Health and Safety Executive **Information Document HSE 668/29**

CONTROL OF FUME ARISING FROM ELECTRIC ARC WELDING OF STAINLESS STEELS

Paragraph **Contents**

INTRODUCTION

1 This document revises and replaces Information Document 668/28, the main changes are at paragraphs 4, 9 and 54-55. The document contains internal guidance which has been made available to the public. The guidance is considered good practice (rather than compulsory) but 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 objective of producing this document is to increase awareness of the health risks associated with welding fume generated by stainless steel welding and to offer advice on how these risks may be controlled. An exposure matrix is provided at the appendix as an easy to use guide to the type of ventilation that may be required. All guidance documents referred to are HSE publications unless otherwise stated and are available from HSE Books, PO Box 1999, Sudbury, Suffolk CO10 6FS telephone 01787 881165, fax 01787 313995 or via HSE Books website www.hsebooks.co.uk.

3 Welding also creates ozone, particularly when a gas shielded process is used. This document does not address the health risks associated with ozone exposure. An assessment should however be made of likely ozone exposure levels and action taken to control this exposure as appropriate. Further advice on these issues is provided by *Ozone: health hazards and precautionary measures* Guidance Note (GN) EH 38 (Revised) (ISBN 0717612066).

4 Additional advice on the health hazards associated with electric arc welding is contained in HSG 204 *Health and safety in arc welding* (ISBN 0717618137).

COMPOSITION OF STAINLESS STEEL WELDING FUME

5 The welding of stainless steel produces a complex mixture of fine, airborne particles. Striking the arc melts the consumable and parent metal. So much heat is generated that some of the consumable is vaporised and becomes airborne. As it cools it condenses and forms small particles that can be breathed into the lungs.

6 The composition of the fume will vary with:

(1) the consumable being used;

(2) the welding process (eg manual metal arc (MMA), flux cored arc (FCA) metal inert gas (MIG), tungsten inert gas (TIG)); and

(3) the composition of the parent material of the component to be welded.

7 The risk of adverse health effects will therefore vary from job to job. It also depends upon the extent, duration, and frequency of exposure.

HEALTH HAZARDS

8 Health hazards from exposure to stainless steel welding fume can be separated into short-term and long-term effects:

Short-term effects - irritation of the eyes and respiratory tract and, if the concentration is particularly high, tightness of the chest and difficulty in breathing.

Long-term effects - chromium (VI) (a type of chromium, also known as hexavalent chromium) and nickel have the potential to cause occupational asthma. Both these substances can be found in stainless steel welding fume.

9 The evidence for the main causes of asthma have been explored in *Asthmagen? Critical assessments of the evidence for agents implicated in* occupational asthma, informally known as the Asthmagens Compendium (ISBN 0717614654). Entries in the Compendium Section D have to undergo scrutiny by independent experts. Stainless steel welding fume has recently been assessed for inclusion in the Compendium. The review identified that the number of cases of asthma associated with stainless steel welding was small compared to the size of the exposed population. As a result it was concluded that stainless steel welding fume **did not** meet the European Union classification criteria required for inclusion as a substance capable of causing asthma. However, due to the presence of chromium (VI) and nickel in the fume some risk of developing asthma remains.

10 Asthma is characterised by attacks of breathlessness, wheezing and coughing. There may also be rhinitis (runny nose) and eye irritation. It is possible that short-term peak exposures may be of significance for the development of occupational asthma. However, once it has developed, subsequent exposures to even very low concentrations of the causative substance may provoke an asthmatic attack. Detailed guidance for health professionals on occupational asthma can be found in GN MS 25 *Medical aspects of occupational asthma* (ISBN 0717615472).

11 There is also concern that long-term exposure to stainless steel welding fume might pose a risk of lung cancer. This view is based on:

(1) historical ill-health data on welders has shown an elevated incidence of lung cancer among stainless steel welders and also welders in general. However, it has not been possible to clearly identify the (potentially highly variable) inhaled fume generated from the welding process as being the cause; and

(2) the presence in stainless steel welding fume of complex metal compounds (particularly those containing chromium (VI) and nickel) which are related to compounds that have given cause for concern regarding carcinogenicity in other industries.

12 The Health and Safety Executive's (HSE) view is that there is no conclusive evidence of significant increased risk of lung cancer to those involved in stainless steel welding under present conditions. However, there is enough known about the exposures involved to merit sensible concern and the need to adhere to best practice.

LEGAL CONSIDERATIONS

13 The Control of Substances Hazardous to Health Regulations 1999 (COSHH) require a suitable and sufficient assessment of the risks to health associated with hazardous substances used or produced in the workplace. Exposure to welding fume falls into the latter category. The assessment should include consideration of the risks to health arising from exposure to fume and ways of reducing this risk to an acceptable level, by preventing or adequately controlling exposure.

14 In reducing the risk to health a hierarchy of measures has to be followed consisting of elimination, substitution, control using engineering means and finally, personal protective equipment (PPE) including respiratory protective equipment (RPE). Further guidance on these issues is given at paragraphs 36-53. Where a control measure is provided such as local exhaust ventilation (LEV), the employer is further required to take all reasonable steps to ensure it is used properly.

15 As exposure to stainless steel welding fumes has the potential to cause occupational asthma health surveillance may also be necessary (see paragraphs 54-57). For further guidance on the COSHH Regulations see L5 (third edition) *General COSHH Approved Code of Practice* (ISBN 0717616703) and *COSHH - a brief guide to the regulations*, leaflet INDG 136 (rev1).

16 The Personal Protective Equipment at Work Regulations 1992 require employers to undertake an assessment of risks to health and safety that have not been adequately controlled by any other means. For any such risks identified, suitable PPE has to be provided free of charge. Further guidance is contained in L25 *Personal protective equipment at work - guidance on regulations* (ISBN 0118863347).

17 The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995 require cases of occupational asthma caused by exposure to stainless welding fume to be notified to HSE, using form F2508A. For further details see L73 *A guide to the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995* (ISBN 0717624315).

18 The Confined Spaces Regulations 1997 (CS Regulations) will apply to welding conducted 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.

19 This document does not advise on confined space working. Guidance on confined space working is given in: L101 Safe work in confined spaces: *Confined Spaces Regulations 1997: Approved Code of Practice* (ACoP*) Regulations and Guidance* (ISBN 0717614050) and Information Document 288/6 (Rev) *Asphyxiation hazards in welding and allied processes.*

EXPOSURE LIMITS

20 Under the COSHH Regulations specific occupational exposure limits (OELs) are set for certain substances. Guidance Note EH 40 Occupational *Expos*ure *Limits* (ISBN 071761977 X (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.

21 Welding fume has an OES of 5 mg/m^3 (8-hour time weighted average (TWA)). The fume generated by stainless steel welding may however also contain

components such as chromium (VI) and nickel. Such substances have specific MELs, 0.05 mg/m^3 (8-hour TWA) in the case of chromium (VI) compounds and 0.5 mg/m^3 (8-hour TWA) in the case of water-insoluble nickel compounds and 0.1 mg/m^3 (8-hour TWA) for water-soluble nickel compounds. The above limits are current as of GN EH 40/2001, cross reference should however always be made to the latest edition of GN EH 40.

22 The overriding duty is to reduce exposure to these substances as far below the MELs as is reasonably practicable. This applies regardless of whether or not exposure to welding fume has already been reduced to the OES. The OES on its own provides an inadequate level of control of exposure to stainless steel welding fume, particularly when welding consumables containing chromium (VI) or nickel are used. Where such consumables are used exposure to chromium (VI) and nickel will have to be reduced so far as is reasonably practicable even if exposure to welding fume is already within the OES of 5 mg/m^3.

ASSESSMENT OF HEALTH RISK

23 It is essential to carry out an assessment of the risks to health to see what action is needed to ensure exposure is adequately controlled. Detailed guidance on the assessment of health risks associated with exposure to welding fume is contained in GN EH 54 *Assessment of exposure to fume from welding and allied processes* (ISBN 0118854291). Paragraphs 29-36 are particularly relevant when assessing stainless steel welding fume.

24 An interactive computer-based training package on the assessment of risks to health from exposure to welding fume is also available. The disc, produced jointly by HSE and The Welding Institute, is aimed to assist small and medium sized companies. While the disc refers to the COSHH Regulations 1988 which have been replaced by COSHH 99, the advice given by the disc is still valid. Further details of the disc can be obtained from HSE Books or from The Welding Institute, Granta Park, Great Abington, Cambridge CB1 6AL, telephone 01223 891162.

25 It is important that all welding operations are assessed including those conducted off-site, for example at clients' premises. Where welding repairs are conducted in a variety of different locations this may make it difficult to make an accurate assessment of exposure on every occasion. In such circumstances an assessment of exposure in a 'worst case scenario' could be made and control measures taken accordingly. It is also essential that every type of welding process used is included in the assessment regardless of the frequency with which they occur. The assessment should also consider the exposure of people working in the vicinity of welders who may also be exposed to the fume.

26 Consumable manufacturers have a legal duty to produce hazard data sheets containing a chemical analysis of substances present in consumable fume including the chromium and nickel content. The consumable supplier is obliged to provide this information to the end user. As up to 90% of welding fume arises from vaporisation of the consumable, it is essential that if this information is not initially provided, it is asked for as it forms the starting point of the assessment. However, hazard data sheets on their own do not form an adequate assessment. The level of risk to health

given the environment in which the welding is conducted and the adequacy of existing controls still has to be assessed.

27 Stainless steels are not normally coated. However, should a coating have been applied to the parent metal this should be considered by the assessment.

28 As part of the assessment a dust lamp (see GN MDHS 82 *The Dust Lamp* (ISBN 0717613623) can be used to highlight the fume, making it possible to observe the fine particles of fume that would not otherwise be visible (visual observations of fume levels without the use of a dust lamp provide an unreliable assessment of exposure levels). By doing so, the dust lamp can provide an indication of the volume and the extent of the spread of fume. It is therefore a useful aid to observing the direction in which fume evolves and moves, and whether this places the welder at higher or lower risk of exposure.

29 However, the dust lamp on its own provides only a simple, qualitative picture of the level of exposure to welding fume, providing only limited information regarding compliance with occupational exposure limits. For this a quantitative assessment of fume levels is also necessary.

30 Using GN EH 54, in combination with the information contained in the hazard data sheets, it is possible to calculate the total welding fume concentration in mg/m3 at which the MELs for any individual components will be exceeded. By measuring the total fume concentration and comparing this with the calculated level, it is possible to assess compliance with the MELs. In practice this will involve all reasonably practicable measures being taken to reduce total welding fume concentration below the calculated level.

31 This is not a precise method for estimating exposure to a specific substance. It is however a suitable means of assessing whether control is adequate without having to use complex analytical techniques. For example, the above calculations may indicate that exposure is either well below the OELs as is likely to be the case with TIG welding or is well above the OELs as may be the case with MMA welding. In such situations it will be possible to identify what action is required to control exposure without having to conduct personal monitoring of exposure to the fume.

32 Detailed individual component sampling may however be necessary where there is doubt whether exposure will be controlled to below the appropriate OEL. Monitoring of individual exposure of welders may also be necessary where appropriate control measures and systems of work have been put in place but risk to health remains. Each situation will have to be judged on its own merits. Further advice on monitoring strategies can be found in HSG 173 *Monitoring strategies for toxic substances* (ISBN 0717614115).

33 Where welding fume exposure is monitored this can involve placing a sampler device behind the welder’s head shield, where one is worn. The fume measurement readings obtained will be affected by, amongst other things, the relative periods of time the welder spends with his/her head in or out of the plume. As this can vary from welder to welder a single exposure measurement may be insufficient to judge if

exposure limits are complied with. Multiple measurements are therefore likely to be necessary unless measurement is based on a worst case scenario.

CONTROL

34 Detailed advice on controlling exposure to welding fume is given in GN EH 55 *The control of exposure to fume from welding, brazing and similar processes* (ISBN 0118854399). In general, it will be necessary to control fume arising from stainless steel welding unless the assessment indicates otherwise.

35 Although exposure to stainless steel welding fume is measured as an 8-hour TWA, short-term peak exposures should be controlled. This is necessary to prevent immediate irritation to the eyes and respiratory tract, and also to reduce the risk of occupational asthma.

36 The options for controlling exposure should be considered in the following order of priority:

(1) choice of the welding process;

(2) improvement in working practices;

(3) engineering control and/or natural ventilation; and

(4) use of respiratory protection equipment (RPE).

37 There will be some circumstances that may require more than one control measure to be used.

Choice of the welding process

38 Process choice is usually made on the basis of weld quality, economics and equipment availability. However, the process selected will have an impact on the quantity and composition of fume emissions.

MMA welding

39 For normal welding operations, fume exposure will generally exceed the OES of 5 mg/m^3 unless additional control measures are in place. Fume arising from MMA welding of stainless steels also contains a higher percentage of chromium (VI) than MIG or TIG welding. The use of LEV is therefore likely to be necessary.

FCA welding

40 The high welding current levels and higher duty cycle normally utilised by FCA welding results in greater levels of fume than with MMA welding. Self-shielded FCA welding may take place outside without the need for fume removal measures provided sensible precautions are taken. However, for gas-shielded welding inside

a building, precautions similar to those for MMA welding will be necessary, such as LEV.

MIG welding

41 The quantity of fume generated varies according to the welding parameters and the mode of metal transfer. If a choice of metal transfer is available the following should be considered:

(1) dip transfer mode operates at a low welding current level and has a characteristic short arc length - fume levels are lower than for MMA;

(2) pulsed transfer mode operates at similar low current levels but in comparison with dip transfer has a longer arc length, increased travel speed and a higher deposition rate. Low fume generation rates can be achieved; and

(3) spray transfer mode operates at much higher current levels and at a greater arc length - higher fume levels.

42 While the fume generated by MIG welding contains less chromium (VI) than that generated by MMA welding and FCA welding, the nickel content is greater. Action is therefore needed to ensure exposure to nickel is reduced to as far below the MEL as is reasonably practicable.

TIG welding

43 Filler metal is added directly to the weld pool. Metal does not therefore pass through the arc resulting in lower fume levels than with MMA, FCA or MIG welding.

44 Under the COSHH Regulations when controlling exposure to a hazardous substance, the priority is to try to prevent exposure, for example by substitution. In many cases the choice of welding process may be dictated by factors out with the control of the welder or the employer. However, where a choice of welding process is available, the process which has the capacity to reduce the level of fume emissions should be chosen, where reasonably practicable to do so. In the case of controlling exposure to stainless steel welding fume this would involve utilising TIG welding where technically possible to do so. Where TIG welding cannot be utilised but MIG welding can, this should be used in preference to MMA or FCA welding.

45 In confined or semi-confined spaces where there may be a risk of asphyxiation should a build up of shielding gases occur, the use of MIG or TIG welding should be avoided where possible. Information Document 288/6 (Rev) *Asphyxiation hazards in welding and allied processes* provides further guidance.

Improvement in working practices

46 A substantial reduction in exposure to fume is possible by placing the workpiece so the welder can avoid the plume that rises above the weld. In large

scale fabrications the welding sequence should be organised to minimise work carried out in enclosed spaces.

47 Generally the higher the electrical energy usage, the greater the rate of fume production. Consideration should therefore be given to whether it is possible to produce equivalent serviceable welds at lower energy levels, provided they remain within the consumable and equipment suppliers' recommendations and fulfil the weld specification.

Engineering control and/or natural ventilation

48 There are several methods of removing welding fume from the workplace consisting of either natural ventilation, mechanical ventilation (extraction fans), LEV or a combination of the three. To ensure exposure is adequately controlled it is essential the correct method or methods are chosen. The exposure matrix given at the appendix is an easy to use guide to making this decision. However, the matrix should only be used once all efforts have been made to reduce the generation of fume by changes to the welding process and improvements in working practices. Consequently it is an integral part of the COSHH assessment rather than a substitute for it. A reassessment will also be necessary to verify the effectiveness of any control measures established.

49 Where LEV is identified as necessary, the following may assist in selecting the type of LEV that will be suitable:

Type of work piece	Suitable local exhaust ventilation
For small work pieces on a bench or jig	Bench top booth (extracted from top or rear) or under bench extraction (where however the work piece effectively blocks off the exhaust inlet, as may be the case with a solid, flat plate an alternative form of LEV should be used).
Type of work piece	**Suitable local exhaust ventilation**
For larger workpieces on a jig or moveable work piece	Walk in booth with extraction from the rear. The best welder position is side-on to airflow. An acceptable position may be with back to airflow. Use of a rotating jig is also effective to ensure the welder is positioned correctly.
For large or immovable workpieces	Point extraction using adjustable trunking and exhaust from piped or mobile extraction units.

50 To ensure the LEV is used effectively the following points should be considered:

(1) welders should be trained in its proper use and be supervised to verify the LEV is correctly used;

(2) hoods or duct inlets should be positioned close to the weld, ie no more than the distance of about one hood/duct diameter away. The hood should also be positioned above the weld to make use of the thermal lift. The necessary constant adjustment may be impossible to achieve with continuous welds of more than a few tens of centimetres;

(3) on-gun extraction may be a viable alternative although it is suitable for only a limited range of jobs, mainly involving down hand welding;

(4) if using an extraction booth work pieces should be fully within the booth;

(5) airflow towards the extraction should not be prevented by the shape of the work piece or by the welder;

(6) where a number of extraction systems are used in the same workplace, they should be carefully selected and sited, to avoid competing with each other; and

(7) all extraction equipment is subject to a statutory thorough examination and test at 14 month intervals. It should also be checked regularly, eg weekly to ensure it is supplying the required airflow. Further guidance is given in HSG 54 *Maintenance, examination and testing of local exhaust ventilation* (ISBN 0717614859).

51 If the welding is conducted in a restricted space (but outside the definition of confined space as defined by the Confined Spaces Regulations 1997), additional care is required when planning and siting LEV. The point of extraction should always be as close to the weld as possible. There should be a free flow of make-up air into the space and it may be necessary to apply fan assistance to achieve this.

52 The capture of fume by LEV can be visualised by using smoke tubes. However, the results must be viewed with care because the quantity, direction and speed of the fume will not be directly mimicked. Alternatively, a dust lamp can be used to highlight the fume, thereby providing a further indication of the extent of fume capture.

Respiratory protective equipment (RPE)

53 Where fume control is required this should be achieved as far as possible by mechanical ventilation. Respiratory protective equipment may also be necessary if, for example, LEV is needed but it is either not reasonably practicable, or its use does not achieve adequate control of exposure. However, RPE is the least preferred means of control because it only protects the wearer and it should be used **in addition to** other control measures. Bear in mind that:

(1) suitable RPE requires careful selection and may have to protect against both particulates and gases. Disposable filtering face piece (FFP) respirators can be worn together with other personal protective equipment (PPE) for welding. At least FFP 2 should be used and care should be taken to ensure that it is compatible with other PPE worn;

(2) the majority of face pieces are available in one size whereas people come in varying shapes and sizes. Where RPE is used which depends on a face seal it is important each welder is personally fitted with the RPE to ensure it provides a tight fit and hence affords adequate protection (this can be further assessed by conducting a quantitative face fit test); and

(3) should be provided in the correct use, storage and maintenance of RPE.

Further information on RPE can be found in HSG 53 *The selection, and maintenance of respiratory protective equipment, a practical guide* (ISBN 0717615375) and Information Document 668/25 *Personal protective equipment for welding and allied processes: practical guidance on assessment and selection.*

HEALTH SURVEILLANCE

54 As discussed in paragraph 8, stainless steel welding fume can contain chromium (VI) and nickel. Both substances have the potential to cause occupational asthma. Health surveillance will therefore be appropriate unless the COSHH assessment identifies that exposure to stainless steel welding fume is most unlikely to result in occupational asthma. The chromium (VI) and nickel content of the fume being central to the assessment. In the case of TIG welding, the very low nickel and chromium (VI) content of its fume make it very unlikely that health surveillance will be necessary. Instead, employers should keep a simple work history record detailing the fact that TIG welding has been undertaken.

55 Where health surveillance is identified as necessary, the level of surveillance required depends upon the degree of risk of developing asthma.

56 Where stainless steel welding takes place infrequently, resulting in very limited exposure to welding fume, a low level of health surveillance will be adequate. This consists of using a questionnaire to find out from employees exposed to the fume about past or present symptoms of occupational asthma (for baseline information). Those employees should also be informed of the symptoms to watch for and advised to report such symptoms, should they occur, to an identified responsible person so that further investigations may be organised to confirm the onset of asthma or rhinitis or not as the case may be.

57 Where stainless steel welding will be frequently carried out (ie many hours will be spent welding stainless steel each week) and the assessment identifies a risk of asthma in relation to a particular welding process or processes, a higher level of surveillance is required. This involves a system of regular enquiry which positively seeks evidence of symptoms of asthma among those employees exposed to the

fumes. The enquiries may be carried out by a properly trained responsible person, such as a first aider, in accordance with the instructions of an occupational health doctor or nurse. Any symptoms identified by the responsible person which suggest asthma, should be referred immediately to the doctor or nurse for further investigation. In addition, it would be prudent to undertake lung function testing prior to commencing the work, to have a baseline for comparison with any future lung function test that may be required in the investigation of possible occupational asthma. Further advice on health surveillance is contained in HSG 61 *Health surveillance at work* (ISBN 071761705X).

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APPENDIX
(paras 2 and 48)

AN EXPOSURE MATRIX - A SIMPLE GUIDE TO SELECTING VENTILATION TO CONTROL STAINLESS STEEL WELDING FUME

Purpose of the exposure matrix

1 The exposure matrix is a simple and easy-to-use guide to the type of ventilation likely to adequately control welding fume exposure for the purpose of complying with the Control of Substances Hazardous to Health (COSHH) Regulations 1999. It is to be read in conjunction with HSE Information Document (ID) 668/29 *Control of fume arising from electric arc welding of stainless steels*.

2 This guidance will help in selecting ventilation controls, **but** to comply with COSHH Regulations you must consider other aspects of COSHH. These include carrying out a suitable and sufficient assessment of risks, ensuring the controls are adequate, use and maintenance of controls, health surveillance of workers where appropriate, and provision of instructions, information and training to workers (see also ID paragraphs 13-15).

Information on the exposure matrix

3 The exposure matrix shown in Table 1 is based upon 3 main factors that affect exposure to welding fume:

(1) the amount of fume generated - determined mainly by the welding current and the type of materials and consumables;

(2) the potential for welder's exposure to fume - determined mainly by the welding location and the welder's proximity to fume; and

(3) the exposure time - determined mainly by the total welding time and the actual arcing time.

4 There are 4 exposure categories for stainless steel welding described in Table 1. Categories 1, 2, or 3 give exposure scores of 1, 2 and 3 respectively. A higher score indicates a greater fume hazard or exposure risk. The scores given by the matrix lead to ventilation control solutions.

5 Category S is for 'special cases' and a 'hit' in this category guides the user to more detailed information.

6 The matrix is based on measured exposures in real situations and the suggested solutions have been checked against workable controls based on these measurements.

Terms used in the exposure matrix

7 To obtain the information required for the matrix it is necessary to both talk to the welders and observe them welding. Data is also required regarding the content of the welding fume. This can be obtained from the information provided by the welding rod or welding wire supplier (see also ID paragraph 26). If the welding process or work conditions vary between welders, Table 1 will need to be completed for each welder. The highest level of control indicated will be required.

8 The guidance only refers to TIG, MIG, FCA and MMA welding operations carried out indoors. It is assumed that the welder is either using a hand-held welding shield or wearing a welder's visor.

9 The following text explains the terms used in the exposure matrix.

Welding current: the current setting will mainly depend on the diameter of the consumable electrode. The current values quoted below are indicative of the typical current settings for most welding processes.

Extremely high	special applications with current in excess 300 A or settings well in excess of the manufacturer's recommended range are used.
High	current used is between 200-300A.
Normal	current used is between 100-200A.
Low	current used is up to 100A (see also ID paragraph 47).

Welding materials/consumables:

High fume	where manufacturer's information on fume shows greater than 15% total chromium and greater than 6% nickel.
Medium fume	where manufacturer's information on fume shows 5-15% total chromium and 3-6% nickel.
Low fume	where manufacturer's information on fume shows less than 5% total chromium and less than 3% nickel.

Welding location:

Confined space	a space that is substantially enclosed and where there is a foreseeable risk of a build up of hazardous substances or lack of oxygen (due to welding work and use of shielding gases). Examples of confined spaces are tanks, pipes, silos.
Badly ventilated	for example a very small and restricted work area with no natural ventilation which therefore results in rapid build-up of fume.
Poorly ventilated	for example a work area with a low roof and no open windows or doors, or a booth with 3 sides closed thereby limiting natural air movement.

Well ventilated	for example a work area with a high ceiling and with good natural ventilation via door and windows, etc.

Welder's position:

Always in fume	welder's face is in the path of the fume for all the arc time.
Mostly in fume	the face is close to or above the rising fume cloud for 2/3rd of arc time.
Frequently in fume	the welder's position varies and for about 1/3rd of the arc time the welder's face is directly in the path of the fume.
Occasionally in fume	the face is not close to the rising fume but due to the welding circumstances the welder's face is sometimes in the fume.

Welding Time (WT): The total hours spent in a day on welding and its associated work.

Arc Time (% of WT): The percentage of the welding time used in 'active' welding with the arc struck. So, 5% implies that in every welding hour the arc is lit for 3 minutes; 10% implies that arc is lit for 6 minutes and so on.

Using the exposure matrix

Follow the simple steps described below to find a ventilation control approach.

STEP 1 (Table 1) There are 6 entries, a-f, in the 'process parameters' column in Table 1. For each process parameter decide which exposure category best describes the conditions during welding.

STEP 2 (Table 1) Category S is for 'special cases'. If you score even a single hit under Category S you cannot use the matrix and you need to carry out a more thorough assessment.

STEP 3 (Table 1) If you have no 'special cases' entries then record the score for each process parameter in the 'exposure score' box. For example, if your answer for parameter 'a' welding current, was 'normal' this is in column '2' and scores 2 in box 'a'. Add up the 6 scores to give the total exposure score.

STEP 4 (Table 1) Calculate 'weighted exposure score' by multiplying the total exposure score with the weighting factor for the type of welding you are using. The weighting factors are given in Table 1. For example, if you are using MIG then your score is multiplied by 2.
STEP 5 (Table 2) Using the weighted exposure score from Table 1, find the ventilation system required from Table 2. Note the information given in the notes about the use of RPE.

TABLE (1) Exposure matrix for indoor stainless steel welding
(for calculating exposure score)

Process Parameters		EXPOSURE CATEGORIES			
		S ***Special Cases*** Thorough assessment needed	**3** ***Most Exposure Score 3***	**2** ***Moderate Exposure Score 2***	**1** ***Least Exposure Score 1***
a	**Welding Current**	Extremely high	High	Normal	Low
b	**Welding Materials / Consumables**	Coated work-piece or other hazards	High fume	Medium fume	Low fume
c	**Welding Location**	Confined space	Badly ventilated	Poorly ventilated	Well ventilated
d	**Welder's Position**	Face always directly in the path of fume	Face mostly in fume	Face frequently in fume	Face occasionally in fume
e	**Welding Time (WT)**	More than 8 hours/day	About 8 hours/day	About 4 hours/day	About 2 hour/day
f	**Arc Time (% of WT)**	More than 20%	About 20%	About 10%	About 5%
Exposure Score		a b c d e f .... + ... + ... + ... + ... + ... = ...			
Weighting Factor		For TIG welding = 1 For MIG welding = 2 For FCA and MMA welding = 3			
Weighted Exposure Score		(Exposure Score) ..... x (Weighting Factor)..... = ...			

Now use the weighted exposure score to find the appropriate control approach using Table 2.

TABLE (2) selecting a control approach based on weighted exposure score for stainless steel welding

Weighted Exposure Score (from Table 1)	**Ventilation Control Approach***
Less than 10	Natural ventilation via open doors and windows is probably adequate. If this is not available, it should be provided as the minimum level of ventilation.
10-19	In most cases natural ventilation is inadequate, in which case mechanical exhaust ventilation is necessary. Mechanical exhaust ventilation reduces the background fume in the working area by addition of fresh, uncontaminated air. One way of achieving this is to provide exhaust fans in welding areas together with fresh air inlets into the workplace.
20-30	In most cases mechanical exhaust ventilation is inadequate, in which case local exhaust ventilation (LEV) is necessary. LEV involves capture of the fume as soon as it is generated into a system of ducting connected to an extract fan. Further guidance on LEV is given in the ID paragraphs 48-50 and in HSE documents HSG 37 and GN EH 55.
31-54	Local exhaust ventilation (LEV) is required. Further guidance is as above.
Special cases One or more hits in Category S of Table 1	You need to carry out a more thorough assessment of ventilation and respiratory protective equipment requirements.

***Respiratory protective equipment (RPE)**

In addition to the ventilation control approaches given in Table (2), RPE may also be necessary if:

(1) The ventilation system alone does not provide adequate control over exposure to fume or its individual constituents, eg Cr(VI).

(2) The ventilation system cannot prevent oxygen deficiency caused by shield gases.

(3) The ventilation control approach identified in Table (2) is either not possible or is not cost effective due to the welding circumstances.

See also ID paragraph 53.

Special cases

10 Any entry scored under Category S in Table 1 indicates that the matrix cannot be used and that a more thorough assessment is needed. Tables 3 gives further information to help you. Where surface coatings are present, exposure risks arise from contamination generated as a result of thermal degradation of surface coatings during welding. In such cases priority should be given to prevention of exposure to fumes etc from the coating, for example by removing the surface coating prior to welding. If this is not reasonably practicable, control measures should be in place to minimise any exposure, for example by use of local exhaust ventilation. The level of control required will depend upon the nature of the contamination generated from the surface coating.

Table (3) Risks from shield gases

<table>
<tr><th>Shielding gas</th><th>Hazard</th><th>Risks</th><th>Solution</th></tr>
<tr><td>Argon (Ar)</td><td>Asphyxiation caused by displacement of air.</td><td>A very heavy gas which collects at low points in tanks, pipes, rooms, etc.</td><td rowspan="4">Use in a well ventilated area or with exhaust extraction.

Test atmosphere for oxygen levels in confined spaces.

See HSE Information Document 288/6 (Rev)</td></tr>
<tr><td>Helium (He)</td><td>Asphyxiation caused by displacement of air.</td><td>A very light gas which may collect in covered areas of tanks, pipes, etc.</td></tr>
<tr><td>Nitrogen (N_2)</td><td>Asphyxiation caused by displacement of air.</td><td>A gas which may collect in tanks, pipes, rooms, etc.</td></tr>
<tr><td>Carbon dioxide (CO_2)</td><td>Asphyxiation caused by displacement of air. Also directly affects breathing.</td><td>A gas which is heavier than air and which may collect in tanks, pipes, rooms, etc.</td></tr>
<tr><td colspan="4">Mixtures of the gases will have a combination of these properties.</td></tr>
</table>

Obtaining further advice

11 If you need specialist advice you should contact an occupational hygienist. The British Institute of Occupational Hygienists (BIOH) will supply a list of professional occupational hygienists. Tel: 01332 298087.