Department of Consumer
and Employment Protection
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WorkSafe

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SUMMARY PROJECT REPORT 2006/2007

Hexavalent chromium exposure in the electroplating industry

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1. **Introduction**

From December 2006 to May 2007 WorkSafe conducted a workplace inspection and monitoring project at various electroplating workplaces including those in the hard chrome, decorative chrome and zinc electroplating industries.

1.1 Hazardous substances in electroplating

The electroplating process involves the use of a range of hazardous substances including acids and solvents. Both chrome and zinc electroplating use hexavalent chromium, a known human carcinogen. Historically, high exposures to hexavalent chromium have been associated with a range of health effects from skin lesions (known as chrome sores), perforation of the nasal septum; skin and lung sensitisation through to cancer of the lung. The highest potential exposures to hexavalent chromium occur in the hard chrome plating industry followed by decorative chrome plating and to a lesser degree, zinc electroplating.

1.2 Hazard controls – hexavalent chrome exposure

Current controls used to reduce hexavalent chromium exposure in the electroplating industry centre on substitution, engineering, administration and personal protective equipment and clothing.

1.21 Substitution

The less toxic trivalent chromium can be substituted for hexavalent chromium with an associated reduction in health risk but cost and process limitations apply. The use of trivalent chromium in hard chrome plating is currently under trial in Australia and it anticipated that a practicable process will be available within a few years.

1.22 Engineering controls

Engineering controls involve the use of local exhaust ventilation (LEV) to capture and remove chromic acid mist from the tank surface in chrome plating (and acid mist in zinc electroplating).

General ventilation (natural ventilation and/or fans in the roof) is in place at many workplaces. This may dilute the contaminants in the air by means of drawing fresh air through the workplace, however the contaminants will still pass through the employees' breathing zone, rather than being captured close to the tank as occurs when local extraction ventilation is used.

1.23 Administrative controls

Administrative controls include the use of surfactant (known as fume suppressant) to reduce the surface tension of the plating solution resulting in a significant reduction in the bursting of hydrogen and oxygen bubbles that result in the production of the chromic acid mist. The dosing of fume suppressant into chrome tanks is carried out on a manual or automated basis. Automatic pumps for dosing tanks with fume suppressant are available that monitor current draw in order to ensure that the required amount of fume suppressant is delivered as required and provide a more reliable (and economical) control over chromic acid mist generation than manual dosing alone. Other administrative controls required where there is a risk from chrome or hazardous substance exposure include:

- Health surveillance by an appointed medical practitioner (and weekly hand and forearm inspections by a competent person at the workplace)
- Personal hygiene procedures to ensure plating staff do not eat, drink or smoke on the plating lines (and wash hands before eating, drinking or smoking in designated areas)
- Procedures for confined space entry when cleaning plating tanks
- Spill and decanting procedures for the use of hazardous substances

1.24 Personal protective equipment and clothing

Personal protective equipment and clothing includes acid resistant clothing (long sleeves and trousers), splash proof apron, respiratory protective devices, chemical resistant safety boots, gloves and appropriate eye protection (safety glasses, splash-proof goggles or face-shield depending on the task).

2. AIMS

This project sought to assess occupational safety and health (osh) management in the electroplating industry by carrying out inspections at workplaces with particular reference to:

- Hexavalent chromium exposure control
- Hazardous substances management generally
- Other relevant priority areas (i.e. electricity, forklifts, guarding)

3. IMPLEMENTATION

Background research was carried out between October and November 2006 to determine the main hazards present in the electroplating industry and to gain an understanding of the processes involved. Seventeen electroplating companies were visited between December 2006 and April 2007 and monitoring was conducted at six workplaces in May 2007.

4. METHODOLOGY FOR ATMOSPHERIC MONITORING (WHERE CONDUCTED)

The air monitoring was conducted with reference to:

- AS 3640 Workplace atmospheres
- NIOSH Method 7600
- Analysis was by the Chemistry Centre using ICPAES and colourimetry methods

The results were compared to the Australian Exposure Standards for Atmospheric Contaminants; available at www.ascc.gov.au .

Relevant Exposure Standards

TWA: 50 µg/m^3 Chromium (VI) compounds (as Cr)
500 µg/m^3 Chromium (metal)

5. RESULTS AND DISCUSSION

Number of investigations: 17
Number of Improvement Notices: 250
Number of Prohibition Notices: 5
Number of workplaces where atmospheric monitoring was conducted: 6

A breakdown of enforcement outcomes is provided in Appendix A. The principal issue identified within the electroplating industry related to inadequate identification, assessment and control of hazardous substances hazards with 125 improvement notices issued for breaches in this area.

5.1 Monitoring Results

Table 5.1 Results For In Control Process – Personal Sampling of Electroplating Employees

Type of Electroplating	Number of Premises Monitored	Range of Results Approximate Total Cr µg/m^3	Approximate Average Total Cr µg/m^3	Range of Results Approximate Cr (VI) µg/m^3	Approximate Average Cr (VI) µg/m^3
Hardchrome	4	3 to 19	9.5	0.08 to 3.9	1.1
Decorative Chrome	1	5	5	0.1	0.1
Galvanising	1	1 to 1.5	1.3	Below the Limit of Detection	Below the Limit of Detection

Table 5.2 Results For In Control Process – Static Area Sampling In Electroplating Work Area

Type of Electroplating	Number of Premises Monitored	Range of Results Approximate Total Cr µg/m^3	Approximate Average Total Cr µg/m^3	Range of Results Approximate Cr (VI) µg/m^3	Approximate Average Cr (VI) µg/m^3
Hardchrome	4	2 to 19	10	0.04 to 18.4	4.3
Decorative Chrome	1	4.5 to 5.5	5	0.09 to 0.12	0.1
Galvanising	1	Not Conducted	Not Conducted	Not Conducted	Not Conducted

These results show at the time of monitoring, the levels of airborne chrome for “in control” processes were well below the exposure standards. It was noted that the ratio of chromium six to total chromium was fairly low, which may be due either to sampling other forms of chromium (eg from polishing operations) or due to reduction of chromium prior to analysis. This may mean that a larger proportion of the total chromium than tabled above is actually chromium six.

Note that (with the exception of the galvanising workplace) the lowest atmospheric chrome levels found came from premises using relatively efficient local exhaust ventilation systems.

5.2 Hard-chrome Workplace Monitoring

Atmospheric monitoring of four premises involved with hard-chroming showed that for normal, in control processes the total chrome exposure for chrome shop employees ranged from 3 to 19 µg/m^3 with the average being approximately 9.5 µg/m^3.

The hexavalent chrome exposure to employees ranged from 0.08 to 3.9 µg/m^3 with the average being approximately 1.1 µg/m^3.

Area monitoring near the tanks gave a range of 1.7 µg/m^3 to 19.4 µg/m^3 for total chrome with the average being 10.2 µg/m^3. Hexavalent chrome area monitoring near the chrome tanks ranged from 0.04 µg/m^3 to 18.4 µg/m^3 with the average being 4.3 µg/m^3.

5.3 Decorative Chrome Workplace Monitoring

Monitoring of one workplace showed the employee’s personal total chrome exposure was 5.1 µg/m^3. The employee’s level of exposure to hexavalent chromium was measured at 0.10 µg/m^3.

The total chrome range near the tanks was between 4.7 µg/m^3 and 5.3 µg/m^3 with an average of 5 µg/m. Hexavalent chrome levels in the air near the tanks ranged between 0.09 µg/m^3 and 0.12 µg/m^3, with an average of approximately 0.10 µg/m^3.

These levels are lower than the levels in hard-chrome workplaces, which is expected due to the process differences (lower current and shorter plating times).

5.4 Galvanising Workplace Monitoring

Total chrome was monitored for two employees with results of 1.0 µg/m^3 and 1.5 µg/m^3 giving an average of approximately 1.25 µg/m^3. Hexavalent chrome was below the detection limits. These levels are lower than those at hard-chrome or decorative chrome workplaces, which is to be expected due to the lower concentration of chromium used in the process.

Due to the nature of the workplace it was not considered practicable to take a positional sample (risk of damage to equipment and inconvenience to workplace).

6. ADDITIONAL INFORMATION

Evidence of chromic acid mist fall out ("brown out") was present in most hard chrome plating workplaces, characterised by a film of brown dust throughout the workshops. The presence of chromic acid fall out indicates a loss of control of fume suppressant and/or inadequate local extraction ventilation (LEV). Premises that had reasonably efficient LEV appeared to have significantly less brown dust in the chroming area. Temperature monitoring and systems of work that help control temperatures clearly helps reduce the risk of "brown outs".

7. CONCLUSION

Whilst the atmospheric monitoring results gave low chrome airborne levels during normal work processes (well below the exposure standards), discussions with industry staff and evidence of "brown-outs" indicate that on occasion, many workplaces still lose control of the chroming process, increasing the risk of hexavalent chrome exposure to persons in the area. The most effective control measure based on the results was found to be an efficient local exhaust system

This project has determined that the general level of osh awareness and osh management throughout the electroplating industry needs significant improvement. The current project has resulted in significant enforcement action in relation to the use of hazardous substances (as well as other WorkSafe priority areas) and increased osh awareness throughout the industry.

8. RECOMMENDATIONS

These recommendations take into consideration that many workplaces may occasionally have a loss of control of their tanks with resultant chrome mist "brown-outs" and that hexavalent chromium is carcinogenic, therefore exposure should be reduced as far as practicable. WorkSafe recommends:

1. That workplaces ensure that their chrome plating tank systems as far as practicable minimise the risk of loss of temperature control.

2. Chrome plating workplaces note that local extraction ventilation *in conjunction* with automatic surfactant dosing represents best practice in control of atmospheric chromium, and where practicable implement both of these controls.

3. Where a local extraction ventilation system is installed, air flow is tested to ensure the capture velocity is adequate across the chrome mist generation area (eg a minimum of 0.5 metres per second across all points of the tank). Records of such ventilation testing and any maintenance work carried out on the LEV should be kept.

4. Chrome plating workplaces should incorporate automatic dosing of fume suppressant. Where a manual dosing system is used it will be required by WorkSafe that clear records are kept indicating when doses were added and the quantity of the doses.

5. Where a "brown-out" event or loss of control occurs such that chrome mist levels in the breathing air are likely to be high, including where workers are returning after days off to reopen premises, then there should be a plan to safely deal with this including protecting any person required to enter such an environment. Prior to entering such environments, persons required to activate ventilation, dosing and other controls to improve the working environment for the entry of others should have ready access to respirators and personal protective equipment complying with the appropriate Australian Standards. The procedure should also address adequate ventilation prior to the entry of other employees, and decontamination/showering for employees entering the workplace under "brown-out" conditions.

6. Employers at electroplating workplaces should familiarise themselves with the types of breaches identified during this project (Appendix A) and develop systems (e.g. workplace inspections, toolbox meetings) to manage these osh issues in consultation with employees.

   Refer to the guidance material "Controlling Hazards in the Electroplating Industry" (enclosed), WorkSafe's website www.worksafe.wa.gov.au , or contact WorkSafe on 9327 8777 for further advice on osh issues.

Appendix A: Number of notices issues for different breaches

Section or Regulation	Description of breach	Number
	Hazardous Substances Register/MSDS	10
	Hazardous Substances Risk Assessment/ Risk Assessment Report	12
	Hazardous Substances Risk Assessment Report	10
	Hazardous Substances Training	12
	Hazardous Substances Labelling	8
	Hazardous Substances Storage	2
	Hazardous Substances Health Surveillance – Hexavalent Chromium	13
	Hazardous Substances Spills Procedure	7
	Hazardous Substances Decanting Procedure	6
	Hazardous Substances – chrome plating – records of fume suppressant dosing	4
	Hazardous Substances – personal hygiene – consumption of foodstuffs	9
	Emergency shower/eyewash (fit/repair)	10
	Provision/use/maintenance of Personal Protective Equipment and Clotting	10
	Evacuation	2
	Confined space entry procedures	14
	Edge protection (especially caustic tanks and mezzanine floors)	13
	Bench Grinders (signage/guarding)	9
	Isolation of plant	12
	Emergency stops on plant	2
	Guarding of plant	3
	Air receiver registration and inspection	4
	Gantry / hoist maintenance	5
	Certificate of competency – dogging	1
	Certificate of competency – forklift	6
	Forklift maintenance	9
	Forklift maintenance records	3
	Forklift operators manual	6
	Forklift (operating on rough surfaces)	1
	Forklift wearing of seat belts	2
	Electrical RCD	6
	Electrical maintenance	12
	Fire fighting equipment	2
	General housekeeping	3
	Slippery surfaces	2
	Slips trips and falls	4
	Smoking in the workplace	2
	General induction	2
	General risk assessment	2
	Damaged lifting slings	1
	Unsecured pallet racking	2
	Flashback arrestors	2
	Secure gas cylinders	1
	First aid	1
	Sandblasting	3
Total		250