Cadmium in silver soldering or brazing

Engineering Sheet No 31

Introduction

Silver (hard) soldering or brazing is a very versatile means of making joints by using a fusible alloy as a filler material between similar or dissimilar parent materials. Temperatures above 620°C are applied, usually by hand-held flame torch or another heating device, eg induction or electrical heater/furnace, to melt the filler material into a capillary gap between the parent materials and create a suitable bond.

Such joints are invariably leak proof, will withstand vibration, tensile and torsional loading, and maintain integrity at both sub-zero and elevated temperatures. When well selected and applied, they can also resist attack to a wide range of corrosive environments.

Because of these excellent properties and ability to join dissimilar materials, silver solder alloys are used in practically every branch of the metal fabrication industry.

Background

A wide range of alloys have been developed to provide suitable jointing properties for an even wider variety of parent materials and applications. Although silver is predominantly used, other elements within the filler materials include copper, zinc, tin, nickel, phosphorus, manganese, silicon and cadmium.

The use of cadmium has particular advantages in reducing the working temperature required and providing good flow properties for making the joint. Typically, between 16-25% cadmium may be present in a cadmium-containing silver solder (see Table 1). A cadmium-containing alloy of 42% silver has a melting range of 608-617°C (BS 1845-AG2) whereas the 'cadmium-free' near cost equivalent alloy of 40% silver has a melting range of 650-710°C (BS 1845-AG20).

Table 1

Alloy BS 1845 type	Cadmium content %
AG1	19%
AG2	25%
AG3	20%
AG9	16%
AG10	20%
AG11	21%
AG12	21%

These alloys may be supplied in a variety of forms, eg rods, wires, foil, rings and washers etc. They are widely used in engineering, such as in the manufacture of motor vehicle components, bicycle frames, heat exchangers, tungsten carbide tipped tools, electrical equipment and bathroom fittings.

Health effects of cadmium in silver solders

Cadmium is a silver white ductile metal which melts at 320°C and, when heated above this temperature in air, produces cadmium oxide fumes.

Serious health effects on the lungs and kidneys are the principal concerns.

Acute effects

Initial symptoms from inhalation of cadmium oxide fume include:

- irritation of the eyes, nose and throat, followed by;
- cough, headache, dizziness, weakness, chills, fever, chest pains and breathlessness.

Lung damage may occur in the absence of such symptoms and may be delayed for several hours or days.

Very high exposures can cause death with symptoms of acute pneumonitis.

If cadmium is swallowed, symptoms may also include:

- nausea, vomiting, diarrhoea, muscular cramps and salivation.

Chronic effects

On repeated and cumulative exposure to cadmium oxide fume, irreversible kidney damage may result, characterised by increased excretion of low molecular weight proteins in urine. The half-life of cadmium in the kidneys is estimated at 10-40 years so even after exposure has ceased a high body burden will remain.

Adverse effects on the lungs include loss of lung function and abnormalities characteristic of emphysema. The severity of these effects increases with both cumulative cadmium exposure and cadmium concentration.

On the basis of long-term animal inhalation studies

cadmium oxide has also been classified as a Category 2 carcinogen, ie it may be able to cause cancer in humans.

How exposure occurs

- Breathing in fumes or dust containing cadmium and cadmium oxide;
- Ingestion of dust (see next section).

Who is at risk?

Those primarily at risk are (a) operators doing brazing or silver soldering work with cadmium-containing alloys, and (b) others in the vicinity exposed to the fume which is generated.

The fume can settle on work surfaces to form a fine dust film which may then contaminate hands, food, drink etc and be ingested. This dust may also be disturbed and inhaled. Those carrying out maintenance and cleaning work can be particularly affected in this way.

People who work on articles which have previously been soldered using cadmium-containing silver solder may also be at risk. For example, jig makers and repairers, though not using cadmium-containing silver solders themselves, may work on jigs which were made or repaired using cadmium solders. This can lead to significant exposure to cadmium and cadmium oxide fume when the existing cadmium-containing solder is heated up during the repair.

Occupational exposure limits for cadmium and cadmium oxide

While most of the metallic elements used in silver solders have been assigned occupational exposure limits (see Table 2), those alloys containing cadmium are likely to present the most significant health risks.

Table 2: Exposure limits

Element	*8 hr TWA*	short term 15 min
Cadmium (and cadmium oxide)*	0.025mg/m^3	0.05 mg/m^3
Copper	0.2 mg/m^3	
Manganese	1 mg/m^3	3 mg/m^3
Nickel*	0.5 mg/m^3	
Phosphorus		
Silicon (total dust)	10 mg/m^3	
Silver	0.1mg/m^3	
Tin	2 mg/m^3	4 mg/m^3
Zinc (oxide fume)	5 mg/m^3	10 mg/m^3

* denotes MEL

A short-term MEL for cadmium oxide fume has specifically been set to cover acute high exposures which can occur through intermittent silver soldering.

MELs have a legal status explained in the Control of Substances Hazardous to Health Regulations (COSHH) Approved Code of Practice[1] and EH40: Occupational exposure limits.[2]

For a substance which has been assigned a MEL, exposure must be reduced to the lowest level that is reasonably practicable, and in any case below the MEL.

What should users of cadmium-containing silver solders do?

Under COSHH, employers and the self-employed must:

- prevent exposure to cadmium or its compounds or, where this cannot reasonably be done, adequately control the exposure;

- carry out a proper assessment of the health risks arising from silver soldering or brazing with cadmium-containing alloys and the precautions necessary to prevent or adequately control them. This may require air sampling and biological monitoring. Remember to include all people who may be exposed.

Substitution

Prevention of exposure should always be considered first. A full range of practical and safer 'cadmium-free' silver solders are now available. Users of cadmium-containing alloys have the option of changing to the new range but need to consider price and temperature equivalents.

While the cost of some 'cadmium-free' alternatives may be greater, and further costs can result from extended heating cycles and lower output rates, these can soon be recovered by savings made in the protective measures required.

Always check whether a viable 'cadmium-free' silver solder can be used. This should normally be the case. Only where full justification can be given for the use of a cadmium-containing silver solder based on proper risk assessment and the technical requirements of the job should it continue in use.

Where cadmium-free solders are used, a thorough risk assessment should be made of the substance being substituted, to ensure that no new uncontrolled risks have been introduced.

Further guidance on substitution issues can be found in Seven steps to successful substitution of hazardous substances.[3]

Control of exposure

In the limited cases where use of 'cadmium-free' silver solders is not reasonably practicable, exposure must be adequately controlled by a suitable combination of engineering and process control measures.

As cadmium oxide is a Category 2 carcinogen, all the requirements of regulation 7(3) of COSHH must be followed. These include:

- total enclosure of the process and handling systems as far as is reasonably practicable;
- local and general extract ventilation and the use of other plant, processes and systems of work which minimise, suppress and contain fume and dust;
- minimising the number of people exposed and periods of exposure;
- prohibiting smoking, eating and drinking in contaminated areas;
- regularly cleaning work surfaces to minimise contamination (care should be taken to ensure that cleaning activities do not result in exposure, eg dust should be vacuumed rather than swept up;
- the provision of suitable washing and changing facilities close at hand;
- demarcating potentially contaminated areas and displaying suitable warning signs;
- safe storage, handling and disposal of cadmium-containing silver solders;
- use of closed and clearly labelled containers.

Both the COSHH General ACOP[1] and COSHH Carcinogens ACOP[1] give further advice on the measures to be taken.

Key factors which should be considered in providing adequate control are:

(a) composition of the filler material, ie amount of cadmium;

(b) brazing temperature;

(c) brazing time;

(d) rate of consumption;

(e) size of the workroom;

(f) room ventilation.

Because of the directional nature of brazing torch flames and strong convection currents induced, appreciably higher ventilation capture velocities may be required than for most other fume control situations. Flame torches can scatter a plume of fume from the joint causing it to contaminate adjacent areas. As a consequence, containment in an open-fronted booth fitted with extract ventilation may prove far more effective than captor hoods. Care should be taken to ensure that such control measures are effective. Specialist advice may be needed on the design of control measures. See also The control of exposure to fume from welding, *brazing* and similar processes.[4]

Where it is not possible to ensure that personal exposures are kept below the relevant MELs by engineering and process control measures alone, then suitable and adequate respiratory protective equipment (RPE) should be worn.

Environmental risks

Appropriate environmental control legislation, including regulations for waste disposal, should also be met. Acid pickling or burning off articles with cadmium-containing silver solder joints may present special problems. Pickling can result in significant quantities of cadmium entering effluent systems and limits being breached.

Maintenance of control measures

All control measures should be maintained in efficient working order and good repair at all times. In particular, under COSHH, extract ventilation systems must be examined and tested by a competent person at least once in every 14 months and appropriate records kept.

It is recommended that all engineering control measures in use also receive frequent visual inspections at least weekly.

Preventative maintenance procedures should indicate which engineering control measures require servicing, the nature of the work to be carried out, by whom, and how any defects which are found will be put right.

Respiratory protective equipment (RPE) should also be properly maintained and regularly examined, tested, cleaned and suitably stored when not in use.

Filters will need replacing where appropriate in accordance with the conditions of use and suppliers' instructions.

Monitoring exposure

Where significant exposure to cadmium or its compounds can occur, monitoring may be required to ensure the effectiveness of control measures and establish that exposure levels are being kept within the MELs and as low as is reasonably practicable.

Remember that air sampling will not provide a complete picture of the risks where the intake of cadmium through ingestion occurs. Some biological monitoring may also be appropriate to establish the full extent of exposure and the risks.