Health and Safety Executive OC 668/17

Field Operations Division

To

Agricultural, Factory and Quarries Inspectors

FCG Specialist Inspectors (Occ Hyg)

Railway Inspectors

OZONE AND FUME ARISING FROM WELDING ON ALUMINIUM

This OC provides guidance on the concentrations of ozone and welding fume likely to arise during sustained electric arc welding of aluminium and aluminium alloys.

INTRODUCTION

1 The welding of aluminium and aluminium alloys has become increasingly common, particularly in the manufacture of vehicle trailers and tanks. The majority of aluminium welding involves the use of pure metal or partly alloyed aluminium consumables. The process generates significant levels of ozone, formed by the effect of ultra violet (UV) light on air.

2 The process will also generate particulate fume which will contain substances formed from the consumable and will mainly consist of aluminium oxide. Where aluminium/silicon or aluminium/magnesium consumables are used, or in the manual metal arc (MMA) welding of aluminium, which uses a flux, substances other than aluminium oxide will also be present. Because of this, the occupational exposure standard (OES) of 5mg m^{-3} 8-hour time weighted average (TWA) for welding fume (and not the OES for aluminium metal and oxides of 10mg/m^{-3}) will apply to all aluminium welding processes.

3 The predominant risk associated with aluminium welding is exposure to ozone. Ozone has both an 8-hour TWA OES of 0.1 ppm and a 15 minute short-term exposure limit (STEL) of 0.2 ppm. The STEL is likely to be exceeded at most operations unless there is adequate control.

PROBABLE FUME CONCENTRATIONS

4 The following values are quoted assuming that no control measures (other than natural adventitious ventilation) are being used.

5 Ozone formation only occurs during arcing and the concentration in air drops fairly rapidly during arc extinction usually to below the STEL after 30 seconds. Where welding takes place in semi-confined or confined locations it is highly likely that in most cases the long-term and short-term OESs for ozone will be exceeded (as will the OES for welding fume). During internal welding the reflective surfaces of aluminium vessels and equipment may contribute to an increase in ozone concentrations and the distance at which it is formed from the arc. In other situations concentrations will depend on the welding process employed.

6 MMA welding of alumimium and its alloys is not common but if used for any sustained period will produce welding fume and ozone concentrations in the welder's breathing zone in excess of their respective long-term OESs and the short-term OES for ozone.

7 Wire fed metal inert gas (MIG) welding is often sustained for long runs and concentrations of ozone in the welder's breathing zone will invariably exceed the short-term OES by up to a factor of 3. Welding fume concentrations will vary depending on a variety of factors including the diameter of wire used (this is the main factor affecting the quantity of weld metal deposited), welding set adjustments, the composition of the alloy used, the type of inerting gas used and the operating position of the welder. Down hand welding using 1.6mm aluminium wire at standard welding parameters of 265 amps and 25 volts has produced fume concentrations below 5mg/m^3. For larger diameter wires this figure is likely to be exceeded. Where aluminium alloys containing 0-5% magnesium are used, fume exposures of the order of 10-12 x the OES for welding fume should be expected during arcing time.

8 The figures in paras 1-7 apply to argon arc processes. Where helium is used as the inerting gas, higher welding voltages are necessary and fume emissions will be significantly greater. These may be up to 20 times the welding fume OES during arcing time.

9 Tungsten inert gas (TIG) welding on aluminium and its alloys produces much lower fume emissions (about 10 times less than with MIG welding). However, ozone concentrations will be higher than those encountered in MIG welding, particularly when welding silicone/aluminium alloys.

ASSESSMENT

10 Whilst paras 1-9 provide general guidance, there is always variation in exposure to ozone and welding fume from operation to operation and from welder to welder. When seeking to assess the likelihood of the welding fume or ozone OESs being exceeded information should be obtained on:

(1) duration and nature of work;

(2) diameter of electrode or wire;

(3) current and voltage used;

(4) nature of inerting gas;

(5) nature of electrode metal - pure aluminium or an alloy; and

(6) posture of welder - does the working position leave the operator's head in or out of the welding fume plume?

11 Advice on the calculation of a value for total welding fume concentration which will ensure that all substances are controlled to their respective OESs is contained in Guidance Note (GN) EH 54 *Assessment of exposure to fume from welding and allied processes* paras 28-35 (file 668). This will not however provide a direct means of calculating ozone concentrations.

12 It is normally fairly easy to assess ozone exposure using Draeger tubes. Where the exposure pattern to welding fume and ozone is intermittent it is likely that the best predictor of adequate control, or at least the most convenient is measurement of ozone. Where exposure is fairly continuous, ie routine welding, then assessment should include measuring both particulate fume (8-hour TWA) and ozone (10 minute STEL).

CONTROL MEASURES

13 Where it appears that either the long or short-term OESs for ozone will be exceeded there will be sufficient grounds for requiring local exhaust ventilation (LEV), or respiratory protective equipment (RPE) where the former is not reasonably practicable. Air-fed breathing apparatus will normally be the most appropriate form of RPE.

14 Ozone can be generated at some distance from the welding arc. The particulate fume formed from welding aluminium shields the UV light and hence reduces ozone formation. Conversely, effective control of particulate fume can often enhance ozone formation. Nevertheless the greatest production of ozone occurs close to the arc and LEV at this position should be provided to reduce the exposure below the OESs for ozone in the welder's breathing zone. Adequate general ventilation should ensure that ozone generated beyond the control range of LEV is diluted below OES levels.

15 The control of ozone at MIG processes is best achieved by on-gun extraction. If this type of extraction is not used, and at other processes, it is preferable to extract fume from the plume above the arc. Extraction horizontal to the arc will displace the particulate fume shield thereby increasing ozone formation.

16 Advice on control measures mainly directed at particulate fume control can be found in GN EH 55 *The control of exposure to fume from welding, brazing and similar processes* (file 668).

Annotation of instructions

17 FIC 668/5 - note "See OC 668/17".

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ASI headings

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