches can cut up to about 150mm.

5 Dependent upon the power utilised, plasma torches can cut material in the order of 150mm thick. Such thickness usually means slow cutting rates and is normally only used for stainless steel or non ferrous materials. Plasma cutting of mild steel is typically employed on thinner material (less than 20mm) when very high cutting speeds, in the order of meters per minute, can be employed.

6 Some plasma cutting torches may be used only dry whilst others can also be used underwater (see also paragraphs 28 to 34). Use underwater will reduce cutting capacity both in terms of thickness and speed. However, equipment may often be supplied to a specification in excess of what is strictly required and this might not be a problem.

PLASMA TORCH

7 A plasma torch produces an arc which is struck initially as a pilot arc between a central electrode and the nozzle of the torch. Gas is passed under pressure around the arc and through a restricted opening in the nozzle. This results in a high temperature ionised plasma stream. The arc is thus transferred from the nozzle and passed between the electrode and the workpiece. The constriction of the arc melts

a narrow region of metal which is then blown away by the force of the arc. The torch may be water or gas cooled. Hand-held torches and the smaller torches for mechanised use are usually gas cooled.

PLASMA GAS

8 Pressurised gas passed through the plasma torch nozzle varies in composition. Hand-held torches mostly use air as the plasma gas. Mixtures of argon and either hydrogen or nitrogen may occasionally be used. Air or nitrogen are more usual at mechanised cutting although oxygen and mixtures of argon/hydrogen or argon/nitrogen are all employed. Carbon dioxide may be encountered but is rarely used.

9 In some instances, a second stream of gas may also be employed. The purpose of this secondary gas is to cool the torch, act as a shielding gas and combine with the plasma gas to assist in slag removal. The secondary/shielding gas is often the same as the plasma gas but may be different.

POWER SOURCES

10 Power sources for plasma torches produce direct current at variable levels and high open circuit voltages. Hand-held systems employ sources capable of producing up to 200 amps although those capable of more than 100 amps are rare. Mechanised systems can employ power sources capable of producing up to 1000 amps although most employ 500 or less.

11 Modern power sources for mechanised cutting are invariably capable of 100% duty cycles, ie the ratio between the time that equipment is used for cutting against the availability for use. Sources for hand-held cutting may have duty cycles as low as 50% which will therefore reduce exposure to the hazards described in paragraphs 13 to 18. High duty cycles may be achieved by overspecifying power requirements, ie by using below maximum available power.

MECHANISED PLASMA CUTTING MACHINES

12 Mechanised plasma (profile) cutting machines employ a plasma torch to cut metal plate usually to profiles, ie shapes. The torch is mounted on a gantry and is moved in 2 horizontal axes over plate which is supported on a grid or bed. Machine motion is usually computer numerically controlled. Machine sizes and the power of the plasma torches span a wide range.

HAZARDS GENERATED FROM PLASMA CUTTING

13 Plasma cutting generates fume, gases, noise and ultraviolet radiation (UV) hazards. This document does not deal with UV hazards.

Fumes and gases

14 The nature of fume depends upon the metal being cut and upon any coatings. Cutting of stainless steel is potentially the most hazardous as the fumes will contain chromium and nickel. Copper and its alloys are also commonly cut and can also produce a significant fume hazard. The risks from fumes should be assessed in accordance with HSE Guidance Note EH54 *Assessments of exposure to fume from welding and allied processes* (ISBN 0 7176 0570 1).

15 Oxides of nitrogen are formed during plasma cutting and could accumulate in areas of poor ventilation. These are likely to be most significant during plasma cutting where air or nitrogen is used as the plasma gas. Ozone is most likely to be formed during cutting of aluminium or stainless steel.

16 Where inert gases are used they may accumulate in confined spaces causing an asphyxiation risk. This is most likely to occur when the gas is significantly heavier than air, eg argon/nitrogen mixtures.

17 In poorly ventilated areas, flammable gases may also produce a risk.

18 Gases, particularly oxides of nitrogen, are a more significant hazard at hand-held cutting than at mechanised cutting as the operator is in close proximity to the torch.

Noise

19 Dry plasma cutting can generate high levels of noise with a significant high frequency content. The limited power supplies used with hand-held torches together with the reduced duty cycle mean that noise is less likely to be a problem. The higher power levels employed with mechanised systems produce higher levels of noise. In excess of 100dB(A) is likely to be produced at power levels above 250 amps. The first and second action levels specified in the Noise at Work Regulations 1989 are therefore likely to be exceeded at all except lower power mechanised profile cutting machines.

LEGAL REQUIREMENTS

20 The fumes and gases produced, and many of the gases used in plasma cutting, are substances hazardous to health for the purposes of the Control of Substances Hazardous to Health Regulations 1994 (COSHH). These Regulations set out requirements for the assessment of health risks, the prevention or control of exposure, the use of personal protective equipment (PPE) and information, instruction and training. COSHH also gives legal status to occupational exposure limits for fumes and gases produced during plasma cutting.

21 Where PPE is required, account should also be taken of the Personal Protective Equipment at Work Regulations 1992.

22 Workers using or working near mechanised plasma cutting processes are likely to be exposed above the first and second action levels set out in the Noise at

Work Regulations 1989. These Regulations set out a hierarchy of control measures for reducing exposure to noise which requires assessment of exposure, information and instruction for workers, reduction of exposure by means other than PPE and provision and use of ear protection.

23 If employees' daily noise exposures are likely to be at or above the first action level, the Noise at Work Regulations 1989 require that their exposures are assessed. As the levels of noise produced are likely to vary, assessment of plasma cutting needs to be based on maximum available power as well as likely duration of exposure. It should be appreciated that any other noise exposure of each employee should be included in establishing total daily exposure.

REDUCTION AND CONTROL MEASURES

24 Avoiding the use of excessive power can reduce the levels of noise and fume and help to meet the legal requirements for controlling exposure. High levels of fume are often the result of too much power for the thickness of plate being cut.

25 The type of plasma gas used can also influence levels of fume produced. For a particular thickness of material to be cut and at a specific power level, the use of argon/hydrogen as plasma gas results in lower levels of fume and ought to be considered. Nitrogen produces higher levels and air the most fume.

26 In most instances, unacceptable levels of exposure to fumes, gases and noise are likely to remain, particularly at mechanised cutting, and control measures will be needed.

27 The 2 principal methods of control measure which can be used at plasma cutting are water baths and local exhaust ventilation. Where there is any residual risk, PPE will be required.

Water baths and cutting underwater

28 The grid or bed of a mechanised plasma cutting machine can be built within a water bath so that it can be flooded and cutting therefore carried out underwater. Baths are designed so that the water level can be varied to allow the machine to be set up and cut profiles to be recovered. Level control is normally achieved by introducing air into or releasing it from a submerged air tank.

29 Where aluminium or its alloys are cut, deposits of metal and accumulations of dross in the bath will generate hydrogen. Regular cleaning needs to be carried out and an agitation system is recommended. Hollow spaces under which hydrogen can accumulate should be avoided in the design of water baths and beds. Hydrogen may even accumulate under plates left on a bed.

30 The addition of a corrosion inhibitor will protect the bath and also reduce corrosion when cutting mild steel. Some corrosion inhibitors may break down at high temperatures to produce toxic fumes and these should be avoided for this application.

31 Cutting underwater is a particularly effective control measure. This is capable of reducing noise levels to below 80dB(A); of reducing fumes levels to 10% or less of the dry equivalent; and of some reduction in levels of oxides of nitrogen. These levels of reduction can normally be achieved by cutting under 50mm of water. Further but less significant reductions can be achieved by additional submersion. However, even these levels of control may leave some residual risk from gases which should then be controlled by local exhaust ventilation around the torch.

32 Other advantages of underwater plasma cutting are a reduction in ultraviolet radiation and a reduction of thermal distortion particularly of thinner plate.

33 Dry plasma cutters can cut plate which sits directly on top of water. As most fume generated by plasma cutting is ejected directly below the plate, this method of working will reduce fume levels but reductions in gases and noise levels are unlikely to be significant. The reduction in fume levels may not necessarily achieve adequate control, particularly where high power levels are employed.

34 Retrospective application of underwater cutting is not always possible. The design of dry plasma cutters may not always allow them to be used underwater so manufacturers/suppliers should be consulted before these torches are used in this way.

35 Plasma cutting underwater or on the surface of water may lead to a risk from legionnaires' disease, although there have been no reported incidents. The risk factors are water temperatures between 20 and 45oC, dirty water and agitation of the water during cutting which may produce aerosols of water droplets. If these droplets are contaminated by legionella and are breathed in, infection may occur.

36 These factors should be considered in the COSHH assessment and the Approved Code of Practice L8 The prevention or control of legionellosis (including legionnaires' disease) (ISBN 0 7176 0732 1) should be followed. If the assessment concludes that there is a risk then steps to control it should be taken. Methods of control involve changing the water weekly, and cleaning the tank and adding biocides to the water which are compatible with any rust inhibitors already in use.

Local exhaust ventilation

37 The powerful arc of plasma cutting results in most fumes being emitted below the plate being cut. As a result, down draft high volume local exhaust is necessary for effective control if dry cutting is carried out.

38 At mechanised cutting, local exhaust ventilation (LEV) can be built into the table supporting the cutting grid or bed. A capture velocity of at least 0.75 metres/sec measured at the position where the fume is produced will be required to ensure adequate control.

39 As mechanised cutting beds are often large, this could result in very high volumes of air being extracted. Designs are available which utilise a series of chambers built into the table. The position of the cutting torch actuates dampers which creates air flow only in the chambers in the vicinity of the torch. An alternative

design connects the chambers 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.

40 Detailed design and operation of down draft exhaust tables need to take account of the potential for damage by spatter and offcuts.

41 Where assessment reveals a need for control of exposure to fumes and gases when using hand-held plasma cutting, LEV should be employed. Systems similar in design and application to those employed at welding are most appropriate. Extraction should be placed very close to the source of fumes and gases and, with a long cut, will require frequent repositioning. Filter systems will not remove gases and the unit should exhaust to a safe place. Advice on LEV is given in HSE Guidance Note EH 55 The control of exposure to fume from welding, brazing and allied processes (ISBN 0 11 885439 9).

42 Clearly LEV will not reduce levels of noise and it would therefore be most appropriate for use at lower powered mechanised systems and hand-held cutting where noise is not a significant risk.

43 Local exhaust ventilation requires maintenance if it is to continue to operate effectively. Particular attention needs to be paid to damage, potential leaks and blockage of filters. The rate of extraction at the intended operating position should be periodically tested and compared to the design standard.

Respiratory protective equipment

44 Any RPE to be used should be CE marked or, if the equipment was supplied before 1 July 1995, it should be approved by HSE or meet a standard approved by HSE. The equipment must also give adequate protection against the levels of contamination encountered. It should also suit both the worker and the job to be done.

45 Plasma cutting should not be carried out in a confined space unless a safe system of work has been adopted. A safe system of work may require the use of breathing apparatus. Compressed-air-fed visors or similar devices are not suitable for use in confined spaces, but may be used in other work places.

46 Protection against fume can be provided by respirators designed to protect against particulates. For protection against gases, air-fed equipment will probably be needed.

47 RPE should be well maintained and workers should know how to use it properly. Advice is given in HSE guidance booklet HS(G)53 Respiratory Protective Equipment - A Practical Guide for Users (ISBN 0 7176 1198 1).

REFERENCES

48 Publications mentioned in this ID can be obtained from HSE Books, PO Box 1999, Sudbury, Suffolk, CO10 6FS. Telephone: 01787 881165 or Fax: 01787 313995.

August 1997