

# A small survey of exposure to stainless steel welding fume

Prepared by the **Health and Safety Laboratory**  
for the Health and Safety Executive 2010

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Specific aims and objectives for the project were:

- To visit a representative group of workplaces carrying out welding of stainless steel, scoping the various control strategies proposed in COSHH Essentials for welding, hot work and allied processes.
- To assess compliance with good occupational hygiene practice by:
  - occupational hygiene observations;
  - air monitoring for total inhalable particulate, total and hexavalent chromium, nickel and other metals; and
  - biological monitoring for chromium and nickel.
- Make recommendations for improvements to controls and monitoring where appropriate.

This report and the work it describes were funded by the Health and Safety Executive (HSE). Its contents, including any opinions and/or conclusions expressed, are those of the authors alone and do not necessarily reflect HSE policy.

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First published 2010

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## ACKNOWLEDGEMENTS

The authors would like to thank all companies taking part in this project, with particular thanks to the companies, and their employees, allowing HSL to carry out monitoring on their premises. Russell Atkinson (HSL Occupational Hygiene Section) conducted 3 of the site visits. John Cocker and Jackie Morton (HSL Biological Monitoring Section) provided advice on biological monitoring. All air and urine samples were analysed by HSLs Analytical Sciences Unit.

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# EXECUTIVE SUMMARY

## Objectives

To visit a representative group of workplaces carrying out welding of stainless steel, scoping the various control strategies proposed in COSHH Essentials for welding, hot work and allied processes.

To assess compliance with good occupational hygiene practice by;

- Occupational hygiene observations

- Air monitoring for total inhalable particulate, total and hexavalent chromium, nickel and other metals

- Biological monitoring for chromium and nickel

Make recommendations for improvements to controls and monitoring where appropriate.

To gather information on current stainless steel welding processes and exposures.

To assess the utility of biological monitoring as an exposure assessment tool for stainless steel welding.

## Main Findings

Telephone interviews, conducted with 52 companies, indicate that for stainless steel, Tungsten Inert Gas (TIG) and Metal Inert Gas (MIG) welding accounted for around 90% of welding. Although over half of the companies providing information performed some Manual Metal Arc (MMA) welding, it did not constitute more than 15% of the total welding for any individual company. Flux Cored Arc (FCA) welding was used only by specialist companies for specific applications, and accounted for less than 5% of all stainless welding amongst the companies surveyed.

Approximately 30% of the companies surveyed by telephone use no Local Exhaust Ventilation (LEV) for stainless welding at any time. More than two thirds of these companies did not conduct any form of health surveillance. The organisations surveyed were almost all Small to Medium Enterprises (SMEs), with an average of 6 workers welding stainless in each company, although not all of these would weld stainless exclusively.

A total of 10 site visits were made to 8 different companies. These revealed:

Breaches of occupational exposure limits were uncommon, even where exposure control strategies were judged to be inadequate.

A significant proportion of companies were not controlling stainless welding fume exposures in accordance with COSHH essentials welding guidance.

There appears to be a common perception within industry that TIG welding of stainless steel does not require engineering control.

Based on our findings from on site surveys and phone enquiries the TIG welding of stainless steel is not generally carried out in accordance with the COSHH essentials guidance. Measured exposures for those carrying out these tasks were well within current exposure limits.

A significant proportion of sites welding stainless steel have adequate exposure controls available, but for various reasons these controls are not used or are used incorrectly. Reasons for this include a reluctance to regularly reposition the LEV hood as the job progresses and a common misconception that LEV can affect the weld quality such that that LEV is not used or positioned so far away from the weld that it is not effective.

There have been no significant changes in welding practices, or the use of exposure controls, since the previous HSL study on stainless welding, conducted in 1999.

Biological monitoring results above the Biological Monitoring Guidance Value (BMGV) were generally associated with exposure controls that could be improved.

Biological monitoring results showed that exposure can be well controlled by use of Respiratory Protective Equipment (RPE).

Biological monitoring is a useful aid to the assessment of exposure to chromium and nickel in welding but due to the long half-lives care needs to be taken interpreting results and actions should be based on the trends in results.

## **Recommendations**

This is a factual report, no recommendations are made.

# 1 INTRODUCTION

## 1.1 OBJECTIVES

Specific aims and objectives for the project were;

- To visit a representative group of workplace carrying out welding of stainless steel, scoping the various control strategies proposed in COSHH Essentials for welding, hot work and allied processes.
- Assess compliance with good occupational hygiene practice by;

Occupational hygiene observations

Measurement of worker exposure to total and hexavalent chromium, nickel and other metals

Biological monitoring (BM) for chromium and nickel

- Make recommendations to individual companies for improvements to controls and monitoring where appropriate.

## 1.2 BACKGROUND

The welding of metals generates a complex airborne mixture of metal fume, other particulates and gases. Many of the compounds released during welding have adverse effects on human health. The welding of stainless steel is of particular concern due to the generation of fume which, amongst other species, contains nickel and hexavalent chromium. On inhalation these metals can cause lung disease, together with an increased risk of asthma and cancer. Hexavalent chromium compounds are defined as asthmagens (Asthmagens compendium, HSE, 2001) and category 1 (proven human) carcinogens (IARC, 1997). For such substances there is a duty under COSHH regulation 7.7 to reduce exposure as low as reasonably practicable (HSE, 2005(1)). Chromium has an 8-hour Time Weighted Average (TWA) Workplace Exposure Limit (WEL) of 0.5 mg/m<sup>3</sup> as total chromium (HSE, 2005(2)) and a WEL of 0.05 mg/m<sup>3</sup> for hexavalent chromium. Insoluble nickel compounds are assigned an 8-hour TWA WEL of 0.5 mg/m<sup>3</sup>. A generic welding fume exposure limit of 5 mg/m<sup>3</sup> as total inhalable particulate (TIP) was withdrawn in 2005 (Garrod and Ball, 2005) as the limit was not considered to be protective of health.

## 1.3 EXISTING HSE DATA

HSE has conducted limited studies involving stainless steel welding fume exposure. Most recently, during 1998/9, exposure monitoring was carried out at twelve sites (HSL, 2001). This survey was focussed mainly on analytical methodology and as a result information on working practices and any control measures was somewhat limited. Biological monitoring was not in the scope of the work. A total of 54 personal samples were taken. TIP exposures were less than 10 mg/m<sup>3</sup> with the exception of 3 welders at a site where intensive FCA welding was being carried out. These welders had measured TIP exposures of 13.7, 29.5 and 30.4 mg/m<sup>3</sup> although air-fed respiratory protective equipment (RPE) was routinely worn. Chromium (VI) exposure was

measured at 6 of the 12 sites, a total of 33 data points. None of the measured exposures exceeded the Cr (VI) WEL of 0.05 mg/m<sup>3</sup> although 9 welders had exposures of at least half this limit. No Cr (VI) exposures were available for the site where the high TIP exposures had been measured, although it is likely that Cr (VI) exposures would have been significant. Nickel exposures for all welders were all less than the associated WEL, with only 4 of 54 welders with exposures more than half the WEL.

Stainless welding was included in a HSE survey to gather exposure data to establish a Biological Monitoring Guidance Value (BMGV) for chromium (HSL, 2002). BMGVs are not health based limits, they are practicable, attainable values set at the 90<sup>th</sup> percentile of biological monitoring (BM) data obtained from a representative cross section of workplaces found to exhibit good occupational hygiene/industry practice. The BMGV for chromium was set at 10 µmol/mol creatinine (HSE, 2003). As part of this study a site visit was carried out to a company carrying out MIG welding of stainless steel, monitoring the exposure of five workers. All measured inhalation exposures were within the current WELs; Cr (VI) was not detected in any sample (LOD <0.001 mg/m<sup>3</sup> as an 8-hr TWA) and the highest total Chromium exposure was 0.103 mg/m<sup>3</sup> (8-hr TWA). Urinary chromium results were all less than 6 µmol/mol creatinine. No discernable differences were observed between pre and post shift results or between the results obtained at the start of the working week and those obtained at the end of the working week. Recognising the need to gather exposure data on MMA welding of stainless steel, HSL subsequently carried out two visits to sites carrying out such processes in 2003. The data from these visits is summarised in table 1.

Table 1. Exposure data from HSL BMGV project.

Site ID	Welding technique	Measured inhalation (exposure mg/m <sup>3</sup> )		Urinary chromium (µmol/mol creatinine)
		Cr (VI)	Cr	Post shift
1 (n=5)	MIG	ND	ND – 0.1	1.3 – 5.8
2 (n=5)	MMA	ND – 0.21	ND – 0.34	3.7 – 29.4
3 (n=5)	MMA	0.001 – 0.42	0.05 – 0.62	14.4 – 179.9

Note although the data for sites 2 and 3 was collected as part of the BMGV project, the data was not included in the data set presented to the WATCH committee.

Excluding the visits listed above, HSEs National Exposure Database (NEDB) contains data from 12 site visits to assess stainless steel welding fume exposure over the period 2000 to date. A total of 36 inhalation exposure data points were collected; 16 were for TIG welding, 9 for MIG and the remaining 11 were a mixture of combination of welding types. No biological monitoring data was obtained. The data is summarised in table 2.

Table 2. Data from NEDB (2000 to date) relating to stainless steel welding.

Welding type	8-hr TWA inhalation exposure range (mg/m <sup>3</sup> )			
	TIP	Total Cr	Cr (VI)	Ni
MIG	0.83 – 15.2	0.01 – 1.29	ND – 0.04	0.01 – 0.56
TIG	0.09 – 6.3	ND – 0.04	ND	ND – 0.01
Others	1.46 – 9.4	0.01 – 0.71	ND – 0.049	ND – 1.24

Biological monitoring has been shown to be a useful, cost effective exposure assessment tool for a variety of applications. It was thought that if BM could be successfully applied to stainless steel welding then it may provide, in conjunction with airborne exposure assessment, a useful additional exposure assessment tool.

Hexavalent chromium is assigned a UK BMGV of 10 µmol/mol creatinine in a post shift urine sample.

The American Conference of Governmental Industrial Hygienists (ACGIH) Biological Exposure Indices (BEI) for Cr (VI) in a post shift end of working week sample is 25 µg/l urine (ACGIH, 2008); this is approximately 65 µmol/mol creatinine. This is based on a relationship between inhalation exposure and urinary chromium for welders and is applicable to stainless steel MMA welding only. Based on a similar correlation there is a German EKA value for Cr (VI) in an end of shift urine sample of 20 µg/l (DFG, 2007) this is approximately 50 µmol/mol creatinine.

There is no UK BMGV for nickel compounds; A German EKA limit for insoluble nickel compounds has been set at 45 µg/l (which is approximately equivalent to ~ 60 µmol/mol creatinine). There is no ACGIH BEI limit for nickel.

The need for adequate exposure control to stainless steel welding fume has led HSE to produce a series of COSHH essentials guidance sheets to assist employers and employees in their exposure control strategies. (<http://www.hse.gov.uk/pubns/guidance/wlseries.htm>.)

## 1.4 WELDING TECHNIQUES

There are a number of different welding techniques used routinely used for stainless steel.

### **Tungsten Inert Gas (TIG) welding**

This technique is suitable for thinner gauge steel, typically less than 6 mm. TIG welding uses a non-consumable predominantly tungsten electrode. Here an inert gas, typically argon is used to protect the weld from contamination. Normally a filler wire is used, although this is not always the case. TIG is widely used in industry, it is most applicable to thinner gauge material due to it

being a slower process. The process is generally regarded as a more skilled technique than others, and given such skill provides a stronger, high quality weld. The need for a shielding gas means this process is not applicable for welding outdoors where the shielding gas is likely to be disrupted by prevailing winds.

**Metal Inert Gas (MIG) welding**

This technique uses a consumable electrode, together with an inert shielding gas, typically argon. The consumable electrode is continuously fed into the weld. This technique deposits material quicker than TIG and so offers higher productivity and applicability to thicker materials.

**Manual Metal Arc (MMA) welding**

This is more commonly known as “stick” welding, here a consumable electrode is used. The consumable is coated in a chemical flux which disintegrates as the weld is laid, the vapours given off act as a shielding gas to protect the weld together with a layer of slag. This is a popular technique, in particular for use during off site/outdoor welding as no shielding gas is required. The finished welds require more additional cleaning compared to other techniques.

**Flux Cored Arc (FCA) welding**

This technique uses a continuously fed consumable electrode. The electrode contains a chemical flux which disintegrates to provide protection during the weld. This process is carried out both with and without shielding gas, the use of shielding gas is beneficial when welding thicker gauge materials.

**1.5 COSHH ESSENTIALS STAINLESS WELDING GUIDANCE**

The control strategies recommended by COSHH essentials for the indoor (not confined space) application of each welding technique on stainless steel are summarised in table 3;

Table 3. COSHH essentials stainless steel welding guidance summary.

Technique	COSHH essentials guidance (for indoor, non-confined space, application of technique to stainless steel)
MMA	Follow guidance sheet WL9; extracted booth, bench or moveable capture hood. Follow sheet G406 for LEV advice. Consider the use of RPE (sheet R3). Consider health surveillance (sheet G401).
MIG	Follow guidance sheet WL9; extracted booth, bench or moveable capture hood. Follow sheet G406 for LEV advice. Consider the use of RPE (sheet R3). Consider health surveillance (sheet G401).
TIG	Follow guidance sheets WL3 or WL4. Follow sheet G406 for LEV advice. Consider health surveillance (sheet G401).
FCA	Follow guidance sheet WL12; provide RPE, use extracted booth, bench or moveable capture hood. Consider health surveillance (sheet G401).

## **2 METHODOLOGY**

### **2.1 SITE SELECTION**

Sites were selected using a number of different sources including previous surveys and in consultation with The Welding Institute (TWI). It was initially considered that a range of business sizes would be visited covering all types of welding techniques used and scoping the range of exposure control scenarios specified in COSHH essentials. It became apparent when making telephone contacts that, in general terms, there was a considerable reluctance within the industry to assist in this study and hence such selectivity was not possible.

Around 150 companies were contacted by telephone, of these 52 welded stainless steel and were willing to provide information regarding their welding practices over the telephone. Participation in the study was voluntary, as was that of the individual employees. Participants were given feedback from their visit in the form of an occupational hygiene visit report. Information included in this report included airborne and biological monitoring results together with an assessment of any control measures in place and conclusions.

Attempts were made to contact participants from previous HSE studies. A number of these were no longer trading, however two such companies were willing to take part. From discussions over the 'phone it was apparent that processes had not encountered significant change in recent years. This was a good indication that employee exposures had been broadly similar over the ten year period since the previous HSE survey had been carried out, and so it was considered these companies may be of particular interest in the evaluation of biological monitoring.

A total of eight sites were visited for the exposure assessment exercise. Six were general fabrication companies, the remaining two were a large manufacturer of building products and a specialist vehicle manufacturer.

### **2.2 EXPOSURE MEASUREMENT**

#### **2.2.1 Air Monitoring**

All visits used the same procedures for airborne exposure assessment as described in MDHS 14/3 "General methods for sampling and gravimetric analysis of respirable and inhalable dusts" (HSE, 2000). Personal monitoring was performed onto membrane filters, lapel mounted in an IOM sampling head, aspirated at 2.0 litres/minute. Samplers were lapel-mounted due the practical considerations of the welders continually donning their visors throughout the shift and the associated difficulty of mounting the sampling head within the visor. Samples were taken over sufficiently long periods of time to be considered representative of full shift exposures. Additionally a small number of task specific samples were taken. No static sampling was performed.

Total inhalable particulate was determined gravimetrically. Filters were then cut in half to allow analysis to be carried out for metals using X-ray fluorescence on one half. The second half was analysed for hexavalent chromium using wet chemistry methods with ion chromatography. Note that analysis was also performed for manganese and iron but these results are not considered in this report, the focus of this research being on nickel and chromium exposures.

### **2.2.2 Biological Monitoring**

Pre and post shift urine samples were obtained from welders who took part in the air monitoring survey. Urine samples were analysed for nickel and chromium using in-house HSL methods using ICP-MS. Note that all participating individuals provided informed consent, in accordance with HS(G) 167 (HSE, 1997).

## **2.3 ASSESSMENT OF EXPOSURE CONTROLS**

Exposure controls at all sites were assessed by an occupational hygienist. The assessment considered administrative and engineering controls and any Respiratory Protective Equipment (RPE). Details of COSHH assessments, where available, were obtained as were the results of any recent monitoring surveys. To ensure consistency engineering controls were compared to those described in HSEs COSHH essentials welding guidance.

## **2.4 EXTENDED ASSESSMENT OF BIOLOGICAL MONITORING**

To provide additional information on the application of BM over time, we sought further assistance from two sites visited (sites 1 and 2). HSL had visited these sites approximately 8 years previously. It was found that processes, control measures and thus exposure patterns had undergone little or no change over a number of years. Both sites were willing to assist, unfortunately site 2 did not have a production schedule that included stainless steel at the required time and so the extended assessment was carried out at site 1 only.

Site 1 was revisited on Monday 26<sup>th</sup> November 2007 and pre shift urine samples were taken from those staff who agreed to take part in the survey. Air monitoring was also carried out on these staff for the whole of the shift. Post shift urines samples were also taken. The site was left with sufficient equipment, including a freezer, such that pre and post shift urine samples could be provided for the rest of the week. The site was visited Friday 30<sup>th</sup> November to collect the week's urine samples and provide fresh sampling equipment for the following week. The site was then visited on Friday 7<sup>th</sup> December and air monitoring carried out again over the working shift. The pre and post shift urine samples that had been provided over the week were also collected for transporting back to the lab. Participants were asked to complete a questionnaire on daily basis, providing basic details of welding work undertaken.

The site had a twelve day shutdown over the Christmas/New Year period. Pre-shift urine samples were taken on the first day back after the shutdown to measure urinary chrome and nickel after a period where the workers had not been occupationally exposed to stainless steel welding fume.

## 3 MAIN FINDINGS

### 3.1 INFORMATION SURVEY RESULTS

A total of 52 companies, out of approximately 150 contacted by telephone, carried out stainless steel welding and were willing to discuss their working practices. Information was gathered on;

Amount of stainless steel welding carried out

The percentage of stainless welding relative to all fabrication

Techniques used for stainless welding

RPE usage

LEV usage

Whether health surveillance is carried out

Numbers of those carrying out stainless steel welding on site

Not all companies canvassed provided all the information described above. However, telephone contact with these companies provided useful information on current stainless steel welding processes and practices. A summary of the key information obtained is shown below.

- 52 companies stated they carried out welding of stainless steel. 48 (92 %) of these carried out TIG welding.
- Of the 39 companies providing a breakdown of which techniques they use, 34 (87 %) reported that at least 75 % of the stainless welding carried out was TIG.
- 23 (59 %) companies reported some use of MMA welding. All of these reported that MMA accounted for less than 15% of their total stainless welding.
- 35 (90 %) companies reported some use of MIG welding, 4 of these said it represented more than 75 % of the total stainless welding.
- 3 (8 %) companies reported use of FCA welding, only one company said it was more than 75% of their total stainless work
- The average number of employees potentially exposed to stainless steel welding fume was 6, range 1 - 25.
- 48 companies responded regarding use of LEV systems, 33 (69%) reported using LEV of some type.
- 35 companies answered a question regarding health surveillance, 11 (31 %) of these carried out some form of health surveillance.
- 45 companies provided information on RPE usage. 27 (60 %) of these reported usage of RPE as a control measure for stainless welding.

### 3.2 SITE VISITS

A total of eight different sites were visited. As one site was visited on three occasions (see paragraph 2.3), a total of ten exposure assessment visits were carried out. A summary of the sites visited is shown in table 4. An anonymous summary of the sites visited is included in the appendices. Conditions observed on the day of the sampling visits were reported as being typical at all sites. Quantitative exposure data is summarised in table 5, and presented graphically in figures 1 to 6. The rectangular portion on the box and whisker plots extends from the lower quartile to the upper quartile, the solid line within the rectangular portion represents the sample median, the cross represents the sample mean. The whiskers extend from above and below the boxes to the minimum and maximum values in each data set.

Table 4. Summary data from sites visited.

Site	Number exposed	Welding type (on day of visit)	LEV	RPE used	COSHH assessment prepared	Health surveillance
1	12	85% MIG, 15% TIG	Flexi-arm	Positive pressure P3	Yes	Yes
2	12	100 % FCA	On-gun	Positive pressure P3	Yes	Yes
3	8	100 % TIG	None	No	No	No
4	6	90% TIG, 10 % MMA	Flexi-arm (For MMA)	Positive pressure P3 (for MMA)	No	No
5	8	85 % TIG, 15% FCA	Flexi-arm (for FCA)	No	Yes	Yes
6	1	100 % TIG	None	No	No	No
7	2	100 % TIG	Flexi-arm	FFP3	Yes	Yes
8	1	100 % TIG	Flexi-arm	No	Yes	No

Table 5. Exposure data from the sites visited.

Site	8-hr TWA inhalation exposure range (mg/m <sup>3</sup> )				Post shift urine results (µmol/mol creatinine)	
	TIP	Total Cr	Cr (VI)	Ni	BM Cr	BM Ni
1, visit 1	0.89 - 6.69	0.048 - 0.23	0.0012 - 0.0075	0.021 - 0.095	2.87 - 56.56	5.56 - 48.78
1, visit 2	0.56 - 11.4	0.009 - 1.16	<0.001 - 0.027	<0.01 - 0.35	0.5 - 33.03	5 - 38.9
1, visit 3	0.46 - 8.34	0.018 - 0.45	<0.001 - 0.0013	<0.01 - 0.17	4.55 - 19.32	8.99 - 34.17
2	3.01 - 6.60	0.01 - 0.45	<0.001 - 0.082	<0.01 - 0.08	4.43 - 26.09	5.78 - 25.64
3	0.73 - 4.75	0.01 - 0.04	All <0.001	<0.01 - <0.019	0.96 - 2.47	6.97 - 14.75
4	0.93 - 1.17	0.03 - 0.07	<0.001 - 0.002	0.02 - 0.05	4.76 - 10.51	5.67 - 16.02
5	0.86 - 2.51	0.03 - 0.06	0.002 - 0.005	0.01 - 0.02	4.67 - 11.04	10.94 - 26.06
6	3.9	0.08	0.003	0.03	0.46 - 3.67	6 - 9.19
7	1.8 - 2.2	All <0.02	All <0.002	All <0.01	< 0.0001 - 0.43	<0.002 - 10.66
8	1.2	<0.02	<0.002	0.01	5.22	17.36

Table 6. Breakdown of exposure data by welding type.

		Geometric means					
		Inhalation exposure (mg/m <sup>3</sup> )				Post shift BM results (µmol/mol creatinine)	
Welding type	Number of data	TIP	Cr total	Cr (VI)	Ni	Cr	Ni
All	46	1.83	0.049	0.0023	0.020	4.6	9.7
MIG	23	1.95	0.068	0.0020	0.028	7.0	17.2
FCA	9	2.85	0.054	0.0067	0.015	4.8	4.0
TIG	12	1.24	0.024	0.0012	0.014	2.5	6.4
MMA	Insufficient data						

Figure 1: Breakdown of TIP exposure by site

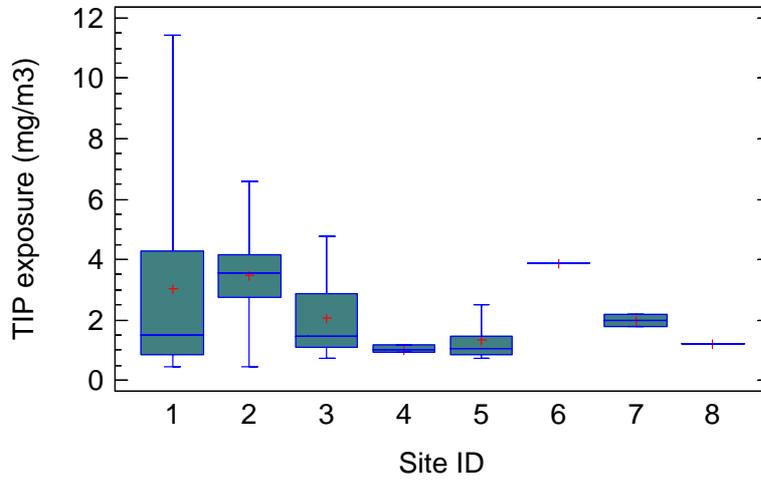


Figure 2: Breakdown of total chromium exposure by site

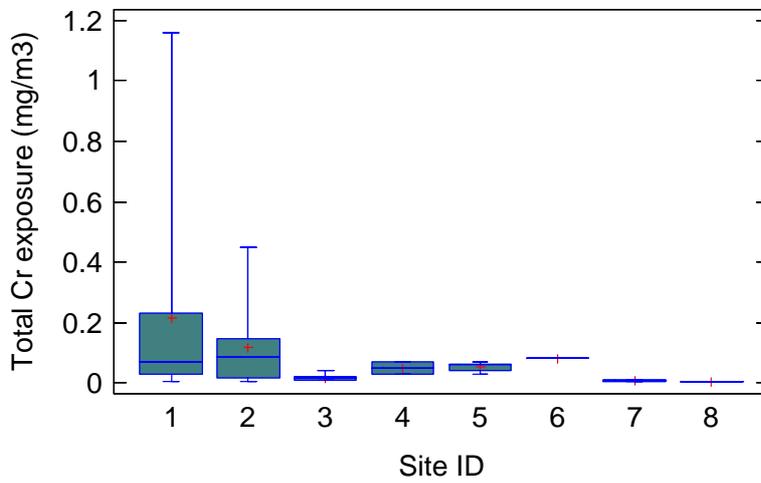


Figure 3: Breakdown of chromium (VI) exposure by site

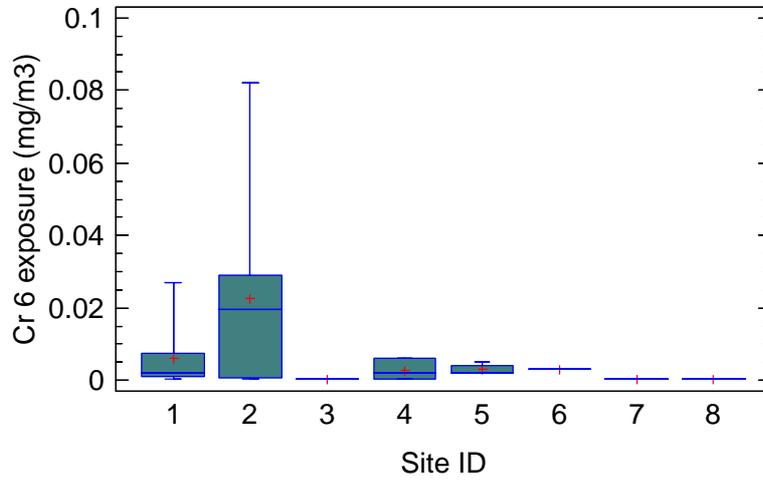


Figure 4: Breakdown of nickel exposure by site

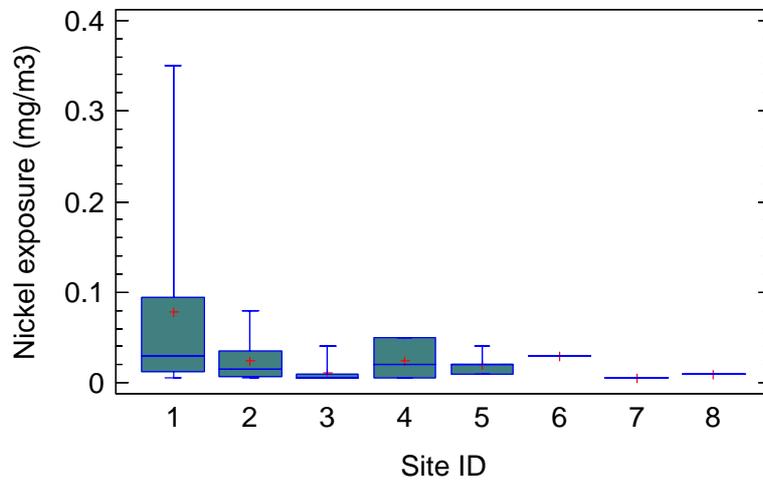


Figure 5: Post shift urinary chromium by site

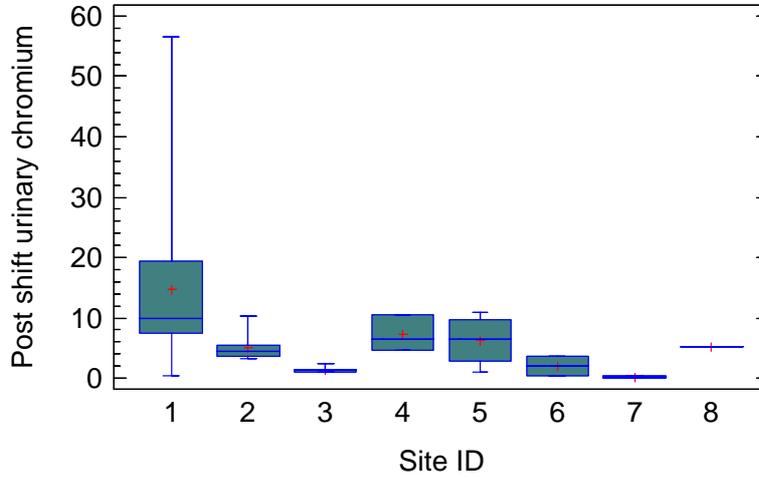
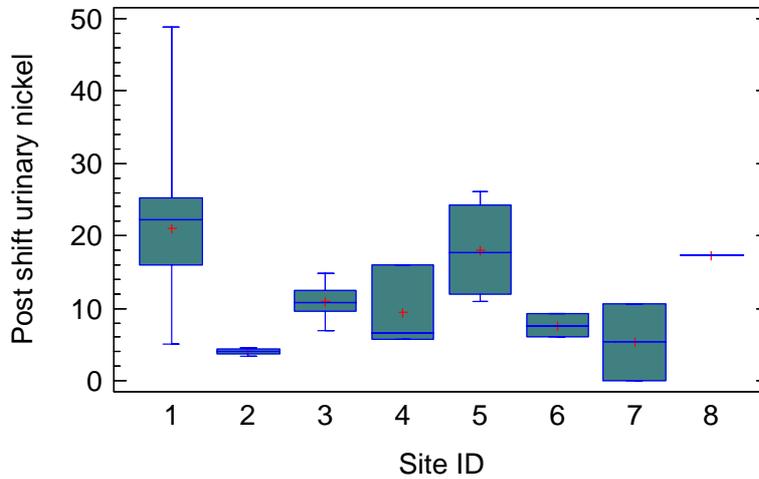


Figure 6: Post shift urinary nickel by site



### 3.2.1 Extended assessment of biological monitoring

An extended programme of BM was conducted at site 1, see paragraph 2.3 for full description of this exercise. Data from three workers is shown in figures 7 and 8, note all data points are post shift results with the exception of the final one which is the pre shift sample following the prolonged break.

Figure 7. Variation in urinary chromium

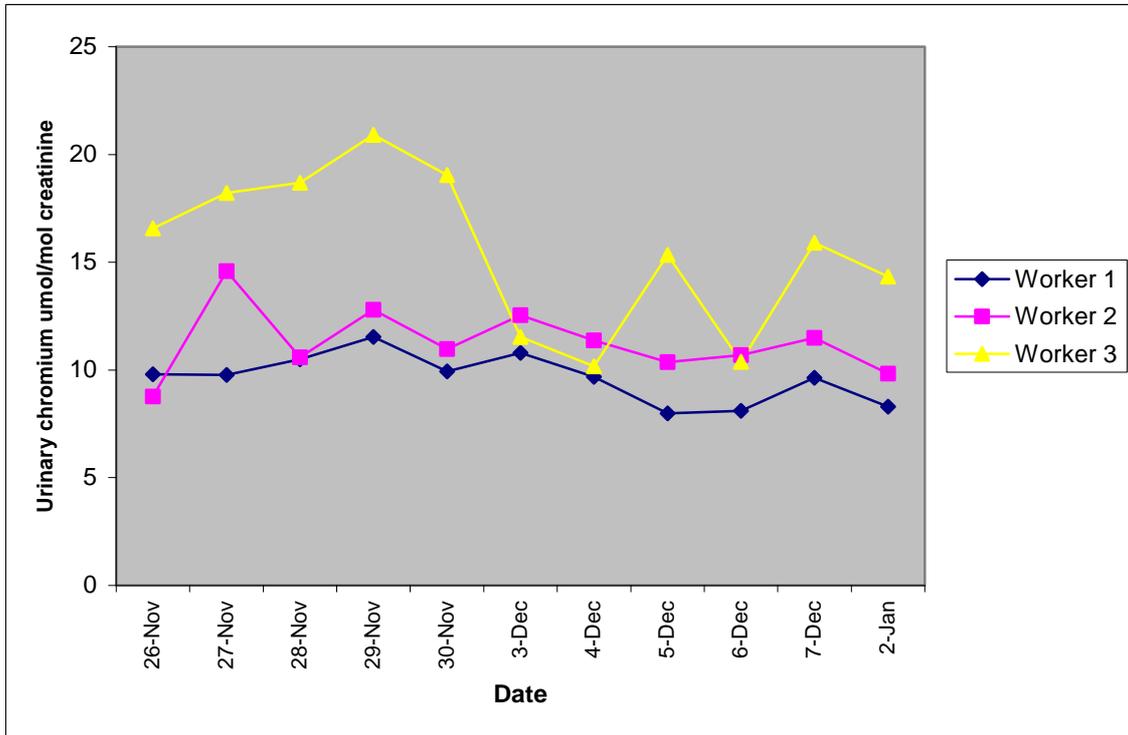
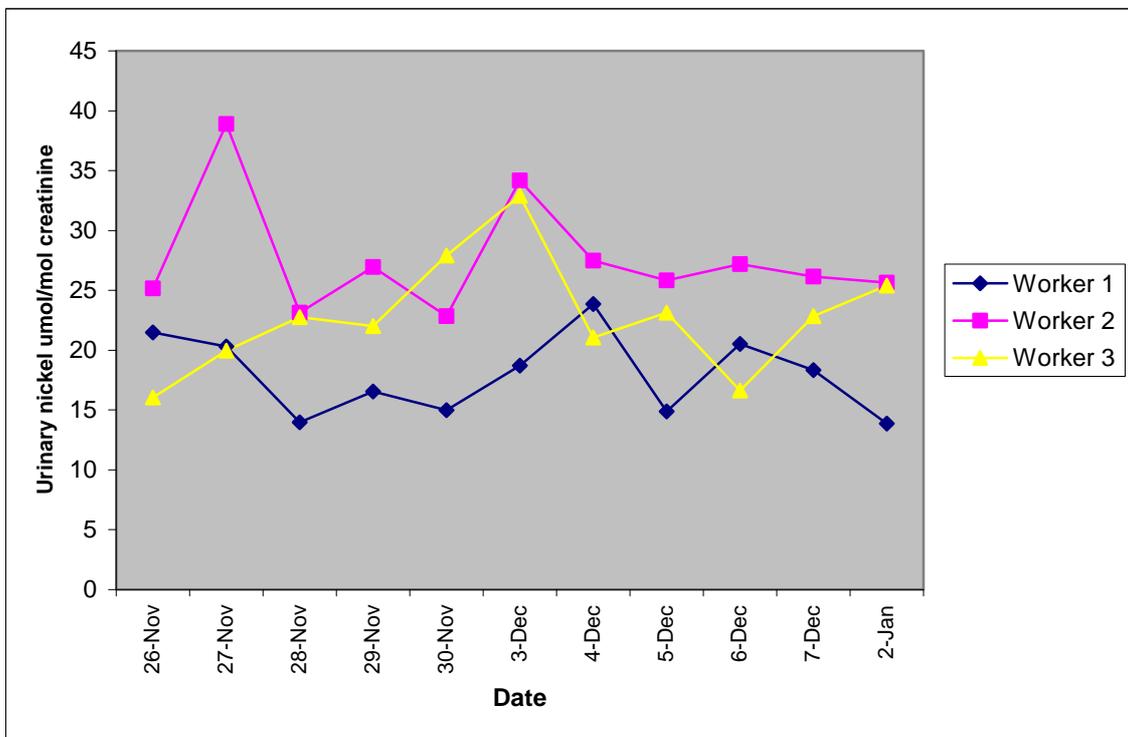


Figure 8. Variation in urinary nickel



## 4 DISCUSSION

### 4.1 TELEPHONE INTERVIEWS

Although the primary role of the initial telephone contacts was to identify suitable sites to visit for the main phase of the work, a range of relevant information was obtained by administering a brief questionnaire over the telephone at this stage.

The initial telephone interviews, conducted with 52 companies, indicate that for stainless steel, TIG and MIG welding accounted for around 90% of welding. Although over half of the companies providing information performed some MMA welding, it did not constitute more than 15% of the total welding for any individual company. FCA welding was used only by specialist companies for specific applications, and accounted for less than 5% of all stainless welding amongst the companies surveyed.

Approximately 30% of the companies surveyed by telephone use no LEV for stainless welding at any time. More than two thirds of these companies did not conduct any form of health surveillance. The organisations surveyed were almost all SMEs, with an average of 6 workers welding stainless in each company, although not all of these would weld stainless exclusively.

### 4.2 SITE VISITS

#### 4.2.1 Inhalation exposure

All exposures discussed below are 8-hour TWAs.

The substantial majority of measured TIP exposures were below  $5 \text{ mg/m}^3$ . Only 4 exposures from 45 exceeded this value. Three of these occurred at site 1, which was visited on 3 occasions, and represented fairly intensive MIG welding with poorly positioned flexi arm LEV. The other result in excess of  $5 \text{ mg/m}^3$  was FCA welding, with a significant amount of work performed in a confined space. All four of the individuals with TIP exposures above  $5 \text{ mg/m}^3$  wore positive pressure filtered RPE during welding.

Breaches of WELs for individual metallic components of the welding fume were not common. The WEL of  $0.5 \text{ mg/m}^3$  for insoluble nickel was not breached in any case. There were two total chromium exposures exceeding  $0.5 \text{ mg/m}^3$ , both obtained from site 1 on samples which also exceeded  $5 \text{ mg/m}^3$  TIP. Only a single chromium (VI) exposure was measured which exceeded  $0.05 \text{ mg/m}^3$ . This was for FCA welding at site 2, and was the same sample which also exceeded  $5 \text{ mg/m}^3$  TIP.

For the sites visited for this work, the highest fume exposures were associated with FCA welding, followed by MIG, with the lowest exposures occurring for TIG welding. Conclusions regarding exposures for MMA welding are not possible due to insufficient data.

#### 4.2.2 Biological monitoring

44 post shift urinary chromium samples, with corresponding inhalation data, were obtained. The results from 12 of these exceeded the BMGV of  $10 \text{ } \mu\text{mol/mol}$  creatinine. The BMGV was exceeded at four of the eight sites visited. One of the four sites (site 1) had several employees

whose urinary chromium results were significantly above the BMGV. This site had a good standard of exposure controls available, however they were not used consistently.

The 90<sup>th</sup> percentile value for post shift urinary chromium results from this survey was 19.3  $\mu\text{mol/mol}$  creatinine. When pre and post shift samples are compared it is apparent that there is no significant increase observed between pre and post shift urinary chromium results.

The correlation between measured chromium inhalation exposures and post shift urinary chromium was investigated. Plots of the correlation between these two variables are presented in figures 9 and 10.

Figure 9. Correlation between measured total chromium inhalation exposure and post shift urinary chromium results, for all data (N = 42).

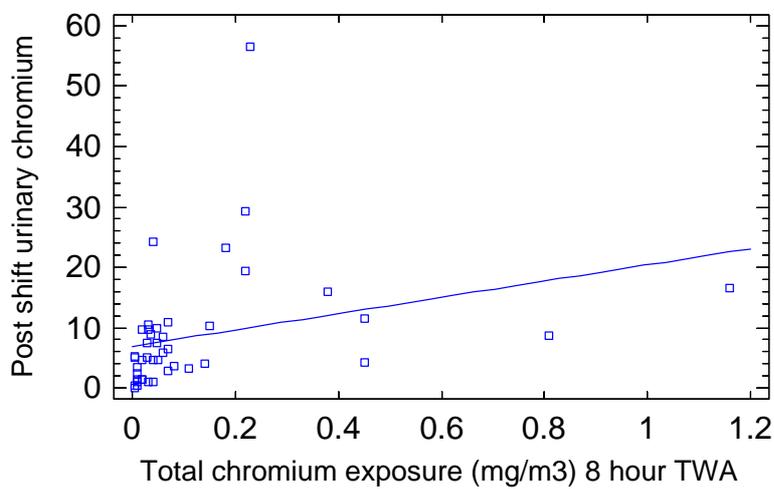
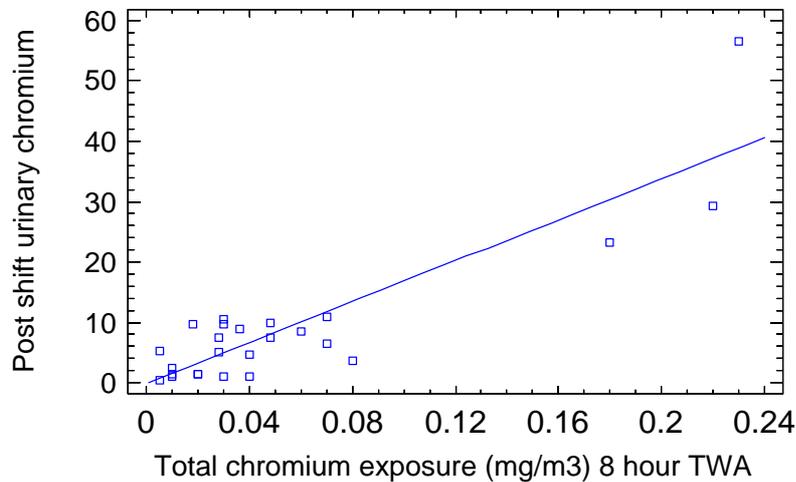


Figure 10. Correlation between measured total chromium inhalation exposure and post shift urinary chromium results, for data obtained from welders not using RPE (N=24).



Statistical analysis indicates a weak relationship between urinary chromium and inhalation exposure when all data are considered, with a correlation coefficient of 0.29. However, when data is removed for the 10 workers using RPE, the relationship becomes more significant, with a correlation coefficient of 0.88.

Urinary nickel results were all within the German EKA value of 45  $\mu\text{g/l}$  (approximately equivalent to  $\sim 90 \mu\text{mol/mol}$  creatinine). The 90<sup>th</sup> percentile value for post shift urinary nickel results from this survey was 26.1  $\mu\text{mol/mol}$  creatinine. As observed for chromium there is no significant increase observed between pre and post shift urinary nickel results.

Plots of the correlation between measured nickel inhalation exposure and post shift urinary nickel are presented in figures 11 and 12.

Figure 11. Correlation between measured nickel inhalation exposure and post shift urinary nickel results, for all data (N=42).

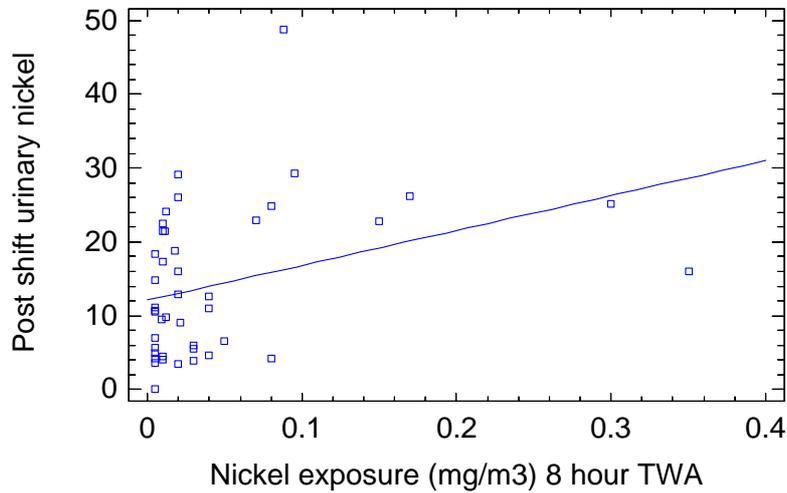
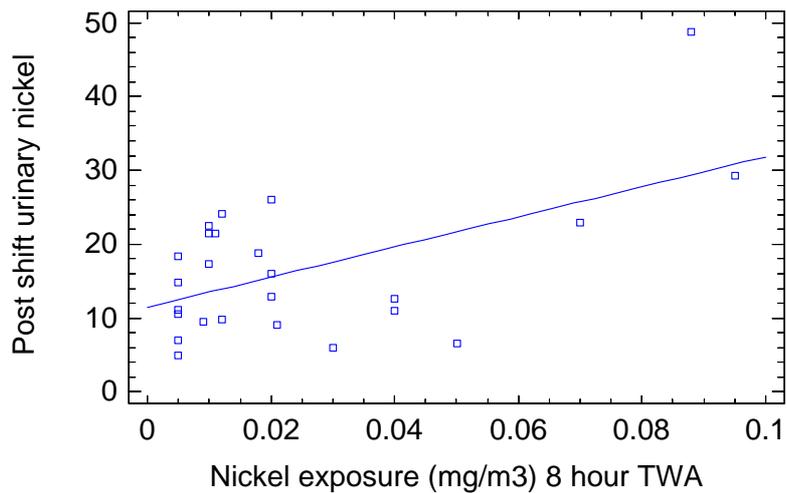


Figure 12. Correlation between measured nickel inhalation exposure and post shift urinary nickel results, for data obtained from welders not using RPE (N= 24).



As observed with chromium, statistical analysis indicates a weak relationship between urinary nickel and inhalation exposure when all data are considered, with a correlation coefficient of 0.35. However, when data is removed for the 10 workers using RPE, the relationship becomes more significant, with a correlation coefficient of 0.55.

The good correlation between inhalation exposures to chromium and nickel (when workers were not wearing RPE) and their urinary concentrations is surprising and encouraging. The correlation is surprising because the air measurements reflect a short period of exposure whereas because of the relatively long half-lives of urinary chromium and nickel the biological monitoring results are indicative of a combination of recent and long-term exposure. The correlations are encouraging because even at these relatively low levels of exposure, where 'background levels' are a significant component of the biological monitoring results they are still indicative of increased exposure. HSLs Biological Monitoring team quote reference values for unexposed subjects of 0 - 3  $\mu\text{mol/mol}$  creatinine for chromium and 0.5 - 10  $\mu\text{mol/mol}$  creatinine for nickel. Site 2 carried out FCA welding using a stainless consumable and so a significant amount of nickel and chrome are generated in the fume. The site has been carrying out the same process for at least 10 years and there is good evidence to show exposures have been broadly similar in this time. Air-fed RPE is routinely used and has been for at least 10 years and yet the BM results obtained for chromium are within the BMGV for 7 of the 8 workers sampled. The 8<sup>th</sup> worker had a post shift of 10.34  $\mu\text{mol/mol}$  creatinine. This suggests that the RPE is providing good protection and that control within the BMGV can be achieved given use of appropriate control measures, even for those welding techniques generating high levels of airborne contaminants.

When the chrome (VI) BMGV was established it was acknowledged that stainless steel welders may have difficulty in meeting the proposed BMGV (HSE, 2003). To some extent the data collected in the course of this survey support this. However, breaches of the BMGV, where good standards of exposure controls were consistently applied, were uncommon. Hence breaches of the BMGV were generally associated with workplaces and practices where exposure controls could be improved.

#### **4.2.3 Extended assessment of biological monitoring**

The extended assessment of biological monitoring conducted at site 1 allowed a structured study of the relationship between inhalation exposure and urinary metal excretion to be made which was not possible from the one day 'snap-shots' obtained at the other sites. Further detailed information of this nature should allow firmer conclusions to be drawn regarding the utility of BM as an exposure assessment tool for welders. As stated previously, agreement for an extended assessment of biological monitoring was obtained from site 2 but this was not done as the site's production schedules did not fit with the timescale of this project.

At site 1 a total of eight workers provided samples for this extended assessment. Five of eight workers had average post shift urinary chromium results above the UK BMGV of 10  $\mu\text{mol/mol}$  creatinine. None of these urinary chromium results were above the corresponding EKA or BEI values. Table 7 shows a comparison of Monday pre shift and Friday post shift results. There is no UK BMGV for nickel, all urinary nickel results were within the German EKA value which is approximately equivalent to 90  $\mu\text{mol/mol}$  creatinine.

The data show that even after a two week break in potential exposure to stainless steel welding fume there is no discernable decrease in urinary chromium and nickel concentrations. Only one of the six workers sampled following the extended break had a urine result which was the lowest result obtained from their complete data set, this was a nickel result for a worker carrying out MIG welding. This is not surprising given the findings of Petersen *et al* (2000), they studied the half life of chromium in the urine of a former plasma cutter of stainless steel. It was found

that after cessation of exposure, the elimination of chromium is very slow, the half life of chromium in urine was 129 months.

The long half lives of chromium and nickel mean that interpretation of BM results needs some care. Action should not be based on a single result but on the trend in several results over a period; a trend for increasing results should trigger a review of the exposure controls, preferably before the levels exceed the BMGV. For workers with a body burden accumulated from previous exposures, perhaps from previous employment, controls should be implemented such that the trend in BM results is downward. If a biological monitoring programme is to be carried out to assess stainless steel welding fume exposure, then consideration should be given to testing new employees at their induction to establish a baseline value.

Table 7. Comparison of data at start and end of working week.

	Metal concentration in urine ( $\mu\text{mol/mol}$ creatinine)			
	Chromium		Nickel	
	Monday pre shift	Friday post shift	Monday pre shift	Friday post shift
Worker 1 week 1	13.07	9.94	12.99	14.97
Worker 1 week 2	10.0	9.64	19.52	18.33
Worker 2 week 1	7.37	9.43	27.07	15.19
Worker 2 week 2	7.97	7.49	9.67	21.42
Worker 3 week 1	29.19	19.77	20.36	27.77
Worker 4 week 1	10.66	10.97	22.83	22.85
Worker 4 week 2	10.87	11.49	19.68	26.16
Worker 5 week 1	15.03	19.05	32.69	27.91
Worker 5 week 2	14.57	15.9	22.31	22.84

#### 4.2.4 Exposure controls

Three of the eight sites visited had no written COSHH assessment covering welding processes. Where they existed, the COSHH assessments were generally deemed to be of a reasonable standard, although minor to moderate deficiencies were observed. Four of the 8 sites visited conducted no health surveillance on their welders, three of these were the same sites with no written COSHH assessments.

LEV was available for use at six of the eight sites visited. At one site this was in the form of on gun extraction. This provided only partially effective fume capture, with a substantial proportion of the welding fume evading capture. The other five sites with LEV all relied upon flexible arm systems. No use of extracted booths or downdraft benches, as described in COSHH essentials control sheet WL3, was observed at any site. A number of the companies visited were fabrication companies and it is recognised that the differing nature of the workpieces creates a challenge for the design of LEV systems.

The flexible arm LEV observed on these visits provided variable degrees of control. It was common to see incorrect positioning, with the hood too far from the fume source to provide adequate capture. In some cases this was due to the welding being performed at several points

on a single, moderately sized workpiece. Welders are not prepared to constantly reposition flexi arm mounted capture hoods during welding. The only times when this type of equipment was observed to provide adequate fume capture was when small workpieces were being welded on a benchtop. In such situations the captor hood could be left in a fixed position, with the workpieces easily brought within the influence of the hood. There also seems to be common misconception that LEV can affect the weld quality hence it is not used or positioned too far away – this contradicts recent research undertaken by HSL (HSL, 2007).

TIG welding was commonly observed with no engineering control. This even occurred at sites where LEV was available, and was used for other welding techniques. There would appear to be a common perception in the industry that engineering control is not required when TIG welding. This contradicts COSHH essentials guidance, which specifies that LEV should be applied when TIG welding stainless steel.

RPE was available for use at four of the sites visited. At three sites, this consisted of power assisted filtered respirators, incorporated into welding visors. The fourth site provided negative pressure filtered half masks. RPE was used consistently for all welding at one site. This site was performing FCA welding and the engineering controls alone did not provide adequate exposure control. One site specified the use of RPE for MMA welding, but not TIG welding. This policy was adhered to on the day of the sampling visit. The other two sites where RPE was available appeared to leave the use of this equipment to the discretion of the welders.

To summarise, two of the eight sites visited were controlling stainless steel welding processes in accordance with the COSHH essentials welding guidance. The most common deficiencies related to LEV, which was either not present, not used or incorrectly positioned. Two sites had no LEV whatsoever. LEV was available but not routinely used at four of the six remaining sites. Implementation of improved administrative control to ensure that exposure controls are used consistently at these four sites would result in a control strategy compliant with COSHH essentials guidance and a concomitant reduction in exposures.

## 5 CONCLUSIONS

TIG welding is the most common technique for the welding of stainless steel, in conjunction with MIG welding the two techniques account for approximately 90 % of stainless welding.

Breaches of occupational exposure limits were uncommon, even where exposure control strategies were judged to be inadequate.

A significant proportion of companies were not controlling stainless welding fume exposures in accordance with COSHH essentials welding guidance.

There appears to be a common perception within industry that TIG welding of stainless steel does not require engineering control.

Based on the findings from on site surveys and phone enquiries the TIG welding of stainless steel is not generally carried out in accordance with the COSHH essentials guidance. Measured exposures for those carrying out these tasks were well within current exposure limits.

A significant proportion of sites welding stainless steel have adequate exposure controls available, but for various reasons these controls are not used or are used incorrectly. Reasons for this include a reluctance to regularly reposition the LEV hood as the job progresses and a common misconception that LEV can affect the weld quality such that that LEV is not used or positioned so far away from the weld that it is not effective.

There have been no significant changes in welding practices, or the use of exposure controls, since the previous HSL study on stainless welding, conducted in 1999.

Biological monitoring results above the BMGV for chromium were generally associated with exposure controls that could be improved.

Biological monitoring results showed that exposure can be well controlled by the correct use of RPE.

Biological monitoring appears to be a useful aid to the assessment of exposure to chromium and nickel in stainless steel welding. However, due to long half lives of these compounds care needs to be exercised when interpreting results and any actions need to be based on trends in results.

## 6 APPENDICES

### Site 1

The company is based at a large industrial unit manufacturing a range of building products solely in stainless steel. This company was previously visited in 1999 as part of a HSE study. The company predominantly perform MIG welding of differing grades of stainless steel with the same grade of consumable. Those carrying out the MIG welding will also routinely carry out general fabricating duties. Some TIG welding is also performed.

RPE was available, although not always used. Flexible arm LEV was observed to adequately control smaller sized MIG and TIG welding tasks although was less applicable to the sizeable amount of welding performed on larger pieces. Dedicated welding bays were in use. COSHH assessments were comprehensive and the company had recently commissioned an exposure monitoring survey and results of this were made available. An occupational nurse performed various health checks although it is not recalled whether lung functions tests were performed.

This site was visited on three occasions, first in December 2006 where seven workers were monitored. A more in depth study was carried out over a two week period November/December 2007 with eight workers where urine samples were collected over two weeks with air monitoring being carried out on the first Monday and the second Friday. Further urine samples were collected in January 2008 on the first day back after a 12 day shutdown. A summary of the measured exposures is shown in table 8 below, with BM results in table 9.

Table 8. Summary of inhalation exposure data from site 1.

Airborne contaminant	Measured inhalation exposure range (mg/m <sup>3</sup> )		
	Visit 1 December 2006	Visit 2 November 2007	Visit 3 December 2007
Total inhalable particulate (8-hr TWA)	0.86 - 4.29	0.56 - 11.4	0.46 - 8.34
Total chromium (8-hr TWA)	0.048 - 0.23	0.009 - 1.16	0.018 - 0.45
Chromium (VI) (8-hr TWA)	0.0012 - 0.0075	<0.001 - 0.027	<0.001 - 0.013
Nickel (8-hr TWA)	0.021 - 0.095	<0.01 - 0.35	<0.01 - 0.17

Note that in cases where the WEL has been exceeded, the welders were using power assisted RPE with a P3 filter, which, given adequate maintenance and correct usage is given an APF of 10. Hence, the actual inhalation exposures would be somewhat lower than those measured.

Table 9. Site 1 biological monitoring data summary.

Metal in urine concentration	Visit 1 December 2006	Visit 2 Week 1 November 2007	Visit 3 Week 2 December 2007	Pre-shift January 2008
Chromium ( $\mu\text{mol/mol}$ creatinine)	2.87 - 56.56	0.5 - 33.03	4.55 - 19.32	4.43 - 26.09
Nickel ( $\mu\text{mol/mol}$ creatinine)	5.56 - 48.78	5 - 38.9	8.99 - 34.17	5.78 - 25.64

Recommendations made to the company related to ensuring that the LEV is positioned correctly and that the RPE was used more consistently.

## Site 2

The company manufactures specialist vehicles, which involves FCA welding of steel using a stainless steel consumable. This site was visited in 1999 as part of a HSE study. The process, and exposure controls, were essentially unchanged in the intervening years.

On-gun extraction was in use. This was previously evaluated in a HSE study and found not to be particularly effective. The welding is carried out in a large open workshop, which had a basic general ventilation system which was assessed to offer minimal air movement. The site is highly reliant on the use of RPE for adequate exposure control. This equipment is routinely used and well maintained. The BM results are a good indicator of well controlled exposure over a prolonged period of time.

Exposure monitoring was carried out on eight welders carrying out the FCA welding process. The company has had monitoring surveys commissioned in the past and the most recent results were obtained for inspection during the site visit. A COSHH assessment for the welding process monitored was available, although had not been reviewed for a number of years. A point of some concern at the site was that we observed what was considered a significant amount of welding in a confined space within the hull of an armoured vehicle. This was not acknowledged in the COSHH assessment, failure of the RPE in this instance would give rise to very high exposures. It was recommended that the company consider improving ventilation during the confined space work and that the COSHH assessment is reviewed more regularly.

Measured exposures to total inhalable particulate ranged from  $3.01 \text{ mg/m}^3$  to  $6.60 \text{ mg/m}^3$  as 8-hour TWAs. Measured exposures to total chromium ranged from  $0.01 \text{ mg/m}^3$  to  $0.45 \text{ mg/m}^3$  as 8-hour TWAs. Measured exposures to chromium (VI) ranged from  $<0.001 \text{ mg/m}^3$  to  $0.082 \text{ mg/m}^3$  as 8-hour TWAs. Measured exposures to nickel ranged from  $<0.01 \text{ mg/m}^3$  to  $0.08 \text{ mg/m}^3$  as 8-hour TWAs.

Post shift urinary chromium results ranged from  $3.29 \mu\text{mol/mol}$  creatinine to  $10.34 \mu\text{mol/mol}$  creatinine and post shift urinary nickel results ranged from  $3.4 \mu\text{mol/mol}$  creatinine to  $4.63 \mu\text{mol/mol}$  creatinine.

### Site 3

This was a general fabrication company producing custom built equipment for use in the water treatment, petrochemical industries and also for hygienic applications. All welding performed is TIG welding of 316 grade stainless steel. No LEV was used. General ventilation was provided by two fans. The main work area is a large open workshop with no dedicated welding bays, although various welding screens were in place. Welder will also routinely perform other fabricating duties, although there is a separate polishing shop. Exposure monitoring was carried out on six welder fabricators. One welder was observed welding in a confined space, this workers exposures were the highest measured.

Points of concern were the lack of a COSHH assessment. Welding was not being controlled in accordance with the COSHH essentials guidance, although measured exposures and urine results indicate exposures well within exposure limits. The main recommendations made were that a COSHH assessment be carried out and some form of control measure be installed to comply with the minimum standard specified in the COSHH essentials welding guidance.

Measured exposures to total inhalable particulate ranged from 0.73 mg/m<sup>3</sup> to 4.75 mg/m<sup>3</sup> as 8-hour TWAs. Measured exposures to total chromium ranged from 0.01 mg/m<sup>3</sup> to 0.04 mg/m<sup>3</sup> as 8-hour TWAs. Measured exposures to nickel ranged from <0.01 mg/m<sup>3</sup> to <0.019 mg/m<sup>3</sup> as 8-hour TWAs.

Post shift urinary chromium results ranged from 0.96 µmol/mol creatinine to 2.47 µmol/mol creatinine and urinary nickel results ranged from 6.97 µmol/mol creatinine to 14.75 µmol/mol creatinine.

### Site 4

This company is a specialist stainless steel fabricator manufacturing custom built equipment for use in hygienic applications and in the water and petrochemical industries. Most items are produced to order and will involve a significant amount of TIG welding of stainless steel.

The welding is carried out in a single workshop, which does not have dedicated welding bays, although there are welding screens in place. The workshop had a single roof-mounted axial fan, together with a heating system which will provide some air movement. The company also had a Nederman portable extraction system, approximately 2 years old at the time of visit. This had not had a 14-monthly check as per COSHH regulations. This is used for MMA or MIG welding of stainless steel, but is not used for any TIG welding of stainless steel.

Welders are provided with welding visors, protective gloves, safety boots and coveralls. Those carrying out TIG welding do not use any RPE. However powered particulate filtering respirators were available and was observed in use for a welder carrying out MMA welding of stainless steel.

Exposure monitoring was carried out on two welder fabricators TIG welding stainless steel and on one welder fabricator performing MMA welding of stainless steel.

A point of concern was the lack of COSHH assessments for the welding processes observed. TIG welding of stainless steel was not being controlled in accordance with the COSHH essentials guidance, although measured exposures were well within prescribed limits. The MMA welding of stainless steel was being controlled in accordance with the COSHH essentials guidance.

Measured exposures to total inhalable particulate ranged from 0.93 mg/m<sup>3</sup> to 1.17 mg/m<sup>3</sup> to as 8-hour TWAs. Measured exposures to total chromium ranged from 0.03 mg/m<sup>3</sup> to 0.07 mg/m<sup>3</sup> as 8-hour TWAs. Measured exposures to chromium (VI) ranged from <0.001 mg/m<sup>3</sup> to 0.002 mg/m<sup>3</sup> as 8-hour TWAs. Measured exposures to nickel ranged from 0.02 mg/m<sup>3</sup> to 0.05 mg/m<sup>3</sup> as 8-hour TWAs.

Post shift urinary chromium results ranged from 4.76 µmol/mol creatinine to 10.51 µmol/mol creatinine and post shift urinary nickel results ranged from 5.67 µmol/mol creatinine to 16.02 µmol/mol creatinine.

Recommendations made to the company were that COSHH assessments be carried out for all welding processes carried out, consideration be given to installing some form of control measure(s) for the stainless steel TIG welding to comply with the COSHH essentials guidance. Furthermore suggestions relating to RPE were made; staff should be trained in correct use and maintenance, monthly checks should be made and documented.

## Site 5

This company is a specialist engineering company, with main areas of work being anti-corrosion cladding and fabrication work, often in stainless steel. Most fabrication will involve a significant amount of stainless steel welding using either TIG or FCA techniques.

The welding is carried out in two industrial units, located side by side, known as units 7 and 8. Each has dedicated welding bays installed. Unit 7 has a forced mechanical general ventilation system, comprising 5 extract grilles above head height, ducted away and discharged at height. Unit 8 has a single roof-mounted axial fan providing some general ventilation. Unit 8 also has a LEV system with 3 flexible arms extraction units serving three welding bays. This system had been tested in accordance with the 14-monthly checks specified in the COSHH regulations. The system was observed to provide effective fume capture given careful positioning by the operator. There were a number of occasions where the LEV was not correctly positioned and effective fume capture was not achieved.

On the day of the visit exposure monitoring was carried out on four welder fabricators. One was carrying out FCA welding using a stainless consumable in unit 8. This worker used the LEV system supplied. No RPE was worn. The remaining three operators worked in unit 7 and were carrying out TIG welding of 304 grade stainless steel with a 308 grade stainless wire. These operators did not wear any RPE although it was reportedly available if required. Standard PPE comprised welding visor, protective gloves, safety boots and hearing protection.

The Managing Director (MD) had a positive attitude towards Health and Safety and there was a good awareness of the health risks relating to stainless steel welding. The company had suitable and sufficient risk/COSHH assessments in place for the welding tasks observed. The company had also commissioned an airborne monitoring survey and results of this were made available. The company also ensure that an occupational nurse sees all employees on an annual basis.

Measured exposures to total inhalable particulate ranged from 0.86 mg/m<sup>3</sup> to 2.51 mg/m<sup>3</sup> as 8-hour TWAs. Measured exposures to total chromium ranged from 0.03 mg/m<sup>3</sup> to 0.06 mg/m<sup>3</sup> as 8-hour TWAs. Measured exposures to chromium (VI) ranged from 0.002 mg/m<sup>3</sup> to 0.005 mg/m<sup>3</sup> as 8-hour TWAs. Measured exposures to nickel ranged from 0.01 mg/m<sup>3</sup> to 0.02 mg/m<sup>3</sup> as 8-hour TWAs.

Post shift urinary chromium results ranged from 4.67  $\mu\text{mol/mol}$  creatinine to 11.04  $\mu\text{mol/mol}$  creatinine and post shift urinary nickel results ranged from 10.91  $\mu\text{mol/mol}$  creatinine to 26.06  $\mu\text{mol/mol}$  creatinine.

Recommendations made to the company were to implement control measures to comply with the COSHH welding guidance, or to provide thorough assessment and documentation to show that the alternative controls measured used are achieving adequate control.

### **Site 6**

This is newly established company, specialising in the fabrication of stainless steel products to a variety of customers. Typical products are balustrades, staircases and industrial kitchenware.

The welding is carried out in a single large open workshop, which has three roof mounted fans together with a blown air heating system which will offer some natural ventilation. No LEV systems are in place. Standard PPE comprised flame retardant coveralls, safety shoes, protective gloves and welding visor. RPE was not used although, reportedly was available.

On the day of the visit air monitoring was carried out on a single welder fabricator who was performing TIG welding of stainless steel. Urine samples were taken from this welder and also from another worker who spent a significant amount of time on the shop floor.

The company's MD showed a positive attitude towards health and safety, and had good knowledge of the health risks associated with stainless steel welding. However, no COSHH assessment for the welding processes existed.

Measured 8-hour TWA exposure to total inhalable particulate was 3.9  $\text{mg/m}^3$ . Measured 8-hour TWA exposure to total chromium was 0.08  $\text{mg/m}^3$ . Measured 8-hour TWA exposure to chromium (VI) was 0.003  $\text{mg/m}^3$ . Measured 8-hour TWA exposure to nickel was 0.03  $\text{mg/m}^3$ .

Post shift Urinary chromium results ranged from 0.46  $\mu\text{mol/mol}$  creatinine to 1.54  $\mu\text{mol/mol}$  creatinine and post shift urinary nickel results ranged from 7.57  $\mu\text{mol/mol}$  creatinine to 9.19  $\mu\text{mol/mol}$  creatinine.

Recommendations made to the company were that a COSHH assessment be carried out and also some form of exposure control be installed to comply with the COSHH welding guidance.

### **Site 7**

This company is a metal fabrication company mainly serving the oil and gas industry. Stainless steel welding does not form a large part of the companies workload, although the stainless workload is variable.

The company has a dedicated SHEQ manager, and had conducted COSHH assessments for the stainless steel welding processes. Annual health surveillance is carried out and this includes spirometry, audiometry and sensorineural testing.

On the day of the visit exposure monitoring was carried out on two welder fabricators carrying out TIG welding of stainless steel. The premises comprise a large main workshop with 5 welding bays attached, one of which is allocated for stainless steel work. General ventilation was provided by roof vents. LEV was present in the stainless steel welding bay in the form of flexible arm extraction, one being wall mounted and the other a mobile unit. The LEV was subject to a quarterly maintenance regime. Standard issue PPE comprised flame retardant overalls, safety boots, protective gloves, hearing protection and welding visor. RPE was worn

by one of the two workers, this was a ori-nasal respirator with P3 filter, this appeared in good order and was apparently suitable stored although no face fit test had been carried out.

Measured 8-hour TWA exposures to total inhalable particulate were 2.2 and 1.8 mg/m<sup>3</sup>. Measured 8-hour TWA exposures to total chromium were <0.02 mg/m<sup>3</sup>. Measured 8-hour TWA exposures to chromium (VI) were <0.002 mg/m<sup>3</sup>. Measured 8-hour TWA exposures to nickel were <0.01 mg/m<sup>3</sup>.

Post shift urinary chromium results ranged from < 1 nmol/mol creatinine to 0.43 µmol/mol creatinine and urinary nickel results ranged from <20 nmol/mol creatinine to 10.66 µmol/mol creatinine.

Recommendations made to the company were that correct and continual use of LEV be enforced by management to include appropriate training.

### **Site 8**

This company is a metal fabrication company mostly producing stainless steel products for the construction and manufacturing sectors. Typical products are staircases, storage vessels and industrial pipework. A significant amount of the company work involves welding offsite, this was not monitored.

The company has a generic welding risk assessment, identifying the welding fume as hazardous. A separate assessment exists for the TIG welding of stainless steel, acknowledging the risk of Chromium (VI). Health surveillance is not performed.

The welding is carried out in an open plan workshop, which had 3 roof mounted vents (2 with fans) which will offer some general ventilation. LEV was present as flexible arm captor hoods (three of) connected to a single axial fan which discharged outdoors, unfiltered. The company also hired a portable extraction system as required. Such a system was in use on the day of our visit. Reportedly LEV systems were checked on a weekly basis, although no evidence to support this was provided.

Standard issue PPE comprised flame retardant coveralls, safety shoes, protective gloves, ear protection and welding visor. Exposure monitoring was carried out on one welder fabricator, this employee did not wear any RPE although P2 disposable respirators were available. No face fit tests had been carried out.

Measured 8-hour TWA exposure to total inhalable particulate was 1.2 mg/m<sup>3</sup>. Measured 8-hour TWA exposure to total chromium was <0.02 mg/m<sup>3</sup>. Measured 8-hour TWA exposure to chromium (VI) was <0.002 mg/m<sup>3</sup>. Measured 8-hour TWA exposure to nickel was 0.01 mg/m<sup>3</sup>.

Post shift urinary chromium was 5.22 µmol/mol creatinine and post shift urinary nickel was 17.36 µmol/mol creatinine.

No particular recommendations were made to the company but it was observed that on one occasion the flex-arm LEV was incorrectly positioned. The correct training for employees together with a regular maintenance program and management supervision in necessary to ensure adequate control is maintained with these types of system.

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# A small survey of exposure to stainless steel welding fume

Specific aims and objectives for the project were:

- To visit a representative group of workplaces carrying out welding of stainless steel, scoping the various control strategies proposed in COSHH Essentials for welding, hot work and allied processes.
- To assess compliance with good occupational hygiene practice by:  
  
occupational hygiene observations;  
air monitoring for total inhalable particulate, total and hexavalent chromium, nickel and other metals; and biological monitoring for chromium and nickel.
- Make recommendations for improvements to controls and monitoring where appropriate.

This report and the work it describes were funded by the Health and Safety Executive (HSE). Its contents, including any opinions and/or conclusions expressed, are those of the authors alone and do not necessarily reflect HSE policy.