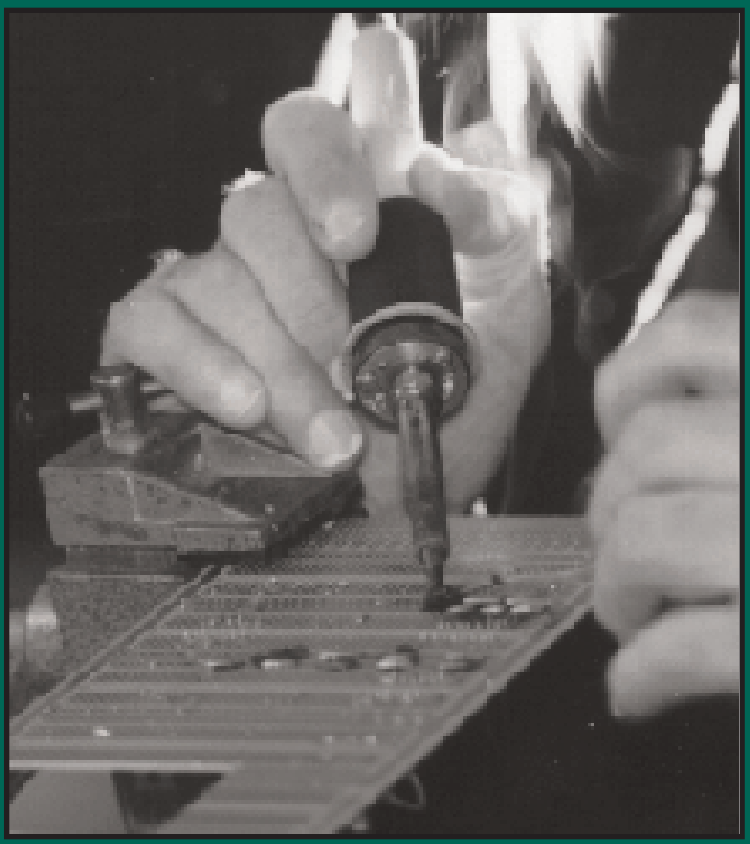

Controlling health risks from rosin (colophony) based solder fluxes

Introduction

Serious health problems may arise from inhalation of fume from rosin (sometimes called 'colophony') or its derivatives (see page 6) contained in solder fluxes. This booklet is concerned only with risks from rosin and its derivatives in solder flux, and not other risks which may arise during soldering. It is aimed at managers of businesses using these fluxes; suppliers of fluxes; and those who supply, use and maintain fume control equipment for soldering work. A separate leaflet, *Solder fume and you,* explains the potential health risks and precautions for people using these fluxes (Ref 1).

What are the health risks?

The heating, during soldering, of the flux containing rosin (or derivatives) produces fume. This fume is one of the most significant causes of occupational asthma in the UK. Once asthma has developed, even small exposures to fume can lead to asthma attacks which may occur immediately or be delayed for several hours. When fully developed, the condition is irreversible. The fumes can also act as an irritant to the upper respiratory tract and eyes, and on contact with the skin these fluxes or their fume can cause dermatitis.

Early symptoms from fume exposure can include:

- watering, prickly eyes
- running or blocked nose
- sore throat
- coughing, wheezing, tight chest and breathlessness.

Sources of exposure

Manual processes

Rosin-based fluxes may be contained in cored solder wire, or in solder paste applied by syringe or other means. Liquid flux can be applied from a bottle or by dipping the component or soldering iron into small jars or pots.

Manual soldering with a hand-held soldering iron poses the greatest risk of fume exposure because the operator's head is likely to be near or actually in the fume rising from the iron or workpiece. Desoldering is likely to become more common due to emphasis on recycling, and when done with a hand-held iron may pose similar risks. Semi-automated processes may also give rise to fume. Without suitable controls, there may be significant risks from fume inhalation and possibly skin contact at any of these processes. People nearby, or exposed elsewhere to drifting or accumulating fume, may also be at risk.

The use of manual soldering in electronic and electrical assembly, repair and re-work is well known. Other processes which are less obvious (but still important) sources of fume exposure include the repair of telecommunications equipment, heating and ventilation installations and domestic appliances. Manual soldering is frequently done in training, research and educational establishments and in a wide range of transient operations on site.

Even intermittent work can lead to high, short-term exposures, particularly if carried out in an enclosed space, or at an awkward angle.

Automated processes

The assembly of printed circuit boards is often highly automated with production lines including wave or reflow soldering. Batch work involving wave or reflow soldering, repair/re-work, desoldering and reclamation may also be automated. Smaller stand-alone units may be found away from production areas, for example in training, research or educational establishments.

Automated equipment can be well enclosed and extracted, reducing the potential for fume exposure. However, workpieces may still be fuming where they emerge from machines at take-off or inspection points, and in areas where they are stacked and left to cool. Even where soldering plant is enclosed and ventilated, fume may escape into the workroom from these other areas. It is often not line operators who are most at risk but others working where fume may drift or accumulate.

Automatic spraying of liquid or foam fluxes is common before wave or reflow soldering. Skin contact with fluxes should be prevented. Fumes may be generated at the pre-heat stage as well as during and after wave or reflow soldering.

Solder pastes are usually applied by stencil, screen printing or syringe dispensing. The main risk initially is from skin contact, but fume will be generated when the flux is heated, as it would with other solder flux applications.

Other areas of potential fume exposure include: automated dipping in solder pots; hot air re-work stations; use of hot plates; at carousels; and during desoldering and reclamation work. Batch reflow and curing ovens not integrated with other automated processes should also be considered.

De-drossing of solder baths may lead to high fume

exposures. Maintenance staff removing residues from soldering and exhaust ventilation systems may also be at risk.

Legal requirements

The Control of Substances Hazardous to Health Regulations (COSHH) require a risk assessment to be carried out where substances hazardous to health are used, and exposure to these substances to be prevented, or adequately controlled (Ref 2). Prevention of exposure should take precedence over adequate control where this is reasonably practicable, and may be achieved by process modification or substitution.

Substitution

When considering any alternative substance or process, users are advised to consult the manufacturers or suppliers on conditions and limitations of use.

Users should first consider whether a rosin-based flux is really necessary. Automated and manual soldering operations, including repair and re-work may be possible with rosin-free materials. However, changing to such a material may significantly affect quality, tolerances, performance levels, output, operational requirements (with the need for new plant and equipment) and re-work costs. There may be no suitable alternative to a rosin-based flux, though new products continue to come on to the market.

A suitable risk assessment will need to be carried out on any potential substitute. Although rosin-free fluxes may remove the asthma risk, they may still present other health and safety risks for which adequate controls, including local exhaust ventilation, may be required.

Check that any fluxes claimed to be 'rosin-free' really do not present similar health risks. Some fluxes contain natural rosin which has been chemically processed or modified to produce derivatives. There are also synthetic fluxes containing resin acid groups similar to those in natural rosin. Such derivatives and synthetic alternatives are still of concern.

Some rosin-based fluxes are described as 'mildly activated', but this does not affect the amount of rosin present or the amount which may be released. They may still present the same risk of asthma.

Where a rosin-free alternative is not viable there may still be scope for significantly reducing the risk through careful consideration of the process. For example, it may be possible to reduce the amount of flux used or the percentage of rosin in the flux which is necessary to do the job. Use of nitrogen inert atmospheres on automated lines is well developed and reduces the amount of flux needed. It may therefore lessen the risk, but should not be regarded as an adequate means of protection in itself.

Rosin-reduced fluxes

Other fluxes may be rosin-reduced. Typical cored solder wire contains up to 3% rosin but some no-clean solder wires contain 0.5 -1.5%. A lower rosin content reduces the level of rosin fume which may be evolved and so is preferable. However, it will still present some health risk, which may be significant when factors such as the duration and frequency of soldering are taken into account. Often, the lower the rosin content, the more difficult it is to achieve a good joint. Users of low-rosin solder wires may be tempted to use extra rosin dip fluxes to compensate.

Alternatives to soldering

Alternatives to soldering exist for electrical and mechanical connections and should be considered, particularly at the design stage of any process.

Mechanical jointing processes such as crimping and wire wrap for electrical connections; fastening using screws or bolts, or compression joints for plumbing and other pipe fitting work may be suitable. Mechanical jointing is not suitable for most electronic assembly operations involving surface mount technology.

Conductive adhesives currently have certain niche applications, but their potential use is expanding. At present, they are not commonly used in electrical assemblies due to their unproven technical properties and cost. Major changes to equipment design may be required and they tend not to be compatible with tin-lead solder alloys. The adhesives are often based on epoxy resins or cyanoacrylates which may themselves present significant health hazards, including occupational asthma and dermatitis. Nevertheless, they could prove suitable in some circumstances.

New technical developments which have the potential to replace traditional solder processes are being made all the time. These include the use of ultrasonic, plasma, laser and micro-welding techniques. The list is not exhaustive.

Control measures in manual soldering processes

The COSHH assessment should identify appropriate control measures (see also *Solder fume and you,* Ref 1). In most cases, some controls will be necessary to protect against inhalation of fume. These will vary

according to:

- ***The type of process:*** How the operators and others are exposed; the size and shape of workpieces; stages of the process, including tinning the iron; the type and gauge of solder; residual fuming of the work and the soldering iron tip while at rest; the number and spread of joints; continuous, repetitive work or intermittent, one-off jobs etc;
- ***The level and nature of the fume:*** Frequency and duration of the work; number of people soldering; temperature of the iron (fume levels can triple between 250-400°C); stickiness of fume affecting extraction design, filtration and maintenance;
- ***Local conditions:*** Size of room; general ventilation; provision of make-up air; air currents and sources of interference such as moving machinery, doors and windows; size of workbench; working position and accessibility.

Specialist advice is recommended before designing a system or purchasing and installing equipment. Remember, various measures may be taken according to the risk. Good general ventilation and careful positioning of the operator may be adequate for small-scale, infrequent work. Where the COSHH assessment shows more complex ventilation systems are required, the system design should ensure:

- effective capture of flux fume at source, so that the level is as low as is reasonably practicable in the breathing zone of everyone in the area;
- suitable location and protection from sticky fume residues of critical components such as pumps, fans and ductwork, to prevent loss of performance;

- effective containment and safe disposal of the fume and, in the case of recirculating systems, effective filtration of the recirculated air;
- adequate provision of make-up air;
- ease of use and maintenance;
- assessment of all running and maintenance costs, including electrical consumption, heat loss and replacement of consumables such as filters.

The extraction systems described below may all be used for fume control during manual soldering, but each has limitations as well as advantages. (Users and potential users are strongly recommended to seek written assurances from suppliers on the standard of control which their products can achieve, together with recommended conditions and limitations of use. All new equipment should be monitored after installation to check that control of fume is adequate.):

1 Multi-position or flexible arm extraction consists of adjustable, self-supporting, flexible ducting or tubing with articulated joints, at the end of which a suitable captor hood is mounted. The proper design and position of the hood is critical to effective capture of the fume. Arm diameters typically range from 12-150 mm depending on the air flow required. The ducting may connect to a single stand-alone extraction filtration system or to a multi-branch system.

***Advantages*:** The ability to set it to an optimum position; flexibility in installation; ease and frequency of maintenance and ability to capture large amounts of fume.

***Disadvantages*:** Reliance on correct adjustment to the work by the operator; applications where the arm needs

to be continually moved over a wide area; restricting movement of the operator and the workpiece at the workstation.

2 Tip extraction, using a narrow bore tube on the iron itself to capture fume at source. The tube (typically 4-12 mm diameter) is either clipped to a normal iron or incorporated in a purpose-made iron. Careful attention should be given to the design of the tip or nozzle and extraction rates for effective fume capture.

***Advantages*:** Continuous removal of fume from the iron while in use or at rest; easy installation; minimal volume/flow rate of air avoiding significant heat loss.

***Disadvantages*:** Blockage of the narrow bore tubes with sticky residues requiring regular and frequent maintenance and cleaning; failure to control fume from components when moved from the work position; less effective for widespread fume production or where there is rapid movement around the workpiece.

3 Fume extraction cabinets are enclosures with one open side or front connected to either a stand-alone or a multi-branch extraction system. They are available in a variety of shapes and sizes depending on the product and required airflow. Small units, if properly designed, can be used to good effect on applications such as solder pots and soldering iron rest positions.

***Advantages*:** Ability to control all fume sources within the enclosure; relatively low maintenance needs; no reliance on correct adjustment by operator.

***Disadvantages*:** Lack of flexibility in installations; possibly poor accessibility; significant installation and running costs; possible need for local lighting.

4 Exhaust ventilated benches have a flush fitting

extraction system, either drawing fumes downwards through the bench or to the rear away from the operator's breathing zone.

***Advantages and disadvantages*:** Similar to those for extraction cabinets. However, without enclosure, the capture of fume may not be as effective, but accessibility is improved. May prove suitable for widespread work on large items.

5 Fume absorber units describe a range of small, boxed, portable, fan/filter, bench-mounted units which may be set close to the soldering operations. Although relatively inexpensive, they can have serious drawbacks.

In particular, the coarse carbon filters usually fitted in these units have been found in tests by HSE to remove only a small proportion of the harmful constituents of the fume. Circumstances in which it may be appropriate to use these devices will be ***very*** limited (eg very light fume, possibly produced intermittently, and very good general ventilation). Care should be taken to site unit discharges away from areas where other people may be affected.

Fume control at other processes

Automated soldering equipment may present serious risks if poorly controlled, but it may also significantly reduce risks by keeping people remote from the fume. Such machines, eg for wave or reflow soldering, usually have purpose-built enclosures to contain fume, with exhaust ports for connection to ducted local extract ventilation systems. Sufficient enclosure and exhaust ports should be provided to ensure effective capture of all fume generated. Equipment suppliers should recommend a suitable exhaust flow rate.

Careful consideration should be given at the design stage to the provision of adequate extract ventilation or other means of fume control at all take-off and inspection points where fume exposure could occur, as well as at the main soldering stations. Further enclosure and extract ventilation may be required on conveyor transfer lines between plant if workpieces still emit fume there. Users and suppliers of plant and control systems will need to assess production operations as a whole, rather than just main soldering stations in isolation.

Adjustable arm extract systems may be useful for hot air re-work, desoldering, solder pots, hot plates and carousels etc.

Protection of the fume control system

Solder fume forms a sticky residue in pumps, fans and ductwork unless these are protected. This residue can rapidly lead to poor extraction, premature pump/fan failure and duct blockage. Suitable filters should be provided to protect against performance loss. Solder fume particles are typically 0.5 -1.0 micron in diameter, requiring high-efficiency filters for effective removal. A planned maintenance schedule should be devised and implemented in consultation with the system manufacturer or supplier, to include regular replacement of filters.

Exhaust to atmosphere and recirculating systems

Systems which exhaust to atmosphere should vent to a safe place outside. They may be less costly to buy and easier to maintain than recirculating systems. However, they may cause significant heat loss.

Any decision to introduce a recirculating system should be included in the risk assessment. A correctly designed system will adequately capture fume and effectively remove it before air is recirculated back into the workplace.

Recirculating systems may reduce the need for lengthy ductwork and prevent the need for some building alterations. They may also prevent significant heat loss. However, if not adequately designed and protected, or if they fail, the reintroduction of harmful fumes back into the workplace will put people at risk. Fume filtration is critical and should be able to remove both particulate and gaseous components. This will involve both high-efficiency particulate filters and suitable chemical filters for the gases. Regular replacement of these filters will be necessary and these costs should be taken into account. In particular, the life of the filter for the gaseous component cannot be easily estimated in situ. A careful estimate of likely life should be made and the filter replaced at the end of its useful life. A suitable fresh air supply should be provided, together with adequate general ventilation of the work-room, to achieve effective control.

Other factors and systems of work

The quantity of fume produced is greatly affected by the process temperature, rosin levels in fluxes, frequency and duration of soldering process, solder type, gauge and total amounts used. These factors in combination can have a considerable overall effect and should be carefully assessed as part of the general control strategy. Operational practices should be developed and implemented to minimise exposure to fume and skin contact. In particular:

- adequate residence times in ovens or other units fitted with extract ventilation should be observed before removal of components;
- inspection, maintenance, setting and cleaning staff should not have access to plant or equipment which is still emitting fumes, unless they are adequately protected; and
- inspection, maintenance and cleaning needs for plant and control systems such as exhaust ventilation should be clearly identified and appropriate procedures drawn up to prevent risk.

Use and maintenance of controls

Controls should always be used when required, and regular checks made that they are working effectively and are properly adjusted. Suppliers' recommended maintenance schedules and procedures should be carefully followed. Maintenance may need to be very frequent to prevent loss of performance, for example, tip extraction tubes may need daily cleaning.

Monitoring and failure detection devices for filters and other parts of the system are available and important in maintaining effective protection. Suitable access and inspection or sampling points should be provided for effective monitoring and maintenance of the ventilation systems.

COSHH requires a thorough examination and test of all extraction systems by a competent person at least every 14 months. In addition, regular visual inspections should be carried out by a responsible person on site and any defects promptly rectified. Suitable records should be kept of all such maintenance inspections, tests and examinations.

Suitable training and instruction in the use and proper maintenance of control systems should be provided for all operators and other relevant staff.

Personal protective equipment and other precautions

Personal protective equipment (PPE) should be used for control only as a last resort when prevention or adequate control by other means are not reasonably practicable. For example, respirators may be appropriate for some transient work such as maintenance or plant cleaning (including de-drossing) where other controls, such as local extraction, are not feasible. Operators should not normally be expected to have to use PPE during routine operation of a plant or process.

The type of any respirator necessary will be determined by the COSHH assessment. Respirators with a combined particulate and organic vapour filter or cartridge will be the minimum requirement. Manufacturers or suppliers should be consulted. Thorough examination and, where appropriate, test of respirators will be necessary at regular intervals. This should not normally exceed one month and may need to be more frequent according to type and use. Manufacturers' recommendations should be followed. Suitable records should be kept of all such tests and examinations.

Suitable gloves and other protective clothing may be needed where there is potential skin contact with rosin-based fluxes or their residues, particularly during inspection of components or cleaning of equipment, work benches or extraction plant. Any potential for splashing of liquid fluxes or other solvent materials may require eye protection. All protective clothing, gloves or eye protection used should be properly maintained

and replaced if necessary.

Adequate washing facilities should be provided, with suitable sinks; clean, running, hot and cold or warm water; soap or other cleansing agents; and towels.

Health surveillance

Health surveillance is a requirement of COSHH where it is appropriate for the protection of the health of employees. It is particularly important where there is a risk of occupational asthma, since detection of early symptoms can prevent the development of asthma. Any problems revealed by health surveillance may also indicate failures in control measures or unsuitable working practices. Extensive guidance on health surveillance can be found in *Preventing asthma at work: How to control respiratory sensitisers; Medical aspects of occupational asthma;* and *Surveillance of people exposed to health risks at work* (Refs 3-5).

The need for and type of health surveillance required for those people exposed to rosin-based solder flux fume will be determined by the risk assessment. It will require supervision by an occupational health practitioner. For many soldering operations, high-level surveillance will be appropriate. This should consist of:

- a questionnaire for identifying relevant symptoms, completed six and 12 weeks after starting work involving exposure to rosin-based solder flux fume, and at yearly intervals afterwards;
- measurement of baseline lung function (peak flow and simple spirometry) at the same intervals; and
- arrangements for relevant symptoms to be reported to a responsible person without delay.

HSE also recommends a pre-employment assessment involving a respiratory questionnaire and the taking of a detailed work history, together with baseline lung function measurements.

A lower level of health surveillance ***may*** be recommended by an occupational health practitioner where there is good evidence of control (for example by sampling and a period of high-level health surveillance indicating no problems) or when work is very intermittent. Some degree of health surveillance will always be necessary.

A health surveillance programme may also need to include skin inspections where the COSHH assessment shows that risks of dermatitis are significant. Typically, enquiries about skin complaints and inspections of exposed skin, mainly hands, forearms and face, by a responsible person at about monthly intervals may be appropriate. Further guidance is available in *Health surveillance of occupational skin disease* (Ref 6).

References from HSE Books

1 *Solder fume and you* IND(G)248L (single copies free, ISBN 0 7176 1351 8 for priced packs)

2 *COSHH: The new brief guide for employers* IND(G)136L (Rev) (single copies free, ISBN 0 7176 1189 2 for priced packs)

3 *Preventing asthma at work: How to control respiratory sensitisers* L55 SBN 0 7176 0661 9

4 *Medical aspects of occupational asthma* MS 25 ISBN 0 11 885584 0

5 *Surveillance of people exposed to health risks at work* HS(G)61 ISBN 0 7176 0525 6

6 *Health surveillance of occupational skin disease* MS24 ISBN 0 11 885583 2

Further reading from HSE Books

Assessment of exposure to rosin (colophony) based solder flux fume Engineering information sheet EIS 17 (free)

Resin acids in rosin (colophony) solder flux fume MDHS 83 ISBN 0 7176 1363 1

Introduction to local exhaust ventilation HS(G)37 ISBN 0 7176 1001 2

Additional information

This leaflet is available in priced packs of 10 from HSE Books, ISBN 0 7176 1383 6. Single free copies are also available from HSE Books.

HSE priced and free publications are available by mail order from: HSE Books, P O Box 1999, Sudbury, Suffolk, CO10 6FS (Tel: 01787 881165; Fax: 01787 313995).

HSE priced publications are also available from good booksellers.

For other enquiries ring HSE's Infoline, Tel: 0541 545500 or write to HSE's Information Centre, Broad Lane, Sheffield, S3 7HQ.

This leaflet contains notes on good practice which are not compulsory but which you may find helpful in considering what you need to do.

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