Safe use of solvent degreasing plant

Engineering Information Sheet No 40

Introduction

This information sheet summarises the main precautions required when carrying out solvent degreasing. It is intended to assist companies using organic solvents (including trichloroethylene) as well as those introducing a 'drop-in' replacement, or converting solvent degreasing plants (degreasers) which previously used trichloroethylene. It should be read in conjunction with HSE's Engineering Information Sheet EIS20(rev1) *Maintenance and cleaning of solvent degreasing plant*.

Most emphasis has been put on open-topped, manually operated degreasing tanks because these have the greatest potential for causing over-exposure. The reclassification of trichloroethylene as a category 2 carcinogen under the Chemicals (Hazard Information and Packaging for Supply) Regulations (CHIP3)) and consequent requirements under the Control of Substances Hazardous to Health Regulations (COSHH) and the Solvent Emissions Directive (SED) are discussed in HSE's Engineering Information Sheet EIS34 *Surface cleaning: Solvent update including the reclassification of trichloroethylene*.

Various organic solvents are used in degreasing. The most commonly used are chlorinated solvents such as trichloroethylene, dichloromethane (methylene chloride) and perchloroethylene. These substances may be harmful to health if inhaled. The ill-health effects from inhalation would depend on the substance in use and the concentration and length of exposure. At high concentrations all organic solvents exert a strong narcotic effect and can be fatal. Skin exposure can cause irritation and dermatitis.

COSHH Regulations

The Control of Substances Hazardous to Health Regulations (COSHH) 2002 require exposure to substances hazardous to health to be prevented or, where this is not reasonably practicable, adequately controlled.

Category 1 and 2 carcinogens are subject to specific requirements under COSHH. Trichloroethylene users need to consider:

(a) substitution, using an alternative solvent or cleaning process; or, if this is not reasonably practicable,
(b) enclosing the degreasing process as far as is reasonably practicable.

The capital expenditure for a fully enclosed degreasing plant may be recovered from reduced solvent usage. Lower solvent consumption may also lead to the process falling outside the requirements of the SED.

For a properly designed, installed, operated and maintained traditional, open-topped degreaser, experience has shown that 8-hour time-weighted operator exposure levels to trichloroethylene can routinely be maintained well below 20 ppm. Exposures can be even lower with fully enclosed and automated plants.

HSE experience shows that exposures are not always adequately controlled. This is mainly due to poor design, installation and maintenance of the plant and poor working practices.

Equipment suppliers should provide comprehensive installation, operating and maintenance instructions which should be followed by users. Clear summaries of operating and maintenance procedures should be kept readily available for easy reference by plant operators.

Suppliers of solvents and other chemical formulations used for cleaning and degreasing should provide material safety data sheets and any other information necessary to enable customers to use their products safely.

Environmental legislation

The Solvent Emissions Directive has far-reaching implications for surface cleaning. This is outside the scope of this information sheet. Advice should be sought from the Environment Agency (EA), Scottish Environmental Protection Agency (SEPA), the Local Authority Environmental Health Department, the Department for Environment, Food and Rural Affairs (DEFRA) or Envirowise.

When assessing your options you should consider the requirements under both COSHH and the SED. You need to ensure that your process satisfies the requirements for both.

Is cleaning necessary?

This is the first question to ask. Some businesses have already found that by changing their process or operation they can avoid components becoming soiled, or they can reduce the level of soil. This makes

subsequent cleaning easier. Some companies have discovered that cleaning was not critical or necessary for their application. In many of these cases the changes have saved money.

If cleaning cannot be avoided, employers should review all the technical options and decide which method or technology is best for their particular operation. This review should take account not only of the ability of the cleaning technique to remove the dirt or soil, but also the health, safety and environmental implications of the alternatives and the respective costs.

There are many different methods of surface cleaning such as mechanical surface preparation (eg sanding, blasting, dry-ice bombardment); organic solvent cleaning; aqueous cleaning; semi-aqueous cleaning; biological cleaning; conversion coating and combined cleaning and coating. These are discussed in detail with their advantages and disadvantages in *Surface cleaning and preparation: Choosing the best option* GG354 (see page 6).

Even if you decide that solvent degreasing is still the best method for your application, you should examine your plant and process and consider how well the vapour is controlled.

Making the change

Most degreasers in use in the UK today were originally designed to use trichloroethylene, or at least used design criteria based on the properties of trichloroethylene. As a result, switching to an alternative solvent will mean that some adjustment to, or modification of, the plant will be necessary, since, strictly speaking, none of the alternatives are truly 'drop-in' replacements. If nothing else, boiling points are likely to differ, and so safety devices would need to be reset to take account of this.

The use of alternative solvents should be assessed taking into consideration all information. It will not be sufficient for users to simply change the solvent if the degreaser tank is in a poor state of repair and working practices are poor. Using a substitute in a badly maintained plant and/or continuing to follow poor working practices may even increase the risks by exposing workers to high levels of a different hazardous substance. The different solvents are not necessarily immediately interchangeable. If changing from trichloroethylene to either perchlorethylene or methylene chloride or any other organic solvent, then existing plant may require modifications. For example, thermostats will need re-setting if changing from trichloroethylene to perchloroethylene while changing to methylene chloride also requires a reduction in heat input.

Employers considering using a different organic solvent in their existing trichoroethylene degreaser should in the first instance consult with the supplier(s) of the equipment and the solvent. The suppliers should be able to advise whether a particular installation meets current or any future emission limits or standards and, if not, what modifications are necessary, recommended and practicable. Upgrading certain plant features, especially on older conventional open-topped degreasers, can have a noticeable impact on operator exposure. For example, fitting a motorised lid, retrofitting enclosures with suitable exhaust ventilation, increasing the plant freeboard zone, using a mechanical hoist to load and unload the plant, installing additional cooling coils or refrigerated cooling coils etc can all help to reduce emissions. Again, the equipment supplier should be consulted before any changes are made.

A new COSHH assessment should be carried out where any significant changes are made to the plant, or its operation. Where an employer employs five or more employees, a record should be kept of the significant findings of the assessment as soon as is practicable after the assessment has been made. Employees should be involved in the changeover, both in terms of information and training.

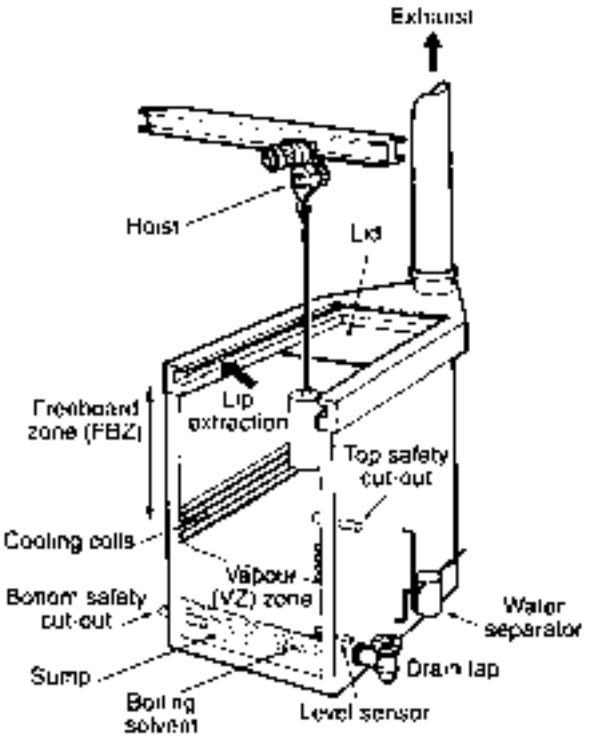
Plant and operational good practices

Failure to maintain and operate a degreaser properly can cause higher exposures than necessary. This information sheet explains what constitutes good practice in the use of solvent degreasers. Guidance is also given in HSE's *COSHH essentials*, Control guidance sheet 227 'Vapour degreasing bath engineering control' (see page 6). A schematic diagram showing the basic features of a widely used design of a conventional open-topped degreaser is given on page 3**.**

Plant and operational good practices which can minimise the operator exposure to solvents include:

Containment. Solvent degreasing should be carried out in an enclosed system where reasonably practicable. If this is not reasonably practicable, the process should be enclosed as far as possible. This may be achieved by the retrofitting of an enclosure to an open-topped degreaser which ensures that both the tank and the load/unload zone are fully enclosed. It is essential that any retrofitted enclosure is designed, installed and operated correctly and, most importantly, fitted with a suitable extraction system to provide adequate ventilation. Guidance is given in *COSHH essentials*, Control guidance sheet 321 'Vapour degreasing bath - Containment' (see page 6).

Retrofitting of an enclosure on a conventional open-topped degreaser can significantly reduce both operator exposure and vapour emissions into the workplace if designed, installed and operated correctly.



Plant location. Air turbulence in the plant area can cause serious solvent losses. The features that create air currents, and thus disturb the vapour in degreasing units, include: doors, windows, heating and ventilation systems, and busy passages. Degreasers should be located away from any draughts and should be positioned in a no-smoking area. They should be isolated from naked flames, hot surfaces and welding operations. All solvent degreasers emit solvent vapour. In a large workroom the vapour may be diluted and dispersed and cause low exposure. But in a small workroom the same emission rate may cause very significant exposure (there is less dilution, and people have to work nearer the source).

Cooling water supply. Anything which increases the movement of vapour from the vapour zone (VZ) into the freeboard zone (FBZ) will increase emissions and exposure to solvent vapour. Factors such as poor cooling and excessive heating can contribute significantly. The water-cooled condensing system is the primary means of containing solvent vapour within the degreasing plant. The correct flow of water through the system and the temperature of the water are of particular importance. If the outlet temperature is too high for the solvent in use, solvent vapours will not be effectively condensed and may escape from the top of the tank. If the outlet temperature is too low and below the dew point, water vapour will condense on the cooling coils and contaminate the solvent. The heating and cooling systems should be balanced in order to avoid overloading the cooling coils. If water is allowed to remain in the degreaser it can degrade the solvent and lead to corrosion problems.

The water outlet temperature will be influenced by the inlet temperature, which may vary throughout the year, and by the work throughput of the plant. The cooling coils should be kept clean to ensure continuing efficient heat transfer.

The adequacy of the cooling coils should be checked considering the solvent in use. In some cases additional cooling coils will be necessary and/or refrigerated cooling coils may be recommended.

Lids. Lids on a conventional open-topped degreaser should be designed to fit within the FBZ, below the rim extraction vents. Unsuitable lids such as those which are fitted above the rim ventilation slot, those causing vapour drag-out when lifted, or which are made of unsuitable material should be replaced.

Using lids is important, particularly when the plant is starting up, closing down or idling. Segmented lids are useful on long degreasing units, since they allow partial opening for degreasing smaller items. Sectional lids or roller shutters, where fitted, should only be opened as far as is needed for loading or unloading. Failure to use covers during work breaks will cause unnecessary evaporation of solvent.

Lids which can be retrofitted to a conventional plant should preferably be of a roller or slide design, rather than lift-out panels, as horizontal movement on roller and sliding shutters is less likely to disturb the vapour in the plant.

Water separator. Water can enter a degreaser in a variety of ways. If allowed to remain, it can cause the solvent to degrade and can lead to corrosion. Water separators are normally fitted for the removal of excess water. For water separation to function correctly, it is vital that the gutters below the cooling coils do not overflow when the plant is running. Dirt and debris can build up in the solvent pipework and cause partial blockage, especially along the horizontal runs to the separator. If it is noticed that the gutters are tending to overflow, the pipework should be cleaned.

Support frames. Provision should be made for support frames within the condensation zone to support jig-mounted components. This enables the lifting device to be removed and the lid closed over the work while degreasing is in progress. Frames also help to prevent damage to vulnerable parts of the plant such as the cooling coils.

Freeboard zone. Above the cooling coils is what is known as the freeboard zone (FBZ). There is always some movement of vapour from the vapour zone (VZ) into the FBZ and from the FBZ into the workroom owing to turbulent air diffusion. The rim ventilation is there to control the movement from the FBZ into the workroom but it does not stop it.

The freeboard ratio is defined as the freeboard height divided by the width of the open area of the tank. The

higher this ratio, the less the chance of solvent leaving the plant and entering into the workplace atmosphere. A freeboard ratio of at least 0.75:1 and preferably 1:1 is recommended. A freeboard ratio of less than 0.75:1 is likely to lead to unnecessarily high operator exposure.

Rim ventilation (Lip extraction). Leakage of vapour-laden air from the FBZ into the work area is minimised by lip extraction applied at the top of the tank usually down both the long sides but sometimes on all four sides. The lip extraction is a secondary, but nevertheless essential, control measure to prevent operator exposure and the escape of solvent vapour into the workroom. It is important to remember that the ventilation will control, rather than eliminate, vapour emissions. An extraction rate of 640-915 m^3/hr per m^2 of bath surface working area is recommended. For any degreaser with a specific rim vent design, extract fan specification and ductwork configuration, there will be a specific rim vent velocity. The degreaser supplier should provide the relevant figure.

Other extraction ventilation systems. Exhaust ventilation should be provided to remove solvent vapours from the load/unload zone of both multiple door degreasers and retrofitted enclosures on conventional open-topped degreasers. Exhaust ventilation should also be provided to remove vapours from the sludge door when this is opened, or from a pit in which a degreaser may be located.

Setting of safety devices. Safety devices such as sensors controlling sump level, sump temperature, top-safety cut-out and bottom safety cut-out should be set correctly for the solvent in use. These should be checked regularly. Top safety cut-out is a temperature sensor fitted within the FBZ just above the cooling coils. Its function is to cut off the heat source to the degreaser if the hot vapour level rises too high, for example because the cooling water supply has not been turned on or is inadequate or fails. Bottom safety cut-out is a safety device which is set to limit the temperature of the solvent to prevent overheating and the risk of fire when the solvent becomes heavily contaminated with oil and grease. Some degreasers are additionally fitted with a low level cut-out device whch is intended to prevent fire or damage to the plant. Where this is fitted, reliance should not be placed totally on it, and visual checks should still be made on the solvent level.

Solvent level. Maintaining the correct solvent level will help avoid solvent acidity, which can lead to corrosion of the plant, causing leaks or solvent decomposition giving rise to chemical reactions. In addition, if the solvent level falls too low on a heavily contaminated plant, there may be a risk that oils will ignite with further noxious fume emissions.

Solvent condition. Decomposition of the solvent can lead to acid conditions in a degreaser. This can lead to corrosion of the degreaser and possible solvent leaks. If aluminum or other light metal alloys are being cleaned, in extreme cases a rapid chemical reaction can occur, releasing hydrogen chloride. Warning of acid condition is sometimes given by the appearance of green corrosion deposits on the lower turns of the condensing coil. Decomposition can best be prevented by avoiding cross contamination of solvents, by preventing overheating, by keeping solvent levels topped up with fresh solvent and by regular cleaning out, particularly if light metal alloys are processed.

Correct stacking of hollow components. Hollow components or components with partial enclosed volumes (eg open tubing) require careful stacking or rotational jigs to facilitate draining; otherwise these will not drain properly and will still contain liquid when removed from the degreaser.

Drying time in the FBZ. Components should be allowed to hang dry in the FBZ of the degreaser until all residual solvent has evaporated (known as the dwell time). If there is no hoist or rest within the FBZ and the operator has to hold the basket manually, then dwell time is likely to be too short. A hook or fixture to facilitate this will be helpful and should be used.

Loading/unloading the plant at the correct speed. Loading work too quickly can create a piston effect, pushing solvent out of the degreaser, while withdrawing work too quickly can create excessive ‘drag out’. The need for a mechanical hoist to reduce manual handling and to reduce operator exposure during loading/ unloading should be considered. Where a hoist is used for loading and unloading, a maximum operating speed of three metres/minute in the vertical plane is recommended.

Workload. Loads should not exceed 50% of the open horizontal area at the plant. Consideration should be given to large components or baskets. Large area components or baskets may cause a pumping action, pushing vapour-laden air out of the FBZ. Large, vertically dimensioned articles may also cause bridging of the VZ and FBZ. Large components or baskets suspended in the FBZ and VZ at the same time may draw high concentrations of vapour into the FBZ.

Correct transfer of work between compartments in the plant. This should be done slowly and preferably below the vapour level. The work should be turned in the FBZ to minimise solvent drag-out.

Topping-up procedures. Fixed pipework should be connected to the sump for topping up with fresh solvent. This avoids operator exposure and possible spillages. If fresh solvent needs to be added, this should be done when the plant is cold, and the solvent should be piped in at a low level within the tank, with the cooling water system and rim ventilation operational. Poor practices such as pouring solvent into

the degreaser from a drum or bucket, particularly when the plant is hot, leads to very high exposures.

Leaks. Solvent leaks can occur from the sump door, pump parts or pipework joints. Corrosion may also result in solvent leaks from the plant. They may be noticed as sligh, visible staining. These should not be ignored on the basis that the staining is slight. The amount of solvent lost may be high, as it evaporates, leaving only the oil and grease as evidence. Leaks should be repaired promptly. Checks for leaks should be done when plants are started up from cold because they are often easier to see. To minimise the likelihood of leaks from sump doors, new gaskets should be used each time a door is opened and replaced, unless the existing gasket is in perfect condition.

Avoid spraying above the vapour layer. Where a manual spray lance is used, the parts being sprayed should remain within the vapour zone below the cooling coils. The use of a lance may cause a lot of turbulence and vapour emission.

Clean-out procedures. These are of particular concern since fatal accidents have occurred to people entering degreasers without adequate precautions. Plant should be cleaned regularly to avoid the need for personnel to enter it. Exhaust ventilation should be fitted or made available to the clean-out hatch in the sump. In addition, adequate and suitable respiratory protection must be worn.

Where anyone has to enter degreasers or pits for cleaning, this must be done after an appropriate period of cooling and with the ventilation of the plant switched on, under a formal permit-to-work procedure. Self-contained or air-fed breathing apparatus and other precautions appropriate to work in confined spaces should be used, as detailed in HSE's Engineering Information Sheet EIS20(rev1) *Maintenance and cleaning of solvent degreasing tanks* (see page 6).

Maintenance of the plant. Whatever solvent you use, it is fundamental to the protection of the health of workers that you maintain your plant in an efficient state, in efficient working order and in good repair, and follow good working practices. The whole ventilation system, including the rim ventilation and any other control measures such as safety devices, should be subjected to thorough examination and testing at least once every 14 months by a competent person and records of each examination should be kept for five years. For such tests to be meaningful, it is essential that the design criteria for the particular plant are known.

Solvent management

It is important to have correct procedures for the management of solvent use in the workplace. This should form part of a solvent management plan which should include: good waste management practices; information on solvent consumption and waste production; correct segregation and labelling of wastes and raw materials; solvent recovery; storage and disposal of waste; policy for dealing with spillages and fugitive emissions etc.

Measurement of emission and exposure

Monitoring of employee exposure to substances hazardous to health is required in circumstances described in regulation 10 of COSHH. Air sampling can form part of such monitoring. For a substance which is assigned an occupational exposure limit (OEL), monitoring is normally required unless the initial assessment shows that the level of exposure is unlikely to exceed the limit. OELs are published in HSE's *EH40 Occupational exposure limits* (ISBN 0 7176 2083 2).

To obtain the best indication of operator exposure and hence compliance with the numerical value, it will be necessary to sample over a full shift or perhaps a shorter, but representative, period from which full shift exposure can be extrapolated. An exposure monitoring regime should consider both short-term and long-term operator exposure to solvents.

This can be done by one of a choice of sampling devices worn on the lapel in the breathing zone. Some have a pump which draws air through a sample tube at a known rate. Others are diffusive samplers which need no pump. With both types, the collected samples are analysed in a laboratory to obtain a concentration value for the substance under test. Companies which do not have such facilities can use independent occupational hygiene consultants or may be able to obtain assistance from the suppliers of the solvent. *The directory of occupational hygiene consultants* is available from the British Institute of Occupational Hygienists (BIOH) (see page 6).

There are also samplers which do not require laboratory back-up because they give a direct reading. One type uses the diffusion principle combined with a coloured stain indicator. Though not as accurate as the more sophisticated methods described above, they can give a good indication of the level of exposure. In the above methods samplers are worn by operators in their breathing zones.

An alternative method of monitoring which may be used is to take measurements at suitable known locations. This can be done using detector tubes. A known amount of air is drawn through a detector tube by means of a set number of strokes of a simple hand-operated pump. The length of the coloured stain produced indicates the concentration of the solvent under test.

Detector tubes can be used for 'spot' measurement of emissions from the process at different points in the

work cycle and in the operator's breathing zone, particularly during the highest emission phase of the work cycle. The highest breathing zone concentration probably occurs when work is taken out of the tank. These are not time-weighted values so there can be difficulties in relating the results to the OEL, but if used properly by trained and competent personnel, detector tubes can give a good indication of vapour-in-air levels and emission patterns.

When carrying out a survey, the movement of air immediately above the plant, especially near the sides, should first be investigated using 'smoke tubes'. These generate a visible smoke to show the pattern of air movement and can also be used to check the rim ventilation. The information they give should be used in deciding where to use the detector tubes.

Measurements should be made at about 5 cm (2") above the middle of the top of the tank and at the locations where tests indicate there might be an escape of solvent vapour.

Detector tubes are typically accurate to +/- 10-15%. They can sometimes suffer from cross-sensitivity. This should be borne in mind when considering results. In cases of doubt, or if measured levels indicate that operator exposure is approaching the occupational exposure limit, a more sophisticated sampling method, as described earlier, may be needed.

Frequency of sampling

Sampling should be carried out:

(a) when a COSHH assessment is first done and at any significant review of the assessment. Although air sampling is not always required for COSHH assessments it will normally be needed at a solvent degreaser because operating practices can vary and are important in controlling exposure;
(b) when a degreaser is first installed and after significant repairs or modifications to any of the engineering controls, including the rim ventilation system, or the cooling system. This is to ensure that the controls are operating correctly;
(c) after major maintenance, including any changes to the hardware;
(d) if there are any significant changes to operators' working methods or if the type of job being done at the degreaser is changed, ie work throughput or type, or changes to operating practices;
(e) if the type of solvent being used is changed;
(f) if problems are suspected, eg if there is any noticeable increase in smell of solvent or complaints from employees about health effects;
(g) to demonstrate to operators the effects of good and bad working practices.

Further reading

COSHH essentials: Easy steps to control chemicals. Control of Substances Hazardous to Health Regulations HSG193 HSE Books 1999 ISBN 0 7176 2421 8

Maintenance and cleaning of solvent degreasing plant EIS20(rev1) HSE Books 2002

Monitoring strategies for toxic substances HSG173 HSE Books 1997 ISBN 0 7176 1411 5

Seven steps to successful substitution of hazardous substances HSG110 HSE Books 1994 ISBN 0 7176 0695 3

n-Propyl bromide:Hazard assessment document EH75/3 HSE Books 2002 ISBN 0 7176 2350 5

n-Propyl bromide, Chemical Hazard Alert Notice CHAN No26 (Revised) (see HSE website)

The directory of occupational hygiene consultants BIOH Tel 01332 298087 (free)

Surface cleaning and preparation: Choosing the best option GG354 (replacing Vapour degreasing GG15) and *Help in choosing cost-effective options for surface cleaning and preparation* EN354 2003 Envirowise, Tel 0800 585794

Metal and precision cleaning and *Cleaning electronics assemblies* National Physical Laboratory Tel: 020 8977 3222 (free)

Surface cleaning suppliers list Engineering Employers' Federation (EEF) Tel: 020 7222 7777 (free)

Additional useful publications can be found in EIS20(rev1).

While every effort has been made to ensure the accuracy of the references listed in this publication, their future availability cannot be guaranteed.

Further information

HSE priced and free publications are available by mail order from HSE Books, PO Box 1999, Sudbury, Suffolk CO10 2WA Tel: 01787 881165 Fax: 01787 313995 Website: www.hsebooks.co.uk (HSE priced publications are also available from bookshops and free leaflets can be downloaded from HSE's website: www.hse.gov.uk)

For information about health and safety ring HSE's Infoline Tel: 08701 545500 Fax: 02920 859260 e-mail: hseinformationservices@natbrit.com or write to HSE Information Services, Caerphilly Business Park, Caerphilly CF83 3GG.

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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