GG413

Reducing solvent use by good housekeeping

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This Good Practice Guide was produced by Envirowise

Prepared with assistance from:

Enviros Consulting Limited

Summary

UK industry uses large quantities of organic liquid solvents that evaporate readily at room temperature, giving rise to harmful volatile organic compound (VOC) emissions. These solvents are used to clean, degrease and dissolve, disperse and thin other materials such as coatings, paints and inks. This Good Practice Guide is intended to help companies save money by reducing the quantity of solvents they use and, at the same time, reduce the associated VOC emissions.

The good housekeeping measures described in this Guide are practical and affordable. Many involve no capital expenditure while others require modest investment that will be paid back quickly by the savings made. Many of the measures are necessary and, in some cases, mandatory, to prevent pollution.

Implementing good housekeeping measures to reduce solvent use can:

- reduce material and waste disposal costs;
- increase productivity;
- improve product quality;
- enhance the company's environmental performance;
- improve working conditions and employee morale;
- reduce the risk of pollution incidents;
- improve the company's public image and relationship with customers, investors, regulators and other stakeholders.

Good housekeeping can be applied throughout your process from delivery, storage, on-site distribution and handling to process use, cleaning, waste recovery and disposal. The Guide describes measures applicable to all solvent-using operations and also those specific to applications such as surface cleaning, coating, printing and timber preservation. Industry examples show how companies have already achieved cost savings and other benefits from introducing good housekeeping measures at their sites.

Many of the measures described can be put into practice immediately. Why not use this Guide as a checklist to track down the numerous cost-saving opportunities that almost certainly exist at your site?

For further **free** advice on all aspects of solvent management, contact the Environment and Energy Helpline on **0800 585794** or visit the Envirowise website (**www.envirowise.gov.uk**).

This Guide updates and replaces *Good housekeeping measures for solvents* (GG28), published in 1996.

Contents

1.1 Why manage solvent use?

Many of the organic solvents used by industry evaporate readily into the atmosphere at room temperature and are known as volatile organic compounds (VOCs). VOCs such as acetone, methyl ethyl ketone (MEK), trichloroethylene, white spirit and isopropyl alcohol (IPA) are widely used in industry for cleaning, degreasing, dispersing and thinning (adjusting the viscosity). Many proprietary paints, inks and adhesives also contain VOCs.

Many VOCs can harm human health - acting as irritants and, in some cases, as carcinogens - and are controlled in respect of workplace air quality. Some VOCs also contribute to global warming and to the formation of low-level ozone. The latter can cause eye, nose and throat irritation, more serious respiratory health problems, damage to crops and natural vegetation, and even damage to some rubbers and plastics. Liquid organic solvents can contaminate the ground or water supplies: one litre is enough to contaminate about 100 million litres of drinking water - equivalent to 50 Olympic-sized swimming pools.

Solvents have long been recognised as hazardous and their use and disposal are subject to many legal requirements related to health, safety and environmental issues. Details of the most recent legislation regarding solvents and their use/disposal can be obtained through the Environment and Energy Helpline on 0800 585794.

Industrial solvents and solvent-based coatings are expensive - some costing hundreds or even thousands of pounds/tonne - while waste solvents, inks and coatings are classed as special (hazardous) waste and thus have high disposal costs.

Cost-effective solvent management can typically save a small site (eg a screen printer or spray shop) £5 000 - £20 000/year, often at no cost or low cost. Larger companies may save hundreds of thousands of pounds.

1.2 What is good housekeeping?

Solvent good housekeeping can be defined as 'practical no-cost and low-cost measures that allow solvent consumption and VOC emissions to be minimised'.

The good housekeeping measures described in this Good Practice Guide cover:

- **technical approaches**, such as fitting conservation valves to bulk tanks, switching to more efficient spraying equipment, fitting condensation equipment to extraction systems and process optimisation;
- **procedural approaches**, such as process elimination, preventative maintenance and better handling and cleaning practices.

Most of the measures are no-cost or low-cost but, for the sake of completeness, the Guide includes practical measures that give good benefits with a reasonably short payback period of ideally less than two years.

1.3 The benefits of solvent good housekeeping

Many companies are effectively applying simple and affordable good housekeeping measures to:

- save money;
- minimise solvent consumption and VOC emissions;
- improve efficiency;
- achieve a cleaner workplace.

Printing or coating companies, for example, often have direct solvent costs (eg for cleaning and thinning) that make up to 2% of their overall operating costs. Additional solvent costs may be 'hidden' in the cost of materials such as inks and paints, where solvents typically represent at least 10% of the coating's value. In other sectors, such as pharmaceuticals, solvent costs can often represent 7 - 8% of operating costs.

Even small percentage reductions can bring significant savings; bulk solvents typically cost around £500/tonne while smaller quantities, such as 205-litre drums, cost around £800/tonne and small quantities of some materials cost over £2 000/tonne.

The information in this Guide can help your company become more competitive and more profitable by:

- reducing direct operating costs through lowering consumption of solvents and associated materials such as coatings, paints and inks;
- reducing disposal costs;
- improving product quality;
- improving your environmental performance;
- enhancing your public image and attractiveness to customers, investors and other stakeholders;
- reducing the risk of pollution incidents, which have associated clean-up costs and potential fines;

Keeping the company solvent

In the mid-1990s, one small company manufacturing spray paints significantly reduced its solvent consumption and improved site hygiene through various good housekeeping measures.

Solvent mixing at the company was carried out in ten steel vats. These were fitted with new hinged lids, each with pneumatic switches to ensure that extraction operated only when the lid was open. The changes reduced daily emissions to atmosphere by an estimated 15 kg/vessel, resulting in annual savings of about £40 000.

Reject aerosols and batch-test cans were previously disposed of at considerable expense through a waste contractor. This practice was then reviewed so that aerosols and cans were punctured and their solvent content recovered before they were crushed for disposal. This recovered about 80 - 90% of the liquid in the can. Recovered solvent, cleaning solvents and other solvent-based wastes were then put through a distillation process. This saved the company a further £40 000/year in reduced acetone purchases, while can disposal costs fell by £20 000/year. The two devices had running costs of around £6 000/year, which gave net cost savings of £54 000/year. The still equipment cost £20 000 and the can crusher £10 000 (including installation and extraction plumbing), giving a payback period for this initiative of approximately seven months.

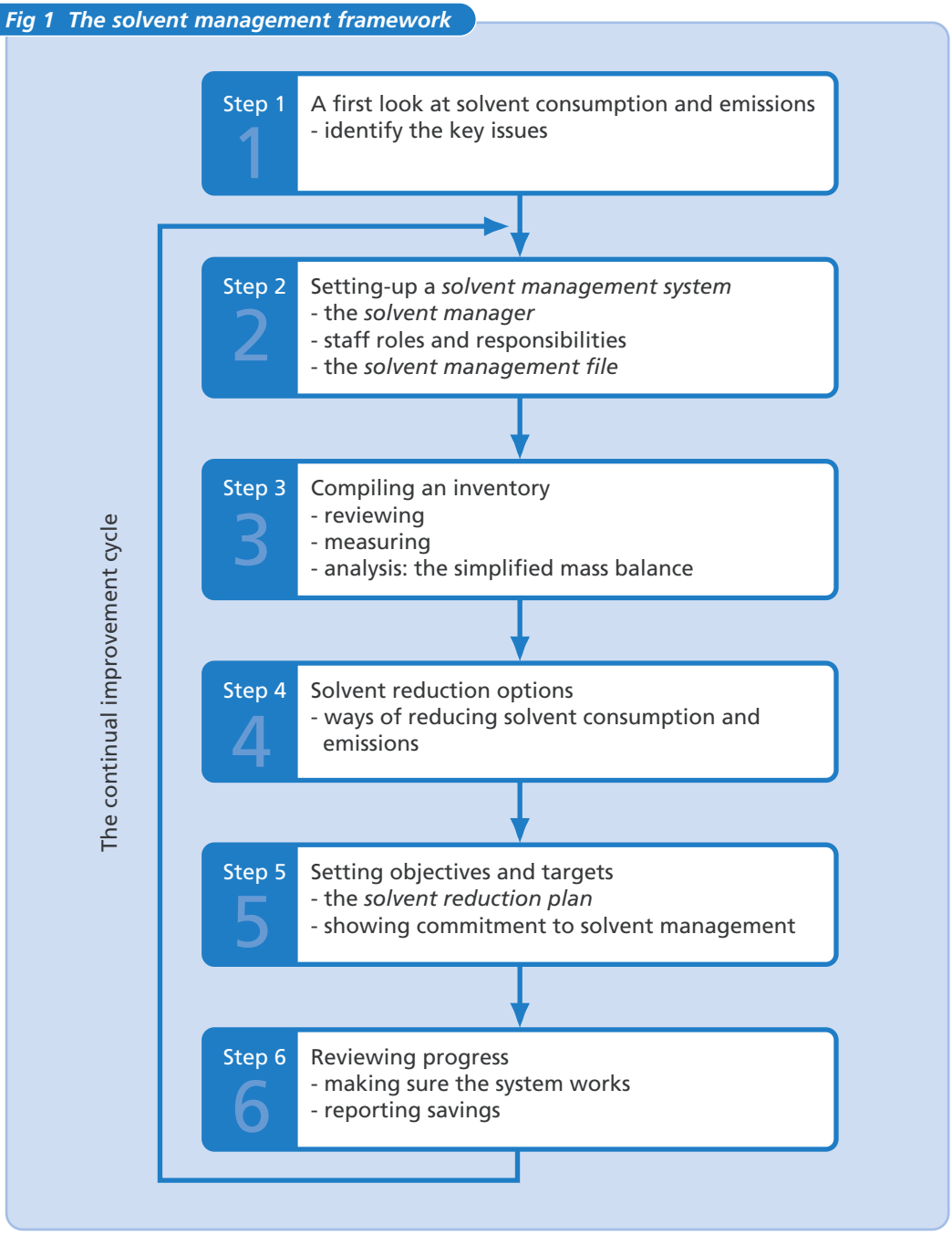
These good housekeeping measures have saved the company a total of £100 000/year.

- reducing the cost of risk-based insurance premiums;
- helping to eliminate the need for abatement equipment by reducing solvent consumption below the legislative threshold or by reducing concentrations/volumes.

1.4 Reducing solvent use as part of a solvent management programme

Cost-effective solvent management involves a systematic approach to solvent reduction based on solvent inventory, reviewing and mass balance approaches (see Fig 1).

Fig 1 The solvent management framework



Once you have identified the key issues and set up a solvent management system and team, the next stage is to measure and record current solvent consumption and compile an inventory. This will give you a base-line against which to monitor progress and quantify your savings. You can then use your knowledge and data to think about solvent reduction options. Good housekeeping is a key element in reducing solvent use.

First, it is important to review ways of minimising the amount of solvent you use and the amount of VOC emitted from your operations. This can:

- reduce the costs of complying with environmental legislation;
- make it easier to comply with current and forthcoming legislation (see section 1.5);
- create a better working environment for your employees;
- demonstrate continual improvement in environmental performance;
- eliminate the need to install expensive pollution abatement equipment.

Reducing solvent use in your operations will lead to less spent solvent/special waste requiring disposal, fewer VOC emissions requiring abatement and a reduced risk of pollution. There are many ways of minimising solvent use and waste, including:

- eliminating the need to use organic solvents at all;
- changing to an alternative material with no or less solvent content;
- changing to a less volatile or less hazardous solvent/material;
- using recycled solvents where possible;
- using low purity or 'dirty' solvents for initial rinses;
- changing working methods and handling procedures to minimise:
  - the need to use solvent, eg for cleaning between processes;
  - the amount of solvent used, eg for thinning;
  - the amount of solvent lost to atmosphere as VOC emissions;
- increased staff training and motivation;
- preventative maintenance and testing (eg to check and rectify leaks);
- adopting no-cost and low-cost good housekeeping measures;
- process optimisation;
- investing in equipment and machinery that is more efficient/emits fewer VOCs;
- investing in distillation equipment for on-site recovery of spent solvent.

Having evaluated various solvent reduction options, the next step is to agree a solvent reduction plan and set realistic improvement targets. The final step is to review progress in reducing solvent consumption and emissions, and publicise the results.

For free advice and information about solvent management, contact the Environment and Energy Helpline on 0800 585794.

1.5 Relevant legislation

VOC emissions from industry are controlled under the Environmental Protection Act 1990 and the subsequent Pollution Prevention and Control Act 1999. Processes with the potential to pollute and which exceed statutory threshold limits on annual solvent use must be authorised under the appropriate control regime and comply with mandatory emission limits. These are stated in Process Guidance Notes issued by either the Department for Environment, Food and Rural Affairs (Defra) or the environmental regulators[1].

[1] Process Guidance Notes are being revised to take account of the introduction of IPPC and the Solvent Emissions Directive. For free advice on the latest situation affecting your company, contact the Environment and Energy Helpline on 0800 585794, which can put you in touch with a specialist in your sector.

Part I of the Environmental Protection Act (EPA) 1990 set up Integrated Pollution Control (IPC) and Local Air Pollution Control (LAPC). The Pollution Prevention and Control Act 1999 established a new regulatory framework to prevent and control pollution from industrial processes in line with the requirements of the Integrated Pollution Prevention and Control (IPPC) Directive. New installations must meet the requirements of this new regime immediately and existing installations by October 2007.

Companies using more than 200 tonnes/year of solvent are deemed Part A processes. Most of these are Part A2 processes, regulated under Local Authority Integrated Pollution Prevention and Control (LA-IPPC) by the relevant local authority. Part A1 processes in England and Wales are regulated by the Environment Agency.

Most companies that use more than 5 tonnes/year of organic solvents (1 tonne in the case of vehicle refinishers[2]) are Part B processes, regulated by their local authority under Local Air Pollution Control (LAPC). These companies must switch to the new Local Air Pollution Prevention and Control (LAPPC) regime in the designated year for their sector. LAPPC represents a continuation of LAPC, but with some modifications to take account of the requirements of IPPC.

The latest versions of Process Guidance Notes also take account of the requirements of the Solvent Emissions Directive (SED). This aims to reduce VOC emissions in EU Member States by 57% of 1990 levels by 2007 and sets out a framework for VOC emission reduction for a range of industries. SED offers companies the option of end-of-pipe abatement or emissions reduction through solvent management, and sets limits for fugitive emissions. Existing processes have until 31 October 2007 to comply.

Environmental legislation may vary between different parts of the UK. For further information on relevant legislation and new legislative developments affecting your company:

- contact the Environment and Energy Helpline on 0800 585794;
- contact the appropriate environmental regulator;
- visit the NetRegs website (www.environment-agency.gov.uk/netregs/) developed by the Environment Agency in collaboration with the Scottish Environment Protection Agency (SEPA) and the Northern Ireland Environment and Heritage Service (EHSNI).

Workplace air quality is regulated under the Control of Substances Hazardous to Health (COSHH) regulations which are enforced by the Health and Safety Executive in England and Wales. This Guide does not aim to cover health and safety. Further advice and guidance are available from the Health and Safety Executive Info Line on 08701 545500.

1.6 Scope of this Guide

This Guide updates and replaces *Good housekeeping measures for solvents* (GG28) published in 1996 by the Environmental Technology Best Practice Programme, now known as Envirowise.

Section 2 describes a range of practical good housekeeping measures applicable to companies in all industrial sectors. **Section 3** describes good housekeeping measures applicable to the manufacture of speciality chemicals, surface cleaning and preparation, surface finishing/coating, printing, the use of adhesives and timber preservation. Although aimed at these specific applications, others may find that this section stimulates ideas and the potential for technology transfer. **Section 4** presents an action plan applicable to all companies seeking to reduce their solvent use. Contact details for a number of useful organisations are given in the **appendix**.

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2 0.5 tonnes/year under the Solvent Emissions Directive.

Many of the good housekeeping measures described in the Guide are no-cost or low-cost. For the sake of completeness, the Guide includes practical measures that give good benefits with a reasonably short payback period, ideally less than two years.

The Guide is relevant to companies of all sizes seeking a cost-effective way of reducing solvent consumption, including those with or working towards the implementation of a quality management system (eg the ISO 9000 series) and/or an environmental management system (EMS) (eg ISO 14001).

Free Envirowise publications on reducing solvent use

Envirowise has published a range of free guides and case studies with practical advice on how companies can manage their solvent use and minimise VOC emissions. Both general information and advice specific to different sectors are available. To find out which publications and tools are most applicable to your company, contact the Environment and Energy Helpline on freephone 0800 585794.

Solvent good housekeeping for all companies

This section contains information on solvent good housekeeping measures applicable to all companies that use solvents and solvent-containing materials.

2.1 Employee training and procedures

Successful waste minimisation and pollution control programmes require the full co-operation and involvement of all levels of staff up to and including the managing director. However, it is important to make sure that staff who are given responsibilities with regard to solvent management are properly trained. Relevant shop-floor and management staff should be trained in:

- the handling, use and clean-up of solvents, solvent-based materials/wastes and related equipment;
- good housekeeping practices;
- waste management procedures.

The training should emphasise the potential cost savings, the health and safety implications, the reduced impact on the environment and other benefits such as improved profitability from adopting good housekeeping measures for solvents. Companies developing an EMS should set training objectives and targets.

Written documentation should be prepared for operations involving the handling or use of solvents. This may form part of an EMS or other management system. The documentation should include:

- operating procedures that explain how to use particular equipment/plant in conjunction with solvents and solvent-based materials;
- process manuals containing health and safety data and describing relevant operating procedures that should be followed;
- material safety data sheets (MSDSs) and other technical information from suppliers. These provide a useful source of information relating to material characteristics and the issues associated with safe storage, handling and use.

To motivate employees and stimulate interest in reducing solvent consumption, consider:

- displaying stickers and posters to raise awareness of the need for solvent good housekeeping in the workplace;
- holding occasional training refresher courses;
- awarding certificates of competence to employees who are ‘solvent aware’;
- setting up a solvent-saving suggestion scheme with financial incentives for ideas which are implemented and result in a reduction in solvent use;
- linking a bonus payment scheme to savings achieved as a result of reduced solvent consumption and lower waste disposal costs;
- giving feedback on the progress in reducing solvent use, eg through notice-boards, newsletters and team briefings.

2.2 Material purchase

2.2.1 Material characteristics

Where possible, look for low or no-solvent alternatives to solvent-based products. Discuss alternative materials with appropriate production staff and key suppliers. Many water-based and low VOC materials (inks, paints, adhesives, etc) are now available at a reasonable cost for many applications.

Where solvents and solvent-based products have to be used, consider issues such as health and safety, ease of storage, handling, etc. Chlorinated solvents need particular care; for example, some chlorinated solvents[3] can form acids when in contact with water, which can corrode metal.

Under the Chemicals (Hazard Information and Packaging for Supply) Regulations 2002 (CHIP 3), the suppliers of most chemicals must provide appropriate information on the hazards and how to use the chemical safely. This requirement is achieved through labelling and the use of MSDSs. Information on CHIP and other health and safety matters is available from the Health and Safety Executive Info Line on 08701 545500 or the HSE website (www.hse.gov.uk).

2.2.2 Over-ordering

Ordering too much material at a time and paying inadequate attention to stock rotation can be costly. In addition to tying up money in stock that is not needed, these practices can lead to stock going out-of-date or becoming obsolete.

- Where possible, adopt a policy of ordering just-in-time (JIT).
- Follow a 'first in, first out' (FIFO) stock policy. Store new supplies behind existing stocks to ensure that 'older' materials are used first.

Some companies over-order because they over-compensate for perceived wastage levels. As waste reduces and becomes more controlled (ie with less variation), material orders should also decrease correspondingly.

- Check that you do not have built-in wastage allowances that are now obsolete.

2.2.3 Buying in bulk

Buying in bulk by the tanker load or in intermediate bulk containers (IBCs) can significantly reduce costs and wastage in terms of packaging and material residues.

It is sometimes possible to create tank and silo space without buying new tanks and silos by switching slower moving materials from bulk delivery to delivery in IBCs, drums or bags.

2.2.4 Control over material quality

Poor control and checking of material deliveries can also be costly.

- Review your 'goods receipt' procedures to ensure that what arrives at the site is what was ordered in terms of its specification and its weight.
- Consider installing a vehicle weighbridge. This will allow you to check bulk deliveries against invoices to ensure that you are getting 'good measure'.
- With container deliveries, weigh sample containers before and immediately after emptying. Comparing the latter with the weight of a thoroughly cleaned container will allow you to gain some indication of container residues and hence annual losses.

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[3] Particularly those that have not been stabilised properly to avoid this problem.

2.3 Delivery and container requirements

Solvents and coatings are delivered in bulk by tanker, in drums, in IBCs and even in small tins and cans.

Some plastics can be susceptible to chemical attack by certain solvents. Carbon steel (generally with solvent-resistant coatings), stainless steel and hot-dip galvanized steel (rather than spray or electro-galvanized steel) are all acceptable materials for solvent storage. Aluminium and magnesium alloys are generally not suitable for solvent containers.

2.3.1 General considerations

The delivery area should be within an impervious bunded area or a sloped area with appropriate drains and a containment sump or tank with shut-off valves. The area should be located away from other site drainage, particularly surface water drains and soakaways. In addition:

- accept deliveries only from drivers who are properly trained to handle solvents;
- ensure deliveries are supervised by a trained member of your staff;
- mark receiving points clearly, identifying the product and the appropriate means of unloading;
- keep the delivery area clear of obstacles and well lit (if possible, accept deliveries only during daylight hours);
- check drains, interceptors, tanks and bunds regularly for any possible source of leaks.

2.3.2 Bulk deliveries

- Before filling, ensure that bulk storage tanks have sufficient spare capacity for the delivery and that vents and overfill protection devices are not obstructed.
- Make sure that any rigid or flexible hoses and their fittings are appropriate in terms of their resistance to pressure, temperature and chemical attack. Particular care has to be taken in terms of the use of linings and braidings[4].
- To minimise the length of discharge hose necessary, make sure that access to filling points is not obstructed. This minimises the likelihood of the discharge hose being damaged (thus leading to leakage and spills) and reduces the amount of residue in the hose that can potentially be lost when the hose is disconnected.
- Ensure that deliveries are discharged through a lockable fixed coupling within the containment area and not outside the bund.
- Check the tanker hose and associated couplings for leaks. Stop the delivery immediately if any leaks are detected.
- Fit all fixed storage tanks with volume indicators and high-level alarms/slam-shut valves to prevent overfilling. Low-level alarms can be used to prevent damage to pumps caused by dry running. Ideally, the high- and low-level alarms should be linked to a pump 'trip' switch.
- Bulk storage tanks should, wherever practicable, be back vented to the delivery tanker or to a nearby tank to avoid the release of displaced vapours.
- If you have a lot of bulk tanks, consider fitting solvent capture systems (eg carbon canisters) to adsorb displaced vapours. These devices have to be regularly replaced/regenerated and, if possible, captured solvents should be recovered for re-use.

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4 For more information, see *Storage and handling of chlorinated solvents* published by the European Chlorinated Solvents Association (ECSA). This can be downloaded (from the ECSA publications area of www.eurochlor.org).

2.3.3 Delivery in containers

- Avoid steel drums with large lids and rim clamps. These can deform easily, causing loss of solvent, and can be prone to corrosion problems. Use only drums (plastic or steel) with small bungs suitable for filling and emptying.
- Where possible, encourage suppliers to deliver materials/solvents in IBCs. IBCs come in a variety of sizes (they are generally 1 000 litres) and two main varieties, ie rigid IBCs (plastic or steel) and flexible (collapsible) IBCs (FIBCs). The latter are cheaper. Rigid IBCs are easier to stack, and easier and safer than drums to move by fork-lift. Evaporative losses and residues are normally low due to the nature of the IBC design.
- Disposable plastic liners can be used with rigid IBCs, thus reducing the volume of liquid cleaning wastes significantly. However, check suitability of use as some plastics are not resistant to certain solvents.

Saving money and solvent by re-using IBCs

In the mid-1990s, a car polish manufacturer began using plastic IBCs for the storage and delivery of many of its products. Used IBCs were bought for £75 each in a clean condition or £40 in a dirty condition. The company used a waste exchange directory to identify wastes that matched the contents of one of its products (eg an IBC contaminated with silicon from a chemicals manufacturer). Laboratory analysis confirmed that no product contamination would occur and thus only limited cleaning had to take place. With new IBCs costing £110, this procedure saved around £70 for each IBC (excluding cleaning solvent and labour costs).

- Refuse to accept damaged containers and do not keep containers that are damaged and beyond repair. Check for:
  - leaks in lid seals, taps, valves, etc;
  - rust holes in steel drums;
  - cracks in plastic seams.
- Refuse to accept damaged pallets that may lead to unstable stacking and/or carriage of drums.
- Where possible, return containers to the material supplier. Many suppliers now operate 'take-back' schemes where they collect empty containers when delivering supplies.
- Consider the use of specialist solvent storage products fitted with features to minimise solvent loss through evaporation or accidental spillage. Such features may include fork-lift points for easy handling, a self-sealing pressure relief valve to avoid any emissions to air via evaporative/breathing losses and an integrated pump to minimise residues left in the container. The supplier may also provide a take-back service, thus avoiding the need for companies to dispose of hazardous and costly solvent wastes.

2.4 Storage

2.4.1 General

- Keep storage areas:
  - away from the main roadways through the site;
  - well lit to avoid accidents;
  - secure to avoid the risk of vandalism.

- Consult MSDSs for advice on specific storage requirements. Some solvents require particularly careful storage to minimise the risk of fire or explosion.
- Ensure that indoor storage areas are well ventilated and flame-proof to meet health and safety regulations.
- To reduce the potential for evaporative losses, keep outdoor storage areas shaded and away from heat sources. If possible, the storage area should have a roof to provide shade and to minimise the ingress of rainwater into bunded areas.
- Ensure that tanks, containers, coatings, seals, bungs, etc are resistant to the solvent to be contained.
- Ensure that tanks, containers, seals, bungs, etc can withstand the pressures and pressure changes that may occur, eg due to summer temperatures. Check the appropriate British Standards.
- Label containers clearly with appropriate and clearly visible warning signs. If possible, segregate containers to avoid any possibility of mis-identification and subsequent solvent misuse or wastage.
- Provide impervious/impermeable bunds and surfaces for all storage areas. The bunded area should provide an emergency storage capacity equal to 110% of the volume of the largest bulk tank or 25% of the total volume of product in the bunded area, whichever is the greater. Concrete is not impervious to all solvents and may require a solvent-resistant membrane or lamination[5]. There should be no drains or soakaways. For more information, see *Concrete bunds for oil storage tanks* published jointly by the Construction Industry Research and Information Association (CIRIA) and the UK environment agencies[6].
- Keep tanks and containers far enough away from the bund wall to ensure that solvent cannot 'jet' into an unbunded area when released under pressure. Where space is limited, it may be necessary to increase the height of the bund wall.
- Arrange for rainwater and materials/solvents to be pumped out of bunded areas regularly.
- Keep bunded areas clean and dry so that spilt solvent can be re-used, eg for cleaning.
- Carry out regular audits of solvent storage areas to check that solvents are being stored correctly.

2.4.2 Bulk storage

- Ensure that all filling points, gauges and outlet valves are within the bund so that any leaks from these points will be captured.
- Fit drip trays under valves and taps. Empty and clean them regularly for solvent re-use.
- Lock all delivery connections when not in use to prevent accidental release or release due to vandalism.
- Position tanks to limit the risk of accidental damage, eg by vehicles manoeuvring. If necessary, minimise this risk by fitting protective walls or bars.
- Inspect all tanks regularly for cracks, leaks and signs of corrosion.
- Where possible, keep bulk storage tanks above ground for easy inspection and maintenance. Tanks should be supported off the ground rather than resting on it to minimise corrosion and to allow any leakage from the base of the tank to be detected. Never place bulk tanks on roofs.

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5 See *Storage and handling of chlorinated solvents* published by ECSA (can be downloaded from the ECSA publications area of www.eurochlor.org).

6 This publication can be downloaded from www.environment-agency.gov.uk (go to the pollution prevention guidance notes area of the Business menu).

- For solvents with a composite vapour pressure that is likely to exceed 0.4 kPa at 20°C, fit pressure relief or conservation valves to static bulk solvent storage tanks. The alternative, an open vent, will result in significant 'breathing losses' as the tank heats up and cools down. Examine all valves at least once every six months for signs of contamination and incorrect seating, and arrange for them to be cleaned/corrected as required. Flame arresters can be fitted to provide a positive flame stop on open vents.
- Fit underground tanks with a manhole for inspection and cleaning purposes. Inspection can be hazardous and the appropriate health and safety procedures (eg the use of breathing apparatus) must be followed.
- Test the properties of any solvents held in underground tanks (this can indicate the ingress of water and other materials). Regular sampling is easier with a hydrostatic suction pipe. Groundwater should also be sampled if any discrepancies in solvent volumes are detected or leaks are suspected.
- Carry out regular testing (ideally annually) of the pressure integrity of all underground tanks and pipe networks.
- Fit level meters or, as a minimum, dipsticks. Use these to reconcile tank levels with process use through a mass balance. Meters reduce the possibility of overfill and help in leak detection. Data from electronic meters can be displayed on a centralised indoor control board or via a computer terminal. This allows accurate and rapid leak detection and offers less labour-intensive and more accurate solvent auditing.
- To minimise heating and subsequent evaporative losses, use light-coloured tanks or paint them with light-reflective paint. For the same reason, use light-coloured IBCs, drums and containers (where possible).

Tank design

- Bulk tanks should be designed to appropriate engineering specifications, eg in terms of withstanding expected pressures (see PD 5500:2003 *Specification for unfired fusion welded pressure vessels*[7]) and providing appropriate corrosion protection (eg galvanizing and solvent-resistant coatings). There are many British Standards applicable to bulk tanks, including:
  - BS 7777-1:1993 *Flat-bottomed, vertical, cylindrical storage tanks for low temperature service. Guide to the general provisions applying for design, construction, installation and operation.*
  - BS 2594:1975 *Specification for carbon steel welded horizontal cylindrical storage tanks.*

  Specific standards apply to underground tanks, tanks made from glass-reinforced plastic (GRP), double-skinned tanks, etc. See *Storage and handling of chlorinated solvents*, published by the European Chlorinated Solvents Association[8] (ECSA), for detailed information on tank design and other aspects of storage.
- Double-skinned tanks can be appropriate in some circumstances, eg when using highly toxic solvents or in areas that are difficult to bund adequately. When using double-skinned tanks, it is important to monitor the interstitial space regularly to check the integrity of the inner skin.
- Consider replacing regular (carbon) steel tanks with tanks constructed from stainless steel or GRP (plastic tanks are not normally regarded as suitable for chlorinated solvents). Although stainless steel tanks may be more expensive to buy initially, this may balance out in the long-term as they do not require any corrosion protection during their operational life. Various British Standards apply including BS 4994:1987 *Specification for design and construction of vessels and tanks in reinforced plastics*[7].

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7 From the British Standards Institution (BSI) (see www.bsi-global.com).

8 This publication can be downloaded from the ECSA publications area of the Euro Chlor website (www.eurochlor.org).

Stop profits evaporating with conservation valves

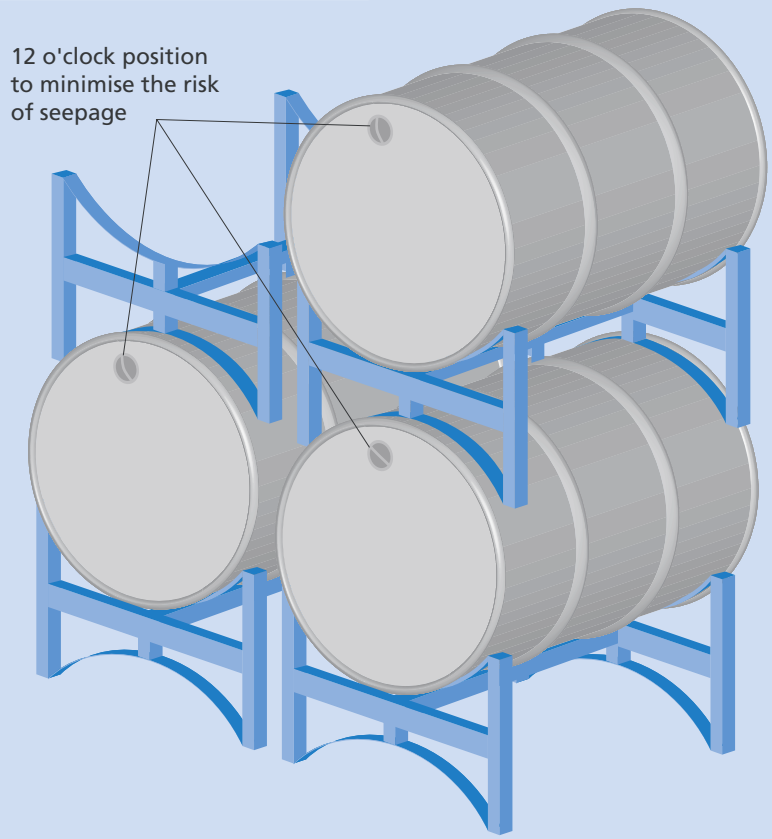
Conservation valves can be cost-effective in reducing solvent losses from tanks, particularly if you are using more volatile solvents such as methyl ethyl ketone, acetone or methylene chloride.

For example, consider a 4 m diameter tank containing acetone with an average vapour height space of 1.8 m. With an average temperature of 21°C and a diurnal temperature change of about 17°C, the tank will lose about 500 kg of acetone/year, costing about £250. If the tank contained methylene chloride, then the loss would be around 1 500 kg/year, costing approximately £750/year. A £500 conservation valve can therefore pay for itself in less than a year.

2.4.3 Container storage

- Unless they are empty, do not stack drums and IBCs more than two high. Stacking drums and pallets on top of one another can lead to accidents, particularly when using a fork-lift. Where possible, stack drums and IBCs on a solid and stable racking system.
- Stack drums horizontally with their valves and bungs orientated in the '12 o'clock position' to minimise the risk of seepage (see Fig 2).

Fig 2 Safe drum racking to avoid spillage



- If practicable, store drums and IBCs on spill decks/pallets (these will contain solvents in the event of a drum/IBC being damaged). Store cans in flammable liquid stores and cabinets that provide appropriate secondary containment.
- Keep spare clean empty drums and IBCs to allow transfer from leaking containers.
- If decanting solvents directly from drums/IBCs in the storage area, fit drip trays under valves and taps. Empty and clean them regularly and re-use the solvent where possible (eg for cleaning).

2.5 On-site distribution

2.5.1 General

- Where possible, avoid manual handling by pumping solvents and solvent-based materials directly through a piped system (eg a ring main) to the point of use. The advantages of piped systems include:
  - reduced risk of spillage during transfer and decanting;
  - better containment and a lower risk of exposure to contaminants;
  - ability to be fitted with flowmeters to allow accurate auditing.
- For companies using viscous materials, warm the materials (eg using a drum or IBC warmer) to facilitate transfer and to reduce the quantity of residue left in containers and pipes.
- Where necessary, decant canned and drummed solvents into a larger sealed tank or IBC to facilitate pumping.
- If possible, avoid pouring when decanting. Use drums/IBCs with appropriate valves at the bottom to facilitate gravity-assisted emptying or use drum pumps and drop pipes.
- Ensure that any decanting areas have impervious flooring and are located away from surface water drains and soakaways. If possible, they should be bunded.
- Locate spill kits in/near decanting areas. Display notices with advice about their use.

2.5.2 Distribution of solvent containers

- Dispense canned and drummed solvents/solvent-based materials from a centralised store, keeping a record of the solvent type, quantity and process/department. This allows a better check to be kept on consumption, spillage and theft. Such checks should be carried out by a fully trained and nominated member of staff.
- Return surplus solvents to the store after use to avoid cans lying around in areas where they might be spilled or misused.
- Where possible, use IBCs rather than drums as they are more stable, and easier and safer to handle by fork-lift/trolley.
- Do not roll full drums on their bottom rims as this can cause seams and lids to distort and leak.
- When moving drums by fork-lift, consider using drum clamps rather than a pallet. Various types of clamps are available for the carriage of 1 - 4 standard drums.
- Use a drum catch when carrying drums on fork-lifts and trolleys. This latches onto the rim of the drum, helping to keep the drum(s) stable and prevent accidents.
- Where more than two drums are carried, tape or strap them together to improve stability.
- Ensure that all movable and partially open containers are not ‘filled to the brim’ to avoid spillage.
- Carry out a ‘hazardous operations’ risk assessment, such as a Hazard and Operability (HazOp) study, to determine whether the routes taken through the site are hazardous in terms of obstacles, drains, flame sources, etc. Keep routes well defined and clear of obstacles.
- Ensure that drums are moved onto raised platforms through safety gates and not through a permanent gap in the platform fence through which they (and people) can accidentally fall. Consider using a drum lift/tilting device, eg a suitable fork-lift attachment.
- Do not decant full drums by tipping them as this can cause accidents and large spills. Instead, pump the material from the drum using a hose and a drop pipe that passes through a bung, to the bottom of the container. Be careful to withdraw the pipe slowly and to avoid spillage from the pipe. Only tip the drum manually to empty the final residue into the receiving container.

2.5.3 Piped distribution

- Design pipe systems to the appropriate engineered standards in terms of withstanding expected pressures and temperatures, and in providing appropriate corrosion protection. Check the appropriate British Standard for the relevant type of pipe run. Plastic pipes are not generally suitable for carrying solvents. For more information, see *Storage and handling of chlorinated solvents* published by ECSA[9].
- Where possible, run pipework above ground to minimise corrosion and to make inspection easier. Underground pipes should have a jacket and leakage alarm system for the outer space.
- Check (both visually and by pressure testing) all pipes, valves and joints for leaks regularly (at least annually) and record the inspection findings in a log.
- Ensure that pipework is not in a position where it can be damaged accidentally, eg by fork-lifts and trucks manoeuvring.
- Keep pipe runs as short as possible. Minimise the number of connections (using one-piece/welded sections where possible) and valves.
- Design pipework without material traps and with a slight drop over its length to ensure good drainage of lines.
- Where line pigging (see section 2.9) may be required, design pipelines to allow for the use of pigs, ie no sharp bends, use of suitable valves, etc.
- Ensure that new and replacement valves, gaskets and seals are 'low emission' types (eg carbon/graphite or polytetrafluoroethylene (PTFE) coated) and resistant to the solvent in question.
- Note that magnetically-driven pumps eliminate the need for the conventional shaft seal found in most pumps and hence cannot leak.

Piped system losses that add up

Solvent losses from individual pumps, flanges and valves are usually small but, across a site, they can add up over time. A typical pressurised system with two pumps, two sample ports, 20 flanged joints and two pressure relief valves may lose an average of 0.3 kg/hour. For a system that is pressurised for 8 500 hours/year, this equates to a loss of about 2.55 tonnes/year of solvent. Assuming solvent costs of £500/tonne, this loss equates to £1 275/year. Pressure relief valves and pumps/compressors are particularly susceptible and should be targeted first. Regular inspection and maintenance can help to reduce these losses.

2.6 Maintenance and drainage plans

Proper maintenance procedures are important in terms of preventing vapour release, leakage and spillage. LAPPC/LAPC guidance requires an effective preventative maintenance programme to be employed on all aspects of the process/activity concerned with the control of emissions to air.

- Establish a preventative maintenance programme based on scheduled activities, with additional unscheduled maintenance only where necessary:
  - Prepare a preventative maintenance schedule. If possible, use commercially available computer software to organise and support the maintenance programme. Such software can help to ensure that no maintenance jobs are forgotten by flagging up planned maintenance on a daily basis until it is completed.
  - Record all inspections and maintenance activities for future reference.

[9] This publication can be downloaded from the ECSA publications area of the Euro Chlor website (www.eurochlor.org).

- Check regularly for wear and tear and leaks on tanks, valves, pumps, flanges, welds, bunds, etc, and rectify as appropriate.
- Carry out pressure testing of pipelines, tanks, etc as appropriate using approved testing procedures and contractors. Check the appropriate British Standards.
- Recalibrate metering and dosing systems regularly to ensure continued product quality and to avoid overuse of solvents and other materials.
- Carry out monitoring to identify fugitive VOC emissions, eg as part of a leak detection and repair (LDAR) programme. Process operators can be provided with personal devices to help identify fugitive losses and hence focus unscheduled maintenance.
- Apply appropriate corrosion protection to mild steel tanks, vessels and pipework. The protection used must be resistant to the solvent in question. Carry out regular inspections and take appropriate remedial action (eg rubbing down and repainting) as necessary.
- Check and, where necessary, replace critical items as they approach the end of their predicted life expectancy. This will avoid failure and leaks.

It is essential to pay proper attention to site drainage as solvent from leaks and spills can enter drains, effluent treatment plants (affecting their operation) and, potentially, watercourses (causing harm to aquatic life and potentially to human health).

- Prepare a drainage plan showing surface water and foul water drains. These should be colour coded on the plan (blue for surface water, red for foul) and drain covers/grids painted accordingly. Flow direction should also be shown on the plan. Ensure that the plan is readily available.
- If the location of drains is not known and a drainage plan is not available, arrange for a survey to be carried out by an appropriately qualified person or contractor. CCTV systems can be used for this purpose.
- Inspect drains, interceptors, etc regularly to check their integrity.

2.7 Managing spills and preventing pollution

A number of good housekeeping measures aim to reduce the risk of solvent/material spills. However, it is important that employees know how to deal with and manage those spills that do occur. Companies and their managers may face prosecution by the Environment Agency or other regulators if they allow solvents to pollute watercourses, groundwater, land, etc.

- Provide spill kits in solvent storage areas and other areas where spillages are most likely to occur (eg decanting areas). Spill kits can either be purchased from specialist manufacturers or be put together on-site with 'socks' and booms using various absorbent materials (textile or garment factory waste can be a cheap option).
- Provide drain covers or fit drain valves to prevent the spillage entering local drains (particularly surface water drains).
- Set up a reporting system for significant spills (eg those involving more than 0.5 litre of solvent or solvent-based material) to discourage careless practice and encourage effective spills management.
- Set up a spillage procedure for significant spills. This may involve:
  - alerting maintenance staff to fit drain covers and close drain valves;
  - using spill kits to contain and mop up the spill;
  - placing solvent-soaked materials into a sealed drum for recovery/disposal;
  - reporting the spill.
- Ensure that all employees have received spill response training and understand spill procedures.

2.8 Using solvents in the process

The following general measures and principles apply to most industrial processes. Further measures for specific processes are given in section 3.

- Talk to suppliers, trade associations and other companies in your sector to identify new products, equipment and processes that can significantly reduce solvent use, eg compliant coatings and fully enclosed degreasing cabinets.
- Put lids back on partly emptied drums or cans of solvent and, where possible, make them airtight (eg seal with adhesive tape if the lid fits poorly).
- Keep solvent containers away from sources of heat and draughts to minimise evaporation.
- Encapsulate vessels, reservoirs and machinery as much as possible using well-fitting sealed lids and covers.
- Where reservoirs and containers do not have proper covers, use anti-static plastic covers (attached by elastic bands or nylon hook and loop fasteners, etc) or stretch-wrap. Such covers have the added advantage of keeping out dust and debris.
- When mixing solvents and coatings, pour the least volatile material first and the most volatile last to reduce losses.
- When thinning, eliminate residue losses (eg of coating) by using some of the thinning solvent to swill out the material from the container and add it to the mix.
- For manual processing, use precise measuring techniques (eg measuring jugs) rather than estimating the amount to be added.
- When decanting from large drums or IBCs, use measures of a known size (eg litre jugs) or mark the side of the container with set measures (eg 100, 200 litres) to prevent waste from over-estimation.
- When filling mixing vessels and machine reservoirs, reduce losses by avoiding splashing and excessive disturbance of the fluid surface, eg use drop pipes that pass to the bottom of the container. If the filler pipe needs to be withdrawn, switch off any pump and empty any residual solvent from the pipe into the container before withdrawing the filler pipe slowly.
- If pumping is not practical and pouring is necessary, use a funnel to reduce the risk of spillage. This is applicable to both virgin materials and waste solvents.
- Make all practicable efforts to minimise the amount of solvent-based material left in drums and other containers after 'emptying'. For example, turn cans upside down and allow them to drain. Where this still leaves a residue (eg trapped around the filler neck) and where there is no significant risk of explosion, cans can be punctured or crushed and allowed to drain.
- Remove containers of residual solvent from working areas to safe storage areas (eg flammable liquid stores) regularly to avoid misuse and accidental spillage.

Capturing container residues saves money

The furniture manufacturer, Ducal, realised that valuable coating and solvent were being lost from the container crushing process. Fitting a drip tray and pouring the collected material into a drum enabled the company to save around 100 litres/week of coating residue. This reduced residue losses by an estimated 70%, with net savings of around £14 000/year.

- Where possible, pump materials/solvents into the mixing vessel according to an accurate metering system or formulation computer. Use load cells to allow accurate weight measurement of the vessel's contents. The information gathered can also be used in mass balance calculations, eg to help compile the site's solvent inventory.
- Fit mixing vessels and reservoirs with overfill protection (eg automatically closing inlet valves and alarms) to avoid accidental spillage.
- Ensure that any air extraction system (local exhaust ventilation) fitted to degreasing and mixing vessels is:
  - fitted above any lid;
  - interlocked to the lid and operates only when the vessel is open or when pressure increases require it.
- Optimise extraction rates to minimise VOC emission losses while maintaining a pleasant and safe workplace atmosphere (within mandatory COSHH[10] limits). Extraction rates are often set too high so as to err on the side of caution with regard to health and safety.
- Fit alarm systems to pollution abatement equipment such as condensers, scrubbers and oxidisers to provide rapid warning of uncontrolled VOC emissions to air. Companies that breach their IPC authorisation or IPPC permit conditions for VOC emissions to air face prosecution by the Environment Agency or other regulators.

2.9 Cleaning, dedication and batch sequencing

Cleaning operations often use unnecessarily large quantities of solvent. In many cases, such operations can be avoided altogether or the process improved to reduce the quantity of solvent used.

- Examine all cleaning operations throughout the company to determine whether alternative cleaning solutions are already being used and, if they are, whether they can be applied in any other cleaning operations. For information about alternatives, see Good Practice Guide *Surface cleaning and preparation: choosing the best option* (GG354)[11].
- Consider using low-VOC cleaning agents such as citrus/water-based and vegetable-based degreasing agents. For example, vegetable-based and other non-solvent cleaners are being used in printing with negligible net cost associated with the change. Many alternative products are available and it may take several trials to identify the one that is best for your process.
- Use only the minimum amount of solvent that is reasonably required for specific cleaning operations. Ensure that operators are given only the amount of solvent required to do the job, eg to clean spray guns at the end of a shift.
- Spray a dose of cleaning solvent from a triggered dispenser rather than use an open can and rag. This will use less solvent and will reduce operator exposure.
- Remove deposits as soon as possible following a 'clean as you go' policy. A build-up of coating can become increasingly difficult to remove as time passes, and will require a disproportionate amount of effort and cleaning material.
- Where deposits have been left to dry, use a suitable scraper or squeegee first to avoid excessive solvent use.
- For general surface/floor cleaning, try using a detergent and warm water instead of solvent. For more difficult deposits, use a detergent solution in conjunction with mechanical measures such as scrapers, floor scrubbers and high-pressure water jets.

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10 Control of Substances Hazardous to Health Regulations 2002.

11 Available free of charge through the Environment and Energy Helpline on freephone 0800 585794 or via the Envirowise website (www.envirowise.gov.uk).

- Make sure that cleaning areas and washbasins have sumps or drains fitted with solvent interceptors/tanks from which solvent can be pumped for recovery or appropriate disposal.
- Where possible, dedicate vessels, pipelines and other equipment to specific formulations/colours to avoid cleaning between batches. It may be cheaper in the long-term to purchase one or two new process tanks or pipelines than to spend large sums of money on cleaning solvents.

How dedication can pay off

Where batches of different products share the same vessel, normal cleaning operations may take place several times a week between batches. Such operations can often use over 100 litres of cleaning solvent per wash. If two products share a vessel with five changeovers per week and the cleaning solvent costs £0.50/litre, cleaning operations would cost £250/week. Buying an extra vessel at a cost of £5 000 so that each product had its own dedicated vessel would reduce cleaning to once per vessel every two weeks. This would cost £50/week. The net saving of £200/week gives a payback period of 25 weeks (ie just under six months).

- Better batch sequencing of products during manufacture to ensure that the same materials/colours are used in adjacent batches will reduce the cleaning of vessels, lines, guns, etc required between batches.
- Fully enclosed degreasing and cleaning equipment reduces evaporative losses and can allow solvent re-use within the machine. For example, small parts washing machines can be purchased or rented.
- Where large vessels/tanks need regular cleaning, fit automated cleaning-in-place (CIP) systems incorporating spray balls/nozzles/rotating heads. These systems generally use high-pressure cleaning and can significantly reduce solvent use. If fitted with partial solvent recirculation, these systems can increase washing efficiency by 90%.
- Consider line pigging for cleaning pipelines, eg between product batches where cross-contamination is an issue. Line pigging involves inserting a 'pig' (a plug normally made of rubber or steel) into a pipeline and then forcing the pig along the line, usually using compressed air or, where necessary, nitrogen. Various pig designs are available.

  The advantages of line pigging include:

  - recovery of expensive materials from pipelines for re-use;
  - a reduction in the amount of cleaning solvent required.

  Pigging systems can cost as little as a few thousand pounds and often have payback periods of weeks rather than months or years.

Encapsulated savings

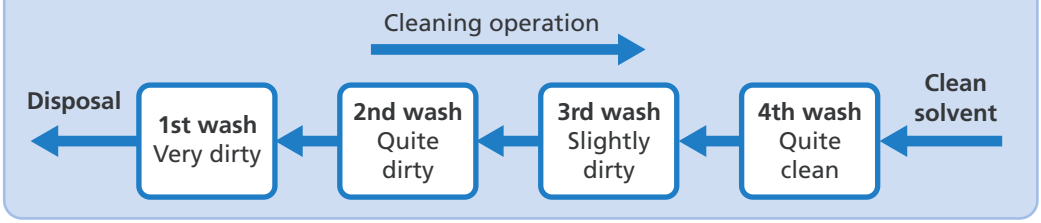
A shoe company altered its adhesive roller-coating machine by using a cloth to improve the sealing of the reservoir lid. This reduced the use of MEK to clean the reservoir by around 300 litres/month (equivalent to around £300/month). The transfer roller itself was stored at night in a sealed container, which was cylindrical and just large enough for the roller, to keep it clean with the minimum use of solvent. Payback was immediate.

2.10 Re-use and recovery on-site

Instead of disposing of spent solvents as waste, it can often be cost-effective to re-use residual solvents directly or recover them through on-site or off-site distillation.

- Keep a careful record of all wastes, product seconds and 'tails' to facilitate re-use. Segregate residues and use clear labelling or drum/tank colouring to avoid cross-contamination and hence aid recovery.
- Use clean solvent (distilled/virgin) only for the last wash. Use dirty solvent for the initial washes as shown in Fig 3.

Fig 3 Countercurrent cleaning to maximise solvent re-use



- Keep items which are to be cleaned or treated in solvent, free from water, dust and other contamination. This will facilitate solvent recovery by minimising sludge build-up.
- Match cleaning solvents to those used in product formulations. This will avoid cross-contamination and may allow the re-use of the cleaning solvent in subsequent product batches.
- Where possible, use obsolete product in new formulations to avoid disposal.
- Consider buying distillation equipment to recover solvents from spent cleaning solutions and waste coatings. This will reduce material costs, lower the volume of hazardous waste solvent stored on-site and reduce disposal costs.

Distillation and better cleaning practices yield significant savings

In its solvent reduction programme, Wood Brothers (Furniture) Ltd focused on reducing the use of cleaning solvents. Better containment of the gun/line flushing area, improved staff training, re-use of cleaning solvents at least three times and installation of a small still (costing less than £4 000) have allowed the company to reduce cleaning solvent use from about 3.7 tonnes/year to around 1.3 tonnes/year, saving over £5 000/year.

- Consider solvent capture and recovery as an abatement option. For more information, see Good Practice Guides *Solvent capture for recovery and re-use from solvent-laden gas streams* (GG12) and *Solvent capture and recovery in practice: industry examples* (GG100)[12].

Solvent recovery system brings printer large savings

Polestar Greaves (formerly DH Greaves) of Scarborough is a large gravure printer using solvents and inks containing toluene. In 1996, replacement of the company's solvent absorption plant increased recovery of solvent emissions to 91%. The new plant uses six granular activated carbon (GAC) beds, which are regenerated using steam. Although the new plant cost £2.5 million, the net annual savings are approximately £810 000, giving a payback period of around three years.

[12] Both guides are available free of charge through the Environment and Energy Helpline on freephone 0800 585794 or via the Envirowise website (www.envirowise.gov.uk).

2.11 Recovery/disposal off-site

Where possible, spent solvents and solvent-based wastes should be sent for recovery rather than disposal. Members of the Chemical Recycling Association (see the appendix for contact details) can provide such services.

- Segregate hazardous wastes, such as solvent wastes, from other wastes. Design solvent mixes to be simple and attractive to solvent recovery specialists.
- Store waste solvents, coatings and contaminated containers in a secure location in accordance with the requirements for full/new containers (ie in a shaded, bunded area with an impervious base, no surface water drains/soakaways and with emergency spill response kits nearby).
- Ensure that waste containers are well sealed and in good condition with no evidence of corrosion or leaks. Keep clean spare containers on-site so that waste solvents can be decanted from any damaged containers.
- Where waste volumes are large, consider using bulk tanks rather than drums to minimise the risk of drum spills and leaks, and reduce disposal charges.
- Label wastes properly using waterproof labels that provide a description of the waste (chemical type, quantity, hazard designation) and the date it was deposited.
- Keep a detailed record of all wastes kept on-site and transferred off-site. Make sure that these records comply with the requirements of the Duty of Care. Detailed records will facilitate overall solvent management and auditing activities.
- Before dispatching waste solvents or solvent-contaminated materials (drums, etc) off-site, ensure that Duty of Care documentation has been completed properly. Most industrial solvents are hazardous (special) wastes and need to be 'consigned' to an appropriate carrier with an accompanying consignment note. For more information about disposal procedures for special wastes, contact the Environment and Energy Helpline on 0800 585794 or your local Environment Agency/SEPA/EHSNI office.
- Arrange for waste solvents to be removed from site regularly. This minimises the possibility of spillage and reduces the risk of drum corrosion, fire and explosion.
- Make full use of waste exchange directories and recovery companies. Contact the Environment and Energy Helpline on 0800 585794 for more information.

Improved waste management brings large savings

A major UK paint company set a target to reduce wastes including coatings, solvent and solid waste by 100 tonnes in 1994/95, with an expected saving of £20 000 in reduced disposal charges. This target was easily exceeded in the first six months, with 160 tonnes of waste and £40 000 being saved. Waste minimisation measures for solvents included:

- Segregation of wastes at source to allow separation of special wastes (eg used solvent containers) from ordinary waste (eg cardboard).
- Switching from drum storage to bulk storage. This allowed cheaper waste disposal (by tanker) and saved the on-going cost of drums. Pumping the wastes to the storage tanks also reduced the risk of spills and leaks.

Good housekeeping for specific applications

This section provides additional information on good housekeeping measures that are particularly relevant to the manufacture and use of solvent-based materials in:

- the manufacture of speciality chemicals;
- surface finishing;
- furniture manufacture;
- vehicle refinishing;
- printing;
- shoemaking;
- timber treatment.

Although this section is aimed at specific applications, many of the ideas and concepts are applicable to other operations. The practical advice given in this section should be applied in conjunction with that given in section 2.

The advice given in this section should be read in conjunction with the relevant process guidance notes (see section 1.5). For free advice on which are applicable to your process(es) and the changeover to the new IPPC regime, contact the Environment and Energy Helpline on 0800 585794, which can put you in touch with a specialist in your sector.

3.1 Manufacture of speciality chemicals

The manufacture of solvent-based speciality chemicals such as inks, paints, stains, lacquers, varnishes, polishes and adhesives can be a significant source of emissions and wastage.

3.1.1 Product formulation/mixing

- Use properly covered or closed mixing vessels to reduce VOC emissions and, hence, solvent losses.
- Use mixing vessels with smooth contours (ie without any corners or areas that can trap mixed coatings) and, ideally, conical so that they can be emptied from the bottom, leaving minimum residue and reducing the need for cleaning.
- Pass the vessel mixer shaft through the smallest hole possible (preferably fitted with a bush and/or some appropriate form of seal).

Reducing losses from conventional mixing vessels

In the 1990s, a large company in south east England operated its adhesive mixers so that air was extracted by a fan working at all times. Monitoring revealed that in one 24-hour period during warm weather about 25 mm of solvent was lost from the 2 m diameter vessel. This represented a loss of about 0.08 m^3/day or about 70 kg/day. The vessels have now been adapted so that vapour is 'lip extracted' only when the lid is open. To allow this, the lid is fitted with interlocks and a good seal. Ingredients are pumped to the mixers from both drums and IBCs, resulting only in displacement losses.

Conversion cost the company about £4 000 per unit. It is estimated that for an approximate solvent price of £0.60/kg, the change saves the company about £42/day for each vessel during warm periods. The initiative thus paid for itself in one summer (four months). More importantly, the changes brought the process below the mass emission threshold for statutory pollution control, thus making the purchase and operation of abatement equipment unnecessary and saving the company hundreds of thousands of pounds.

- Fit vessel lids with interlocks to switch off extraction when the lid is closed. Fit rim extraction above the vessel lid and connect it to solvent recovery or pollution abatement plant.
- Where possible, introduce materials into the mixing vessels through a piped/pumped system rather than chutes. This will minimise both VOC emissions and material releases (eg pigment dust).
- Fit any material chutes with a sealed metal hatch or metal bung to minimise vapour losses. Well-fitting metal bungs will help the condensation of solvent vapours, allowing them to run back into the vessel.
- Where solvent has to be introduced manually into the mix, pump a metered amount carefully and directly into the mixing vessel or decant via another container to obtain more accurate quantities.
- Mount mixing vessels and containers (eg change pans) on load cells linked to a metering system/computer to ensure that the correct quantities are added and to eliminate the risk of over-using solvent/material.
- If milling machines are used to make fine coatings, use fully enclosed bead mills with a piped inlet and outlet. If open vertical bead mills are used, cover the machine with an anti-static plastic cover between mixes.
- Fit condensers to mixing vessel extraction systems to capture escaping vapours for re-use.
- Consider using fully enclosed mixing systems. An example of this technology is described in *Efficient, emission-free mixing* (FP9)[13].

Improved solvent condenser saves large sums of money

Fine Organics, a manufacturer of speciality chemicals, fitted a new improved condenser to a process that was known to emit significant volumes of dichloromethane (methylene chloride). This single measure reduced solvent consumption by 52 tonnes/year and saved the company nearly £73 000/year. The payback period on the investment was just over two years.

[13] Available free of charge through the Environment and Energy Helpline on freephone 0800 585794 or via the Envirowise website (www.envirowise.gov.uk).

3.1.2 Transfer and canning of coatings

Consider the following points during the canning phase of mixed coatings such as paints and inks:

- Pump mixed coatings in a closed transfer system (pipeline) to the blending machine or storage tanks rather than transferring coatings in containers. If this is not possible, ensure that coatings are transferred using closed containers and use the largest container possible to minimise residue losses in the transfer.
- Where mixed coatings are dropped by gravity into a storage vessel, encapsulate as much as possible, eg use a pipe passing from the mixing vessel into the container through a lid bung.
- Avoid manual canning of coatings to minimise quantity variations and spillage.
- Pump coatings, adhesives etc through a piped system to an automatic dispense head. Place product containers on load cells linked to a computer-controlled dispense system. This can allow the feed to change from coarse (fast) to fine (slow) as the target weight is reached, avoiding the possibility of overfilling. Final weight mismatches between actual and target can be fed back automatically to correct the next fill.
- Label products according to the Chemicals (Hazard Information and Packaging for Supply) Regulations 2002 (CHIP 3). Provide information on solvent content by type and weight to assist customer auditing.
- Deliver coatings to the customer in returnable containers such as drums or IBCs. When taken back, these can be cleaned in a controlled environment and cleaning wastes distilled to recover the solvent. This can save you large sums of money and avoids the need for customers to deal with solvent/coating wastes.
- Investigate the cost-effectiveness and feasibility of providing a customer returns system, ie allowing customers to return unused coatings (at a nominal fee) to allow re-sale.

3.2 Surface cleaning and preparation

Degreasing of components using organic solvent methods can be a significant source of emissions and wastage. This section describes measures that can reduce the costs of surface degreasing and pretreatment. Detailed information is given in Good Practice Guide *Surface cleaning and preparation: choosing the best option* (GG354)[14].

3.2.1 Eliminating the need for cleaning

Your first priority should be to eliminate/minimise the need for degreasing operations.

- Keep items well protected (eg using covers and stretch-wrap) and free from contamination between processes. This will reduce the need for grease/oil used as an anti-corrosion measure.
- Spin-off excess oils and/or allow longer drain times between machining and cleaning of components.
- Stack components carefully before cleaning to reduce oil retention.

3.2.2 Alternative cleaning methods

Common chemical pretreatment methods include acid bath (generally hydrochloric acid) and solvent vapour degreasing. The ban on the use of 1,1,1-trichloroethane (an ozone-depleting substance) and the reclassification of trichloroethylene as a Category 2 carcinogen have made

[14] Available free of charge through the Environment and Energy Helpline on freephone 0800 585794 or via the Envirowise website (www.envirowise.gov.uk).

alternative degreasing and pretreatment methods far more attractive. These offer equivalent levels of cleaning with much reduced environmental, health and safety risks.

- ***Mechanical cleaning*** methods such as scraping, brushing, blasting and tumbling/vibration can be useful to remove dirt/grease.
- ***Aqueous cleaning*** systems generally have a wash stage (sometimes ultrasonically assisted), combined with rinse and hot air drying stages. Some use alkaline aqueous solutions and some incorporate a conversion dip (preferably phosphating rather than chromating) to provide extra corrosion protection. Such systems should eliminate the need for any form of manual preparation such as handwiping with organic solvent.
- ***Controlled pyrolysis ovens*** burn off organic coatings and inks from metal surfaces at temperatures of around 930°C. These systems have been successfully used to clean paint jigs and hangers, body panels and other metal components.

3.2.3 Good housekeeping for solvent degreasing

Where solvent degreasing has to be used, consider the following points:

- Where practicable, use modern enclosed degreasing machines, ie with appropriate doors/lids, and, ideally, hermetically sealed machines. Open-topped vapour degreasing plant using risk phrase solvents is unlikely to comply with the requirements of the Solvent Emissions Directive (SED) (see section 1.5).

Cheaper solvent degreasing

In the mid-1990s, engineering company Flight Refuelling Ltd replaced three old open-top vapour degreasers with two efficient enclosed units. These use 75% less solvent than the old models and have resulted in net cost savings of over £35 000/year, with a payback period of less than two years.

- Where practicable, fit cooling condenser coils (attached to a closed-loop chiller unit) below the extraction vent inside the machine to allow internal solvent capture and hence minimise vapour losses.
- Open-topped tanks should be retrofitted where possible with a lid - below any rim or other local exhaust ventilation (LEV) extraction system - and interlocks fitted to ensure that extraction occurs only when the vessel is open.
- Organise (ie rack or jig) the items so that there are as few solvent traps as possible and that the items drain freely. This will reduce drag-out.
- Where possible, equipment that transports the components through the degreasing process should be integral to the machine and should not allow items to carry solvent out of the machine (eg to drip on the floor).
- Turn the work in the freeboard zone to minimise solvent drag-out.
- Where possible, use powered hoists and lifts to ensure that the correct loading and unloading speeds are always used. This will ensure minimum disturbance of the solvent surface and minimum solvent carryover. Use a maximum speed of 3 m/min in the vertical plane and 6 m/min in the horizontal plane.
- When topping up the machine, avoid decanting losses by pumping solvents from the supply tank to the degreasing machine through a pipe system. Alternatively, use sealed drums and a drum pump.

3.3 Surface finishing/coating

Many industries are involved in surface finishing and coating. This section relates mainly to metal and plastic coating, although it also touches upon wood coating. For detailed information, please consult the relevant LAPPC/LAPC Process Guidance Note for your application(s)[15].

3.3.1 Alternative coatings

Many companies have moved away from high solvent-content coatings for reasons of cost, quality, environmental compliance, and health and safety. Alternative coating systems involve the following, either singly or in combination:

- ***Medium/high-solids paints:*** 40 - 70% solids content (30 - 60% VOCs) compared with 20 - 40% for conventional wet paints.
- ***Water-based paints:*** similar solids content to conventional paints but with far less VOCs (typically 10 - 20%).
- ***Powder coatings:*** a 100% solids mixture of paint pigment and resin binder.
- ***Thermal/plasma coatings:*** specialist coatings such as metal and polymeric coatings that have to be applied at high temperature.

Certain low-VOC coatings are regarded as compliant coatings and, where used, exempt the company from compliance with the emission limit requirements of the relevant process guidance notes.

In metal finishing, water-based coatings are now often used as a primer and/or basecoat with a medium to high solids topcoat. Powder coatings (applied electrostatically) are often applied without a primer coat.

Vehicle refinisher benefits from water-based paints

In 1999, a medium-sized independent car repair bodyshop decided to replace two drying ovens. At the same time, it took the opportunity to switch to water-based paints and ovens capable of dealing with the associated drying requirements. The benefits have been significant, with reduced VOC emissions of 55% and a 12% increase in throughput. The latter is worth £74 000/year in extra business and reduced courtesy car needs (savings of £28 000/year). Workplace air quality has also improved significantly.

An example of a coating change in furniture manufacture is the use of tinted lacquers as a one-coat substitute for separate stains and lacquers. Acid-catalysed primers and lacquers are now often used as well as water-based coatings. Furniture manufacturing companies are advised to consult Good Practice Guides *Reducing solvent use in the furniture industry* (GG177) and *Savings through low solvent wood coatings* (GG340)[16] for practical advice on how to reduce solvent costs.

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15 If you're not sure which Process Guidance Notes are applicable, contact the Environment and Energy Helpline on freephone 0800 585794.

16 Available free of charge through the Environment and Energy Helpline on freephone 0800 585794 or via the Envirowise website (www.envirowise.gov.uk).

Water-based coatings in furniture manufacture

The introduction of water-based, UV-cured, low-solvent coatings at Herman Miller, the office furniture manufacturer, resulted in net savings of over £15 000 in 2001. These savings were mainly due to the reduced cost of cleaning solvents. The site's solvents to solids ratio has improved from 2.39:1 to 0.61:1.

For more information about alternative coatings and their application, contact the Environment and Energy Helpline on 0800 585794 or visit the Envirowise website (www.envirowise.gov.uk). Envirowise has published a series of good practice guides and case studies with practical advice for different sectors.

3.3.2 Better equipment

Better application techniques and equipment are often the key to reduced wastage and cost. Application is either by dipping or, more generally, by spraying. Conventional (air atomised) spray guns (whether gravity, siphon or pressure fed) operate at high tip (air cap) pressures and, while they produce the finest sprays, suffer from bounce back, high levels of 'fog' and overspray. Transfer efficiencies are typically 30 - 50%, meaning that for every litre of paint used at least one litre is wasted!

- Consider using electrophoretic and autophoretic dipping for priming and corrosion resistance coating. Electrophoretic deposition (EPD) involves the use of electrodes connected to the bath and the jigs to create the attraction between paint and substrate. Autophoresis relies on a chemical reaction to create the attraction. Both techniques offer high material yield and high quality, and are water-based processes with no VOC emissions.
- If spraying, consider replacing conventional spray guns with high volume low pressure (HVLP) spray guns. These give better control, better coverage of recesses and cavities, and typically offer transfer efficiencies of 65 - 85%. Some Process Guidance Notes require transfer efficiencies of more than 65%.

  HVLP guns are available for gravity, siphon and pressure feeds and can be used with most coatings. In most applications, HVLP guns will pay for themselves within weeks.

Benefiting from HVLP guns

In 1997, the spray shop at the Yeovil Motor Company introduced a range of good housekeeping measures and new HVLP spray guns. Despite a 20% increase in vehicle throughput, paint use has fallen by 66% and solvent use by 15%. Estimated cost savings are around £30 000/year and the payback period was two weeks.

A small furniture company reduced its use of solvents by 3 600 litres/year in the 1990s through various solvent reduction activities and, in particular, a move to HVLP spray guns. The reduction in solvent use has saved the company around £3 100/year, giving a payback period of less than two years.

- When using viscous coatings, consider using hot-spray equipment that can produce the correct coating viscosity without the need for excessive use of thinners.

Hot spraying brings savings to furniture manufacturer

Furniture manufacturer Alston Cabinets reduced its use of thinning solvents by 5 tonnes/year by switching to hot-spray equipment. The capital cost was £25 000 and the net cost saving was £8 000/year, giving a payback period of just over three years.

- Companies with greater resources and/or higher value coatings should consider using electrostatic spraying. With wet paints, this allows the charged paint to be attracted to the earthed piece and hence gives 'wrap around' (onto the back of the piece) and high transfer efficiency. Electrostatic enhancement can be applied to all types of gun.

  Combined with HVLP technology, electrostatics can typically achieve a transfer efficiency of 65 - 95%, depending on the piece's shape and conductivity. In 'centrifugal' electrostatic guns, atomisation takes place as paint spins off a spinning 'bell' or disc(s) rather than in a normal atomisation chamber. Air is used only to help direct and contain the paint fan.

Benefiting from electrostatic spraying and autophoresis

ABT Products Ltd, based in Ross-on-Wye, makes cabs for fork-lift trucks and other vehicles. Between 1994 and 1998, the company made savings of £16 800/year after introducing electrostatic spray guns and solvent recovery equipment. Since then, the company has continued to improve its environmental performance and the quality of its product. It has now reached a position where process authorisation is no longer required.

One of the most recent improvements has been the introduction of an autophoretic primer coating system, which has resulted in cost savings of around £38 000/year through reduced paint consumption and waste disposal costs. Product quality and corrosion resistance have improved, as have workplace and local air quality.

- Consider powder coating. This is a dry electrostatic process performed using a fluidised bed dip or, more commonly, by spraying. In the latter case, a cloud of paint particles (pigment and a binder resin) is attracted to all sides of the piece giving very efficient and high quality coating. Unlike wet paints, powder can be readily collected and recirculated. Appropriate encapsulation, extraction and the use of cyclones, filters and sieves can allow powder utilisation levels of over 90% where product specifications allow (eg with respect to small blemishes).

Big benefits from powder coating

Link Lockers, based in Telford, produces lockers for factories, leisure centres and various other customers. To address concerns about a number of environmental, economic and quality issues surrounding its solvent-based wet paint process, Link Lockers decided to move to powder coatings. This change has resulted in many benefits including:

- a net cost saving of £140 000/year;
- elimination of solvent use;
- the reduction of rework from 15% to virtually zero.

The payback period on the investment was less than three years.

- If using spray guns, pump mixed coatings directly or via a ring main to avoid decanting by individual operators. Some low-pressure pumping equipment can supply a number of spray guns (eg HVLP/electrostatic) directly from one paint container or reservoir without the need for intermediate pressure pots. They do this by offering a gentle, stall-free and pulse-free action that is suitable for direct delivery to the gun. This reduces material wastage and the need for cleaning.
- When considering automatic guns, note that reciprocating guns (those that move up and down on tracks parallel to the item) generally produce an even coating with reduced overspray. On a flat surface, 'nodding' guns create an uneven coat with a 'fan tail' at the extremes.

  Although expensive, robotic spraying is desirable when spraying large and complex shapes as it offers high transfer efficiencies, high quality and reduced labour costs. Robotic spraying often reduces coating use by 20 - 30% compared with manual spraying.

- On automatic/robotic spraying equipment, dedicated paint lines often feed a colour changer that, in turn, supplies the gun down a feed line. The closer the colour changer is to the gun, the lower the wastage of paint and cleaning materials on a changeover. This can be achieved by locating the colour changer and pumps in the robot arm close to the spray head. The number of dedicated lines is usually limited to 24 or fewer due to the volume available in the arm and weight constraints. An alternative is to replace the feed lines with cartridges that can be loaded onto the paint atomiser.
- On automatic cleaning systems, pulsed air (in the direction of paint supply) can be used with cleaning materials to improve cleaning and reduce material use. In terms of paint recovery, reversing the direction of the compressed air can drive unused paint back down the supply line into the pressure pot or container, thereby saving paint and cleaning solvents.
- Consider line 'pigging' systems (see section 2.9) to improve paint recovery and reduce the amount of solvent used for cleaning.
- Consider using enclosed gunwashing machines/cabinets. These avoid unnecessary emissions and recover the solvent used in spray gun cleaning to allow its re-use within the machine. Such machines can be bought or rented.

3.3.3 Other measures

There are many other worthwhile measures to consider:

- Use pre-mixed coatings where possible to avoid mixing on-site.
- Thin or mix coatings in a centralised mixing room, or preferably in an enclosed machine. Use trained staff for this task. Where possible, use electronic/computerised equipment.
- Do not allow machine/process operators to mix their own coatings at the machine side. Such 'bucket chemistry' usually leads to significant emissions into the workplace.
- Where possible, use a brush or sponge rather than a spray gun to apply dyes and stains. For example, this method is cost-effective for dyeing sets of shoe soles with their edges exposed.
- Dedicate lines, pots and guns to a particular colour/material to reduce the need for cleaning on changeovers. Careful batch sequencing (ie following one with another of the same or very similar colour) also reduces the need for cleaning and hence wastage.
- Make sure that:
  - spray gun arrangements and settings are optimised;
  - appropriate procedures are provided for spray gun operators to follow.

  Discourage spray gun operators from tampering with spray pressures and other settings without permission.

  With manual guns, the main issues are the air and coating pressures, the fan pattern and the way the gun is used. Ideally, the fan pattern should be only a little wider than the object being sprayed. Movement should be:
  - at a constant speed, eg from side to side;
  - at an optimum distance (a balance between bounce back when too close and fogging when too far away);
  - parallel to the object so as to avoid fan tails (at the extremes) and uneven coating.
- Control the temperature in the spray area to keep it constant and optimum for spraying. Changes in temperature affect viscosity and hence spray gun output. They can also affect transfer efficiency if the operator is unable to compensate. Table 1 overleaf shows the effect of temperature on a typical furniture coating.

Table 1 Impact of temperature on coating viscosity

Time of day	Temperature (°C)	Viscosity measurement (seconds)	Spray gun output (kg/min)
Morning	15	23	13.0
Mid-morning	20	20	14.7
Midday	25	17	15.9

- Spray flat component parts before assembly of a product to avoid over-consumption of the coating.
- Consider using paper masking around spraybooths to reduce the need for booth cleaning.
- Control the use of cleaning solvents by providing operators with a set amount each day/shift. Use triggered spray containers rather than free access to cans.

3.4 Printing

Many printing companies are now using low-VOC, water-based and ultraviolet (UV)-cured inks. However, the use of solvent-based inks is still necessary in several areas of the printing industry and good housekeeping approaches should be applied. For detailed information, please consult the relevant LAPPC/LAPC Process Guidance Notes[17].

Information from the EU SUBSPRINT programme on the substitution of solvents in printing and on vegetable oil-based cleaners may also be useful; contact the Greater Manchester Hazard Centre Ltd on 0161 953 4037.

3.4.1 General

- Store products under conditions that will preserve their shelf-life, eg film processing chemicals can be affected by both temperature extremes and exposure to light.
- Use press-ready inks where possible to avoid mixing on-site.
- Thin or mix inks in a centralised mixing room or, preferably, in an enclosed machine. Use trained staff. Where possible, use electronic/computerised equipment.
- Do not allow machine/process operatives to mix their own inks at the machine side. Such 'bucket chemistry' usually leads to significant emissions into the workplace.
- Where possible, pump ready-mixed inks via a piped system to the press reservoirs.
- Keep printing press ink reservoirs and feeds/returns as fully enclosed as possible.
- Schedule print runs (ie use of same inks/colours on adjacent jobs) to reduce the need for cleaning and the wastage related to start-ups. Good Practice Guide *Cost-effective ink management for printers* (GG163)[18] describes how to manage ink to reduce wastage and contains advice on set-up and work scheduling.
- For larger items such as screens, print rollers and containers, consider buying an enclosed/closed-loop wash machine preferably linked to distillation equipment. This reduces emissions, recovers a large proportion of 'waste' solvents and reduces waste storage and disposal problems. For most companies, the investment is repaid within a year.

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18 Available free of charge through the Environment and Energy Helpline on freephone 0800 585794 or via the Envirowise website (www.envirowise.gov.uk).

3.4.2 Screen printing: work scheduling and set-up

As with all printing operations, job scheduling can help to reduce solvent use significantly.

- When printing separate jobs in more than one colour, complete the run of the first colour before starting the second colour. However, you may need to store part-finished jobs.
- Pay greater attention to screen quality and set-up. Inadequate screen tensioning, worn screens, worn/ill-fitting squeegees, etc all contribute to poor printing and the need for extra screen cleaning and reclamation.
- Produce larger batches of goods less frequently after discussing the issues with production schedulers and customers. Some of the cost savings could be passed on to the customer. Just-in-time production will effectively rule out this option.

3.4.3 Screen printing: Ultraviolet (UV)-cured inks

UV inks, which cure by photopolymerisation, contain little or no organic solvent and hence VOCs are not released during drying. These inks are a viable alternative in many solvent-based ink applications. They also produce much less waste due to inherent process control improvements and lower amounts of solvent-based cleaning chemicals are needed to remove UV inks from screens, etc.

UV inks cost up to twice as much as conventional inks, but overall raw material costs are similar because UV inks:

- cover up to 50% more substrate;
- use less thinners, cleaning fluids and screen cleaning chemicals.

Some UV inks pose specific health and safety risks because they contain acrylates, which are significant skin irritants and skin sensitisers. However, provided suitable training is given and appropriate equipment is used, they pose no greater risk to health than many solvent-based inks.

The factors to consider when evaluating the possibility of switching to UV-cured or water-based inks include:

- Curing costs.
- The effects on the volume and strength of your trade effluent from using water to remove water-based inks from your screens (check that you will still meet your consent conditions).
- Whether your electricity supply can cope with the high currents drawn during start-up by UV driers. However, these driers generally use less electricity than conventional ovens.

UV inks save time and money

A West Country screen printing company has successfully switched from using conventional solvent-based inks to water-based inks cured by UV radiation. The switch resulted in cost savings of over £60 000 in the first year alone. Switching to UV inks had a number of benefits, including:

- a reduction in solvent consumption of over 8 tonnes/year, thus avoiding the need to install expensive abatement plant;
- increased productivity;
- reduced cost of waste disposal, energy and screen re-stretching.

3.4.4 Screen cleaning

Screen printers use large quantities of organic solvents to clean and reclaim screens. Simple good housekeeping measures can usually produce solvent savings of around 10%.

- Use squeeze or trigger spray bottles rather than pouring solvent onto cleaning rags.
- Collect and re-use screen cleaning and reclamation materials. For example, this can be achieved by cleaning/reclaiming screens in a tray with a drain at one end. The used material is drained to a suitably labelled or colour-coded can. The collected material can then be re-used for low-grade cleaning work, eg ink removal.
- Centrifuges and distillation equipment can be used to recover solvent from dirty solvent-soaked rags.

You may also want to consider using alternative methods and materials to clean screens including:

- the use of steam cleaning or high-pressure water jets to clean screens;
- the use of ink degradant rather than haze remover;
- greater dilution of water-based cleaning materials.

It can be worth using disposable screens or contracting out your screen cleaning to a specialised contractor. Screen reclamation companies can afford more expensive equipment (eg enclosed screen cleaning machines) and are able to benefit from economies of scale when buying and using screen reclamation materials.

Benefiting from automatic screen wash equipment

An automatic and fully enclosed screen wash and distillation unit enabled screen printer Bovince to save over £27 000 in 1997. In addition, there were significant productivity and health and safety gains.

The type of materials used to clean and reclaim screens largely depends on the type of ink or stencil used. UV-cured inks are easier to remove, thus reducing the amount of solvent and the time taken to clean a screen. Good Practice Guide *Practical measures to save money in screen cleaning and reclamation* (GG143)[19] provides detailed guidance on reducing solvent use.

3.4.5 Lithographic printing: reducing IPA use

With conventional, alcohol-dampened printing plates, non-image areas are water receptive and image areas are ink-receptive. A thin layer of dampening solution containing water, isopropyl alcohol (IPA) and fountain additives is applied to the plates by dampening rollers.

IPA use in dampening is a particular source of VOCs in lithographic printing. A number of measures can be taken to reduce emissions:

- Ensure that the dampening solution is kept chilled at 10°C.
- Consider reducing the concentration of IPA in the dampening solution. This technique, which is called alcohol replacement chemistry, involves reducing or eliminating IPA by adding small volumes of alternative chemicals such as glycols or glycol ethers.
- Improve press management through better monitoring and control of the interaction between the dampening systems, rollers, ink, paper, water quality and operator skills.

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[19] Available free of charge through the Environment and Energy Helpline on freephone 0800 585794 or via the Envirowise website (www.envirowise.gov.uk).

- Introduce IPA to the mixer unit using automatic dosing units and airtight pumps, thus reducing use and eliminating evaporative losses.

Good Practice Guide *Reducing IPA use: industry examples* (GG283)[20] provides examples of companies that have benefited from alcohol replacement chemistry, generally without any capital investment.

3.4.6 Lithographic printing: waterless printing

Waterless printing is an offset lithographic printing process that eliminates the water-based dampening system used in conventional printing. The plates are covered instead with an ink-repellent, silicone-rubber layer. Removing parts of this layer using chemical development or a computer-to-plate (CtP) process reveals the image area. Waterless presses use zonal cooling systems to maintain the different inking units at their optimum application temperatures.

The similarities of the two printing technologies mean that modern offset lithographic presses can be used for both waterless and alcohol-dampened printing. Waterless printing has a number of inherent benefits, including:

- no need for IPA and other solvents;
- reduced water and energy consumption;
- shorter make-ready times (there is no ink/water balance to achieve), thus reducing wastage and downtime;
- no need for dampening system cleaning;
- increased flexibility of substrate use relative to traditional lithographic printing;
- clearer and more accurate printing, with enhanced colour intensity and consistency.

For more information about waterless printing, see Case Study *Business and environmental benefits of waterless printing* (GC238) and Good Practice Guide *How to convert to waterless printing* (GG391)[21].

3.5 Adhesives use

As with surface finishing and printing, a number of companies that use adhesives (eg in the shoe sector) have moved from solvent-based to water-based materials.

Benefiting from the use of water-based adhesives

UK shoe manufacturer, The Florida Group Ltd, switched in the second half of the 1990s from using solvent-based to water-based adhesives and cleaning materials in two of its main operations - closing (preparing uppers) and making (attaching soles to uppers). Most finishing materials are also now water-based. This change reduced solvent use by 96% and achieved cost savings of around £8 000/year. The only cost to the company was the time required to investigate new materials.

Hot-melt adhesives offer another alternative and are widely used in packaging applications. Stitching, riveting and stapling can also be used successfully and, in some cases, may enhance the design's character or quality image.

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20 Available free of charge through the Environment and Energy Helpline on freephone 0800 585794 or via the Envirowise website (www.envirowise.gov.uk).

21 Both publications are available free of charge through the Environment and Energy Helpline on freephone 0800 585794 or via the Envirowise website (www.envirowise.gov.uk).

For those companies that still use solvent-based adhesives, a number of good housekeeping measures can be adopted.

- Monitor and record product weight regularly to identify where and when excessive quantities of adhesive are being applied.
- If applying adhesive by brush, use adhesive pots that do not allow large adhesive surface areas to be exposed to atmosphere. Suitable pots with vapour traps and appropriate lids are available commercially.
- When not in use, store adhesive brushes in sealed containers with a little cleaning solvent in the bottom. Where possible, attach the containers to a workbench to avoid the possibility of accidental spillage.
- Use pumped glue guns or other appropriate dosing devices to apply adhesive in a measured and economical way. Glue guns also have the advantage of being sealed automatically between each adhesive application through the valve/pump action of the gun.
- Ensure that any reservoirs are sealed properly on machines used for adhesive application. Improve metal-to-metal seals by using a cloth or an appropriate (solvent-resistant) plastic film. This prevents the adhesive drying out, thus reducing the need for top-up solvent and eliminates the need for reservoir cleaning.
- Fully enclose adhesive application machinery (eg tape coating machines) where possible. Fit a perspex window if viewing is necessary.
- Where possible, pump low-viscosity adhesives via a pipe direct to the application point, glue gun or coating head.

Cost savings from good housekeeping

The thorough approach to solvent management implemented by a leading UK shoe manufacturer in the early/mid-1990s led to a solvent reduction of almost 50%. This reduction was partly due to the adoption of good housekeeping measures across a number of sites. The simple measures related to adhesive use included:

- switching sole cementing from a manually applied solvent-based adhesive to a water-based adhesive applied using HVLP spray guns (savings of over £4 000/year);
- storing adhesive brushes in sealed containers with a little solvent, thus eliminating the need for 'active' cleaning and reducing brush purchases (savings of over £9 000/year);
- using a water/citrus-based dissolving agent rather than solvent in crepe sole preparation (producing a material saving worth over £7 000/year).

3.6 Timber preservation

The following measures are specific to timber preservation. For additional information, see the British Wood Preserving and Damp-Proofing Association's *Timber treatment installations 2003: code of practice for safe design and operation*[22].

- Ensure that the plant, associated loading/unloading areas and wood preservative storage vessels are completely contained by bunding (see section 2.4).
- Use covered or enclosed mixing vessels to minimise VOC emissions during the mixing of preservative solutions. When transferring treatment chemicals from vessel to vessel, use enclosed mobile containers, vessels with close-fitting lids or, preferably, enclosed containers with pipeline delivery.

[22] This publication can be downloaded from the Environment Agency's website (www.environment-agency.gov.uk/ commondata/105385/timber.pdf).

- Pre-cut the wood to the desired size and shape to avoid wasting treatment fluids. This avoids the need to treat the timber by hand after cutting.
- To minimise the formation of sludge, brush the wood pack (timber lengths placed together to form a rectangular pack) to remove sawdust, etc.
- Space timbers within the pack to eliminate solvent traps and to allow better run-off within the treatment machine.
- Clean the vessel door seal to remove any dirt that could prevent a proper seal and thus allow VOC emissions to escape to atmosphere.
- Having loaded the timber pack, raise one end (most easily the door end) to facilitate solvent run-off from the wood.
- Use only automated double-vacuum impregnation plant.
- Ensure that an interlock prevents the process from starting without the door being closed. An interlock will also stop the door being opened before the treatment vessel is fully drained.
- Fit an interlock on pressure treatment vessels to prevent the door from opening until ambient pressure has been reached, thus minimising VOC emissions.
- Check the pressure gauge/indicator to confirm that the vessel is not still pressurised before opening the door.
- Allow the wood to stand dripping and drying in the tank for as long as possible before removal. This maximises the amount of solvent that can be recovered within the machine.
- Withdraw the timber on its bogie, allowing excess solvent to be caught in the loading door drip tray (for pumping back to the tank) or in the bund. The vessel floor should slope down to the front door to facilitate vessel drainage.
- Move the wood carefully to a bunded dripping/drying area and collect (pump) free solution into a container for re-use. Cover the dripping/drying area to minimise the ingress of rainwater.
- Consider switching to water-based treatments. These are now gradually being developed and adopted, even by companies producing close-tolerance joinery.

Taking action

Now you have read this Guide, you have taken the first step to reducing your solvent consumption. Below is a suggested action plan to help you successfully build on this start.

- Examine the solvent route through the workplace, looking at each stage of solvent handling. For each stage, consider if you can make improvements. Ask yourself 'do we have to do it this way?'
- Review whether you need to use organic solvents at all or whether you could switch to a 'no solvent' or 'low solvent' alternative. Review your processes and procedures to see if you can eliminate or minimise solvent use and waste at all stages.
- Raise the awareness of the need for good housekeeping when using solvents and train staff who handle solvents about how to avoid misuse, spills and leaks. Put in place procedures for dealing with spills and leaks.
- Investigate ways of improving delivery and storage methods.
- Implement a preventative maintenance programme for all machines and equipment.
- Investigate and prioritise improvement options. Start by implementing no-cost and low-cost measures that will bring quick and/or significant savings from reducing solvent use.
- Consider developing a solvent management system.
- Develop an action plan for your site with appropriate objectives, targets and defined responsibilities.
- Contact the Environment and Energy Helpline on 0800 585794 or visit the Envirowise website (www.envirowise.gov.uk) to:
  - find out about free Envirowise publications relevant to your operations;
  - seek free advice from an Envirowise expert, eg about environmental legislation applicable to your site;
  - request a *Fast*Track visit (a confidential, on-site waste review carried out by an environmental expert and including up to a day's free advice)[23];
  - ask about a counselling visit from an Envirowise consultant to discuss a specific environmental issue at your site.

[23] This service is available to UK companies with fewer than 250 employees.

Useful contacts

Further advice about solvent good housekeeping may be obtained from the **Environment and Energy Helpline on 0800 585794** and from the organisations listed below. The list is not exhaustive and has been compiled from information currently available to Envirowise. The listing of an organisation does not constitute an endorsement by Envirowise of its products, services or competence and neither does the omission of a supplier discriminate against its products, services or competence.

Organisation	*Telephone*	*Website*
British Adhesives and Sealants Association (BASA)	01438 358514	www.basa.uk.com
British Coatings Federation (BCF)	01372 360660	www.coatings.org.uk
British Printing Industry Federation (BPIF)	0870 240 4085	www.bpif.org.uk
British Wood Preserving and Damp-Proofing Association (BWPDA)	01332 225100	www.bwpda.co.uk
Chemical Recycling Association (CRA)	01279 814035	
Environment Agency	01454 624400	www.environment-agency.gov.uk
European Chlorinated Solvents Association (ECSA)	0032 2 676 7354	www.eurochlor.org/chlorsolvents/generalinfo/info.htm
Furniture Industry Research Association (FIRA)	01438 777700	www.fira.co.uk
Health and Safety Executive (HSE) Information Centre	08701 545500	www.hse.gov.uk
Institute of Packaging	01664 500055	www.iop.co.uk
Northern Ireland Environment and Heritage Service	028 242 4754	www.ehsni.gov.uk
Paint Research Association	020 8614 4800	www.pra.org.uk
SATRA Footwear Technology Centre	01536 410000	www.satra.co.uk
Scottish Environment Protection Agency (SEPA)	01786 457700	www.sepa.org.uk
Screen Printing Association	01737 240792	www.spauk.co.uk
Surface Engineering Association	0121 237 1123	www.sea.org.uk
Waste Exchange Services Limited	01642 606055	www.wasteexchange.com

Envirowise - Practical Environmental Advice for Business - is a Government programme that offers free, independent and practical advice to UK businesses to reduce waste at source and increase profits. It is managed by Momenta, an operating division of AEA Technology plc, and Technology Transfer and Innovation Ltd.

Envirowise offers a range of free services including:

- Free advice from Envirowise experts through the Environment and Energy Helpline.
- A variety of publications that provide up-to-date information on waste minimisation issues, methods and successes.
- Free, on-site waste reviews from Envirowise advisors, called *Fast*Track visits, that help businesses identify and realise savings.
- Guidance on waste minimisation clubs across the UK that provide a chance for local companies to meet regularly and share best practices in waste minimisation.
- Best practice seminars and practical workshops that offer an ideal way to examine waste minimisation issues and discuss opportunities and methodologies.

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For further information please contact the

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0800 585794