planet friendly **guide**

screen and digital printing

FESPA
united we print

contents

1. important note and how the guide works

important note

Whilst every effort has been made to ensure the information contained in this guide is correct as at December 2008, FESPA makes no representation, expressed or implied, with regard to the accuracy of the information contained in this guide and cannot accept any legal responsibility or liability for any errors or omissions that may be made.

Much of the content has been based on European environmental legislation, so readers should check the situation in their own country with respect of any specific issue.

We hope that this guide proves a useful information resource for printers throughout Europe.

Whilst it is the case that within the EU we are moving more and more towards an EU wide approach to environmental (and other matters), there are some differences with respect to interpretation and application across Member States.

It is FESPA's intention to see if we can obtain EU Funding to arrange translation of the guide into all EU languages.

This might take some time. However, in the meantime National Associations and Associate members are free to translate the guide into their native language and to use any of the photographic images.

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how the guide works

This document is constructed in such a manner that the essential, common and practical facts – valuable and clear for most of the readers – are the ones you can find "at first sight". This document can be printed or used simply by reading it on your computer as it is in an Adobe© pdf format.

Paul Machin and Michel Caza have tried to be succinct as much as possible when covering such a complicated topic.

This means that some complementary information, often quite technical and/or related to the European Directives and Regulations is shown in shaded boxes throughout the guide and when necessary, if you want more details both technical and legislative, you can find it by clicking where shown.

2. a few words from the FESPA President Anders Nilsson

FESPA shall be the natural partner to all our members to find information on how to become a more environmentally friendly printer, and this guide is one way to find out how to proceed in that direction.

By sharing information, I think we can develop our industry, and by listening to our customers' demands know we can develop our companies for the future.

Together we will find new ways to print, more suitable materials to print on, and better inks to print with, to become more environmentally friendly.

The demands from our customers are an opportunity for us, not a threat, and dealing with it in the right way will make us a stronger partner.

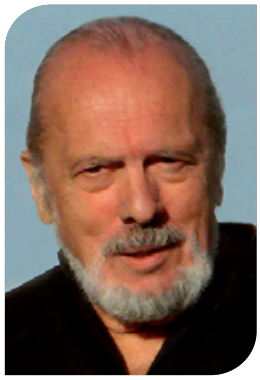
Our responsibility is not only to our client; it is for the whole planet, for our children and their children, and FESPA shall be the source where to find information and knowledge on how to be a green printer in the future.

Anders Nilsson

FESPA President

foreword

3. foreword and introduction to the guide from Michel Caza



This very long awaited "Guide" was born five years ago! For thirty years we have spoken about the problems of pollution in the environment and what it brings to screen printing technology firstly and then digital technology later.

The know-how offering the best answers to most of these problems is UV screen printing technology (since 1979) and digital printing (since 1999). We shall see this explained later.

As a matter of fact, we are in the environmental problem NOW…deeply, in some countries! Almost all the countries in the world, not only the so called "rich countries" from the EU and North America, have these concerns.

The developing countries are also involved, especially such countries where screen and digital printing are growing quickly, like parts of Eastern Europe, China, India and Brazil: they too have to face the problems of water pollution, air pollution, collection and recycling and/or disposal of dangerous waste.

Governments are enforcing laws that are becoming ever more restrictive inside EC. Directives and Rules are created one after the other, despite the restraining action by lobbying from some countries, groups or associations. Generally, these rules follow the hard core ones of the member countries, so now there is in addition RoHS and WEEE to be applied, REACH is also here now!

To be quite clear, it's time to stop burying one's head in the sand, and the Big Question for all screen and many digital printers – the ones using solvent based systems - will be how to adapt and conform.

Water is one of the major problems. Air pollution follows and the elimination of waste is the third major point.

BUT! Try to consider the whole problem as a kind of… Marketing opportunity! The customers, end-users, print buyers, goods manufacturers and retailers, under pressure from their clients or using the "caution principles", want "Green products" for the purpose as well as for the products themselves but also for their "brand image", advertising, etc. As a result, if you "produce clean and green", you can use this more and more as an excellent marketing and selling argument for your own company!

In addition, we have an important chapter about "Energy consumption" which is of course an excellent opportunity to save a lot of money!

It is then important to find technology that is useful, efficient and at a good price, which I hope, as a screen and digital printing technician – in all its applications – and as an ex display manufacturer, will be efficient and safe.

It appears that many countries in Europe and the rest of the world, have no such Guide on these pollution issues or ways to deal with the problems. FESPA does. It has updated the Guide but leaves each of you in your own country, free to translate and to adapt it to local legislation, rules and responsibilities to conform to health and safety.

This Guide will, I hope, answer most of your questions and bring practical solutions.

Michel Caza

Past President of the French Association
Past President of FESPA
Past Chairman of ASPT (Academy of Screen Printing Technology)

4. about Paul Machin

For 20 years Paul ran the regulatory affairs department of a leading ink manufacturer advising on labelling and shipping of hazardous goods and oversaw all health, safety and environmental issues worldwide.

Paul Machin started in the print industry in 1970 having already spent15 years in the surface coating industry. He is also a qualified chemist and lawyer.

As an industry representative on the UK Government's Printing Industry Advisory Committee he has been a major contributor to such UK Health and Safety Executive publications as the Control of Substances Hazardous to Health (COSHH) Essentials and the Printer's Guide to Health and Safety.

Paul proposed the Solvent Reduction Scheme that will now be adopted for all forms of printing with the newly issued Guidance Note revisions and the EU Solvent Emissions Directive.

Paul also represented both the screen and digital printing industry on the Environmental Committee of the European Union dealing with the preparation of best environmental practices.

vision

5. Paul Machin's vision - perspective for the near future

The background to Climate Change and the need for an environmental approach.

Climate change and the printer

Whether it is believed that Climate Change and Global Warming is taking place or not, it is a subject that printers must be aware of if they wish to continue in business over the next decade. Why? Because the European Union (EU) Commission believes it is an issue that needs addressing.

They will be taking potential punitive action to ensure corrective measures are implemented.

This action will have a direct impact upon printers and their customers. To understand why this action will be taken, it is prudent to review the arguments for and against Climate Change.

Who is right?

There are many highly qualified scientists who question the hypothesis of global warming. According to William M Gray, a professor of atmospheric science at Colorado State University, there were articles about the large global warming that had taken place between 1900 and 1945. No one understood or knew if this warming would continue. Then the warming abated and little was heard about such warming through the late 1940s and into the 1970s. In fact, surface measurements showed a small global cooling between the mid-1940s and the early 1970s. During the 1970s, there was speculation concerning an increase in this cooling. Some speculated that a new ice age may not be far off. Then in the 1980s, it all changed again. These small global temperature increases in the last 25 years and over the last century are likely to be natural changes that the globe has seen many times in the past.

This viewpoint is not accepted by most countries who joined an international treaty - the United Nations Framework Convention on Climate Change (UNFCCC) - to begin to consider what can be done to reduce global warming and to cope with whatever temperature increases are inevitable. More recently, a number of nations approved an addition to the treaty: the Kyoto Protocol, which has more powerful measures. Politically within Europe it is assumed that climate change is already happening and represents one of the greatest environmental, social and economic threats facing the planet.

What is the European approach?

The European Union (EU) is committed to working constructively for a global agreement to control climate change, and is leading the way by taking an ambitious action of its own. Following the Kyoto Protocol the EU have generated a number of Directives. The more important are:

Directive **2004/101/EC** establishing a scheme for greenhouse gas emission allowance trading within the Community, in respect of the Kyoto Protocol's project mechanisms,

Directive **2001/77/EC** on the promotion of the electricity produced from renewable energy source in the internal electricity market and...

Directive **2002/91/EC** on the energy performance of buildings. This Directive will directly affect every printer across Europe in due course.

Other environmental based Directives include:

Directive **96/61/EC** Integrated Pollution Prevention and Control concerning emissions to air from printing sites

Directive **2000/60/EC** Community action in the field of water policy

Hazardous Waste Directive **91/689/EEC** affecting a sizeable proportion of printer's waste.

Following the Bali Roadmap the EU is determined to proceed with major reductions in emission levels of greenhouse gases immaterial whether the USA, China and India agree to these changes at the UN Copenhagen Summit in 2009. These three countries are the world's largest generators of greenhouse gases .

What other drivers will affect the printer?

There are a number of perceptions that characterize the general public's opinion that can have a serious impact upon the printer. Many organisations such as Greenpeace, Friends of the Earth and the World Wildlife Fund who have convinced the politicians and the public that all chemicals are hazardous and any activity associated with the use of chemicals is dangerous to mankind and the environment. Printing is tainted by this presumption. This resulted in the EU Registration, Evaluation, Authorisation and restrictions of Chemicals (REACH) Regulation that will radically affect all industries including printing.

With the rise in the industrial and commercial power of some of the Far East countries many commodities such as oil are either becoming scarcer and/or more expensive. This will in turn lead to the consumables used by printers being withdrawn or uneconomic to purchase. The reserves of fossil fuels such as oil have a limited life span and the replacement renewal energy sources are usually more expensive thus increasing the production costs. Over population within Europe places considerable burdens on water supply and disposal of waste. It is because of the approach taken by the European Union on these issues that printers must act.

The Planet Friendly Guide is designed to review the consequences of the European approach and show how the printer can benefit by taking an inclusive approach towards environmental issues.

To succeed the printer must:

1. Ignore the arguments for or against Climate Change and Global Warming
2. Accept that the EU will continue to impose further controls on environmental issues
3. Recognise that improvements in the company's environmental performance will enhance profitability
4. Examine each section of the Planet Friendly Guide to ascertain which best available technique (BAT) will likely produce the quickest profit for the company
5. Set out a priority list of BATs taking into consideration the available management and staff resource as well as the customer's known technical and environmental requirements
6. Inform and encourage staff to participate in the selected projects
7. Implement these projects at the earliest opportunity to demonstrate the commencement to a "green" approach towards the environment
8. Review the cost savings of the BATs undertaken at least every six months
9. Ensure your customers are aware of your approach to environmental issues particularly where these are externally monitored, most will recognise the benefit of trading with environmentally aware suppliers
10. At least once per year review which other BAT can be incorporated into the company's environmental programme.

Every BAT has been scientifically proven and the vast majority will reduce the waste generated within the total print generation process. Any reduction in waste will automatically result in an increase in profitability; this is the value of using the FESPA Planet Friendly Guide

6. the world of screen and digital printing

Screen printing is a direct printing process through a porous form. The uncoated part of the screen lets the ink flow through with the help of a squeegee. The nature of the ink involved in the process itself, needs, in most cases, a drying or curing operation, using forced air, UV or infra-red radiation.

Digital printing is a non contact printing technology, needing no printing form and working directly from computer made images now mostly with the help of ink-jet systems, thermal or piezo.

The screen and digital technologies are used to print on almost all the different substrates (materials). It is used for out-door printing of billboards, Points of Sale advertising, special labels and thousands of other uses in all the industries.

Screen and digital printing can be divided into three main types of application:

1. A purely graphic branch – able to print posters and billboards, POS, stickers – able to use presses having a high resolution quality at high speed (up to 4,000 sheets per hour)

2. Industrial branch that allows printing on very diverse objects such as CDs, DVDs, plastic containers, glass bottles, spare parts for the automotive industry, electronic goods etc. The two technologies now use high-tech machines working at high speeds; screen up 8,000 objects an hour, more or less customised to any shape or form of the objects to be printed or decorated, and very customised by digital, a technology able to print short runs.

3. Textile branch which is divided into two: “textile printing” roll to roll often in wide widths and multi-colours, 80 % of the textiles printed in the world for decoration, clothing etc are printed with rotary screens, 12% with engraving and 8% with digital printing. Then comes the printing of “mounted clothes” or garments involving the printing of T-shirts, sportswear, caps etc. A giant market in some countries, 95% screen...

Now, screen and digital technologies are both jointly used in many companies and with the independent screen and/or digital printer is a sector of activity that makes up around…companies (enter data for your own country) the majority of which is small sized:

% have less than 10 Employees
% have between 10 & 19 Employees
% have between 20 & 49 Employees
% have more than 50 Employees

This sector of activity is extremely compact. Most screen and digital printing companies have a local, regional or national customer base. Only the companies of a certain size can pretend to work in the European or world-wide arena.

There are…(Your data) in-house screen printing departments for industries needing technical or decorative complements to their manufactured products.

7. are screen and digital printing polluting activities?

Purely screen or mixed

1. Water pollution
2. Production of industrial waste
3. Air pollution – Volatile Organic Compounds (VOC), malodorous smells, dusts
4. Indirect pollution – use of energy producing CO_2, products containing dangerous substances, noise, light, selection of substrates.

Purely digital

1. Production of industrial waste
2. Air pollution – Volatile Organic Compounds (VOC), malodorous smells, dusts
3. Indirect pollution – use of energy producing CO_2 products containing dangerous substances, noise, light selection of substrates

The screen printing operations can be divided into 4 main steps:

- **Step 1**: Composition of the image and preparation of the screen: "prepress"
- **Step 2**: Printing on substrates or objects (paper, board, plastics, textiles, etc.)
- **Step 3**: Cleaning and de-coating of the screens
- **Step 4**: Converting, finishing and packing

The digital printing operations can be divided in three steps:

- **Step 1**: Composition of the image and preparation of the file: "prepress"
- **Step 2**: Printing on substrates or objects (paper, board, plastics, textiles, etc.)
- **Step 3**: Converting, finishing and packing

The four steps of screen printing and the three steps of digital printing do not generate the same level of pollutants in the environment

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Water pollution: the run-off of polluted water is mostly coming from a screen printing plant **due to cleaning operations** (stencil making, screen reclaiming and de-coating, sometimes combined into one operation). Also, one must add to this list: fixers and developing fluid from photographic tanks (screen printing).

Waste production: there are four types of waste from screen and digital printing as determined by the Hazardous Waste Directive 91/689/EEC, **which must be separated with a view to their disposal**.

The **non-hazardous waste**: is paper, board, etc and is unprinted clean packaging waste (mostly cardboard) that can be collected separately for re-cycling, the hazardous industrial waste for example is waste ink and solvent, dirty packaging such as ink pots, ink cartridges, solvent containers, dirty clothes, silver film contaminated wipes, fluorescent tubes etc.

Hazardous waste must not be mixed with other waste as it must be collected by specialised companies who handle hazardous waste. All hazardous waste must be described by its European Waste Catalogue (EWC) when it is to be disposed. The EWC number must be specified in the Safety Data Sheet for that ink, solvent etc.

The **clean packaging waste;** to be re-used, re-cycled or valorised.

The **non-dangerous waste** in some countries is collected by public local authority contractors.

Air Pollution: the atmospheric discharges from a screen printing plant and from a digital printing plant using solvent (eco-solvent included) are mostly from solvents (usually the VOC coming from printing and drying of inks, cleaning of screens, open cans or bottles of ink and impregnated clothing). These solvent emissions can also be the origin of olfactory pollution in the neighbourhood when not properly channelled and treated.

Hazardous substances: The products used in some screen and digital printing (inks, solvents etc.) contain polluting elements which can be potentially toxic to humans, animal life and plant life, namely metallic elements and hydrocarbons. These chemicals upset the water table and therefore, disrupt the purifying process of drinking water. Some of these elements need specific treatment. They should not therefore, be discharged either, in the atmosphere nor the drainage system, and certainly not in household waste. They do need specific treatment.

Energy management: Apart from consumables such as substrate, ink, thinners etc., energy is probably the printer's next **highest non-payroll** expenditure. Within the European Union (EU) the paper and printing industry consumes 11% of the total industrial energy usage. With the continued industrial and economic expansion in countries such as China and India the availability of sources of energy worldwide will be under severe strain. This in turn will probably lead to a continual increase in the cost of all forms of energy.

Environmental nuisance: A nuisance can be described as any unlawful interference with a person's use of or enjoyment of land. What act constitutes an unlawful interference is subject to many definitions across Europe. However, it is possible to put forward examples of many acts that could be described as nuisances that may not give rise to any legal redress but affect a neighbour's enjoyment. These could include noise, odour, dust, light pollution, loss of light and rubbish. Where such acts take place can also have a considerable influence as to the perception of a nuisance.

pollution

8. not to pollute or to pollute less

Before we look at the problems of pollution, water, air and waste materials, we should first of all have the simple good sense not to pollute, or to pollute less.

Screen printing technology has known in recent years, a fantastic means of solving the emissions of solvents in the air (VOC) both inside and outside the plant. It also allows one, through considerable investment, to eliminate practically all pollution of air and water when cleaning and reclaiming screens. Solvent digital printing has to follow the same way… or to disappear and be replaced by other “clean systems”.

9. how to avoid pollution with inks and solvents

The solution is simple and has existed for screen printing since 1978 – 30 years ago – and involves departing from using the solvent system and turning instead to UV and UV water-based inks and more recently in flat bed and roll to roll digital printing (1998).

For UV curing inks – that is inks containing no solvents, the drying principle is solely the process of polymerisation. But here is a very peculiar type of reaction: a phenomenon of photocatalysis or photo-polymerisation. In other words, it can be said that "inks of a special formula" are peculiarly sensitive to absorb a form of radiant energy. These radiations are emitted from wave lengths in the "Ultra Violet" portion of the spectrum and this engenders a change of state, we call drying or curing – very fast!

The UV inks, schematically, are composed of oligomers (polyesters, polyester-urethane, epoxy-polyesters and mostly polyester-acrylates) and liquid monomers (acrylates in general) used as "solvents and diluents;" pigments for the colour part; diverse additives such as stabilising agents, thixotropic agents, surface tension correctors etc. and "photo-initiators".

These last elements are of primary importance because they are the ones that will initiate and engender the start of the change, in other words, the transformation of liquid oligomers and monomers into stable polymers that "dry" in the sense that we usually employ this word.

All of which exists in the "liquid" state, through the screen or through the nozzles of a piezo print head in digital printing that is next submitted to UV radiation where all that remains of the ink will be the "dry" polymer. This is "drying" without loss which is to say without any emissions of volatile components such as solvents.

The UV inks bring, in addition, giant technical and economical advantages - which we have not even touched on before in this brochure, but can be summarised below:

- No risk of ink drying in screen meshes with the UV inks provided they are not exposed to any direct source of UV rays.
- From this number one advantage, automatically comes the possibility of screen printing with exceptional fineness: lines of 3 or 4/100th millimetre or halftone printing of 175 or even 200 and more lines/inch if, however, the stencilling system used has a sufficient resolution power.
- Another consequence, cleaning the screen in case production stops, even for a long period, is not necessary.
- The curing or polymerisation treatment (or drying if you so prefer) is almost instantaneous: it can be achieved at a speed of 50 metres/minute, meaning that the curing period of the UV radiation is less than a tenth of a second.
- The adhesion to the substrate being purely mechanical, the curing time extremely short,
- The penetration of ink into the substrate surface is limited, permits excellent definition even on a relatively absorbent substrate.
- In screen, the length of the dryer can be considerably reduced permitting multi-colour in-line machines and, in digital printing, it can be installed on the block supporting the printing-heads.
- The speed of curing limits the risk of distortion on the substrate.
- Last but not least, the lack of solvent emissions inside the plant drastically reduces the risk of fire in the plant.

More about UV printing

1. Ozone production
2. Ozone elimination
3. Protection of the eyes and skin
4. NVP

In screen printing, from the economic point of view, it is possible to measure these advantages in a form of "gain" by percentage that is achieved thanks to the UV systems:

1. gain in energy: from 60% to 80%
2. gain on buying and installing costs of 20% to 40%
3. gain on floor space from 60% to 85%
4. gain in maintenance and depreciation from 10% to 20%
5. gain in health and safety at work from 5% to 20%
6. gain in the increase of productivity from 20% to 60%

Of course the UV ink systems are not quite the "miracle ink" but almost! Practically 98% of printed material using solvent inks can be printed with the UV systems, as well in screen and digital. Besides, the UV technology is the only one that can be applied to in-line multi-colour sheet and reel to reel printing.

For a large or medium sized screen printing plant, to leave the solvent system for the UV system remains a very acceptable choice, financially speaking. Should there be changes in the basic technology they would be relatively unimportant and far from being insurmountable.

Disadvantages, of course there are bound to be some, for no technology is absolutely "perfect", some wave lengths produced by the UV lamps do emit ozone. It is, however, important to note that UV curing units equipped with well-designed lamps emit ozone levels that are way inside the maximum acceptable limits of 0.2mg/m^3 to air.

pollution

1. ozone production

What exactly is ozone?

No more, no less than an allotropic variety of oxygen; chemical notation O_3. It is a strong oxidising agent, generated by the ultraviolet rays between 170 and 200 nanometres. Ozone is a poison for the body at a high dosage, working as a catalyst of oxidation for the oxygen that comes along with it, it can engender an over oxidation of the red corpuscles. The maximum acceptable level is 0.2 mg/M^3 of air. It is interesting to note that the same ozone layer (created in the high atmosphere by the solar UV rays) is amazingly, the layer which protects us from the solar UV radiation!

2. ozone elimination

Two solutions: do not produce it or extract it. Not to produce it may seem a priority, as being the best and the most obvious answer: in this case, it is sufficient to block the emission in the rays positioned between 170 and 200 nanometres. A special coating of quartz covering the lamp will work. Unfortunately, this reduces the efficiency of the lamp by 10% to 15% and thus slows down the speed of curing. The simplest and most efficient method in all the other cases is to extract the ozone through extraction to the outside. The air draught necessary for this evacuation can help in cooling the lamp and reflector. The ozone 0_3 produced anyway, in very small quantities is a very unstable gas; in a few seconds, the third atom leaves the molecule by external combination and this molecule turns back to oxygen (0_2): an almost immediate change of state, but considered anyway as “slightly polluting”.

3. the protection of eyes and skin

Everyone knows that too much UV radiation is dangerous for the skin and the eyes: think of your eyesight and the sunburn when you are exposed to solar UV for too long without protection. In the UV curing units designed by professional manufacturers, those risks are totally eliminated by the use of safety controls. For example any accidental or unexpected opening of doors when the lamps are being used, will cause a close-down of the machine. This reaction is further supported sometimes by the use of opaque or smoked glass and thus avoiding any discharges of direct or reflected radiation.

Some uncured UV inks can still irritate the skin and eyes in times of direct contact. On one hand the reactions that can engender dermatitis can produce on frequent or prolonged exposure to an allergic type – some bodies are more sensitised than others, and can experience such a reaction. However, on the other hand again, the ink manufacturers are performing continuing research to solve these problems and find through thousands of combinations of oligomers and monomers, the less irritating ones.

There are criteria now used by ink manufacturers to take into consideration the sensitising effects. Many, wherever possible, only use resins, oligomers and monomers meeting the following are used criteria:

Skin irritancy rating: <2 (OECD test 404)
Organic solvent content: <0.2%
Acrylic acid content: <0.1%

4. nvp

NVP (n-vinyl-2-pyrrolidone) has been from the outset, an important chemical component of UV inks used in screen printing. At the end of the eighties, a polemic emerged in relation to its harmfulness, without using any strict prohibition of their use. Most of the manufacturers offer inks without NVP, and with few exceptions, are clearly labelled. Studies by the competent authorities within the EU are continuing to ascertain the exact toxicological implications of this chemical.

10. how not to pollute through screen cleaning & reclaiming

This is a problem **mostly related to screen printing**. There exists in the market machines which allow a procedure to either clean or reclaim the screens. There is an even better one that combines the two procedures, all totally automatic and totally enclosed. These are known as the **"cleaning-reclaiming" units**.

The potentially best environmentally performing of these devices, works without solvents, using emulsifiers (surfactants) instead – therefore, totally eliminating the "solvent risk" from both health and environmental exposure and also cuts down the fire risks. However, many of the surfactants used are subject to the EU Detergents Regulation **648/2004** and the choice of possible surfactants will be limited.

The top quality machines work in an enclosed circuit: the water introduced at the beginning of the month can be recycled until the total saturation point has been reached for the effluents from inks and emulsions. At this point, generally once a month, it is necessary to have the remaining "sludge" removed by a company specialising in hazardous waste. This will ensure the transportation and destruction of this "sludge".

The only problem with these machines is the price! The big ones are expensive – but not much more than the other non-polluting devices that we shall come to later. Ask your suppliers and manufacturers for the most sophisticated and safest one to use.

For a large size (to reclaim screens of 3 x 2.5 metres) you are looking at a minimum investment of €80,000 a price that would not be affordable for the smaller companies in Europe and in the rest of the world.

Many big and small manufacturers now offer smaller models – much cheaper - adapted to the exact quantity of screens treated and the volume of water used daily

pollution

replacement of volatile cleaning solvents

The European Union's position for the management of volatile solvents actually follows a tendency to focus on the points below:

- To reduce emissions of volatile hydrocarbons

- Prohibit the use of di/tri-chloro ethane in cleaning solvents and chemicals that have carcinogenic, mutagenic or repro-toxic effects.

- To discourage the use of solvents with noxious smells in the neighbourhood, such as toluene, methyl iso-butyl ketone, xylene.

- To prohibit the use of highly volatile solvents where the flash point is lower than 21ºC (group 1) and even 50ºC (group 2).

- **To recommend the use of solvents from group 3** (flash point between 50ºC & 100ºC) better still group 4 (HBS flash point above 100º) The European Directive applicable is 88/379/EEC – with the exception of Xi (irritating) in combination with R36/37/38 (irritating for the eyes, the lungs and the skin).

This pressure is actually peculiarly strong in Denmark, Netherlands, Germany and France. However, European Community politics means using the rules of those member countries with the strictest conditions as a base line. W e can soon expect a general application of these rules, a tendency that the application of REACH will reinforce in the coming years.

11. environmental nuisance ... in general!

Environmental nuisance: A nuisance can be described as any unlawful interference with a person's use of or enjoyment of land. What act constitutes an unlawful interference is subject to many definitions across Europe. However, it is possible to put forward examples of many acts that could be described as nuisances that may not give rise to any legal redress but affect a neighbour's enjoyment. These could include noise, odour, dust, light pollution,loss of light and rubbish. Where such acts take place can also have a considerable influence as to the perception of a nuisance. If the neighbour is an industrial plant it is less likely than a residential property to be concerned with the noise level emulating from a printing company. The treatment of environmental nuisance can have a considerable influence upon a company's clients and the workforce. Any printing company that has untidy premises with dirty empty containers and other rubbish scattered around the site will automatically give a poor impression to any visiting customer. This is the case especially if the customer is accustomed to working in an office location that is tidy and well maintained. The untidy appearance will raise the presumption that care and in particular quality is not of the highest priority.

Any company that wants to adopt the environmental approach has to have its workforce wholly committed to the concept. Caring for the environment of the printing site will provide a strong message to the workforce that encourages participation in any environmental initiatives that are undertaken within the printing plant. It is an important step towards this goal that employees perceive that their company cares about the "outside environment" just as much as within the plant.

Responsibility

The senior members of the company must show a commitment to reducing the level of environmental nuisance to as low as reasonably possible. The workforce will need to recognise this commitment and give it their active support.

Action Plan

- Review the company's location with respect to its neighbours
- Assess what the environmental impact noise, odour, rubbish ,dust and light could have upon the neighbours
- Take the necessary action to reduce, as far as is reasonably practical, the impact that any environmental nuisance could have on the adjacent properties
- Encourage and foster employee commitment to meet the company's objectives with respect to limiting environmental nuisance.

pollution

Environmental nuisance

Aside from very large printing plants that are required to meet the requirements of EU Directive 96/61/EC concerning integrated pollution prevention and control covering VOC emissions there are very limited controls on environmental nuisance. The exceptions are the Directive 2002/49/EC Official Journal L 189 of 18.07.2002 relating to the assessment and management of environmental noise, the Hazardous Waste Directive 91/689/EEC and the Packaging and Packaging Waste Directive 94/62/EC (PPW) amended by Directives 2004/12/EC and 2005/20/EC.

1. Environmental Guidance
There is no Best Available Techniques (BAT) for Environmental Nuisance except that specified in the Planet Friendly Emissions to Air (go to section 14) and Waste Control (go to section 15)

The various environmental nuisances are described together with practical steps to limit any nuisance and enable an Action Plan to be put in place.

2. Noise
The Noise Directive sets two units for measuring noise levels. Lden is an indicator of the overall noise level during the day, evening and night which is used to describe the annoyance caused by exposure to noise. Lnight is an indicator for the sound level during the night used to describe sleep disturbance. The noise indicators Lden and Lnight are used in the making of strategic noise maps. Member States have had to communicate information to the Commission on any relevant limit values in force or under preparation, expressed in terms of Lden and Lnight and, where appropriate, Lday and Levening, for matters including industrial noise.

Although these noise levels will not in the near future be incorporated into directives or regulations in the long term limits will be set to cover factories throughout the EU. In some countries there are local restrictions concerning noise levels originating from factories. However, it is possible to avoid any potential prosecution by ensuring that the best practical means have been used to limit the noise level. (see page 23)

3. Odour
Many members of the general public find the smell of the organic solvents used in printing preparations offensive and also perceive them as being hazardous and thereby causing pollution. This opinion applies to neighbours and potential clients visiting the site.

Once an odour is released from an odour source such as a chimney it is dispersed and diluted in the atmosphere. The concentration of the odour on release, the magnitude of emission, and the degree of dispersion and dilution that the odour undergoes in its journey from the source to the receptor (e.g. neighbour) are the key factors which influence whether or not the odour is perceptible at this location.

The fact that an odour is perceptible at a given location does not necessarily mean that the odour will cause annoyance. Annoyance is a symptom that is dependent upon the following factors; concentration, offensiveness, duration, frequency of the odour as well as the tolerance and expectation of the receptor.

Sensory techniques utilise human assessors to assess odour. The most commonly applied sensory technique is olfactometry, which is used to measure the concentration of an odour in terms of European Odour Units (ouE/m^3). Olfactometry is aimed at characterising environmental odours, relevant to human beings. As no methods exist at present that simulate and predict the responses of our sense of smell satisfactorily, the human nose is the most suitable 'sensor'. Objective methods have been developed to establish odour concentration, using human assessors. A European standard applies to odour concentration measurement: CEN EN 13725:2003, Air quality - Determination of odour concentration by dynamic olfactometry.

The odour from a printing plant will arise from:
- The exhaust ventilation in the print shop, screen reclamation,
- Any unsealed containers that contain ink, solvents, other sundry products etc. and
- Poor sanitary arrangements.

There are a number of practical means of reducing the potential adverse impact of odours being released from a printing plant. These are:
- Ensure that any release of potentially odorous chemicals such as solvents from extraction equipment is not impeded.
- Remove any "Chinese hat" type covers to vertical exhaust stacks as this will cause the odours to descend to ground level and exacerbate the problem.
- The fitment of a simple Venturi unit to the end of the exhaust stack will greatly assist the dilution of the solvent laden exhaust fumes and will improve the efficiency of the fan.
- All exhaust points should be vertical and be higher than any building to which the stack is attached.
- Keep all doors and windows adjacent to any neighbouring properties closed so as to avoid fugitive emissions from being released.
- Any containers stored outside must be sealed.
- Wherever possible do not store waste ink or chemicals adjacent to fences abutting neighbours.
- Ensure the drainage system is cleaned on a regular basis.

4. Rubbish

Any visible rubbish whether it is hazardous or not creates a very bad impression upon visitors or neighbours. Because the rubbish or waste is perceived to have no value it is frequently ignored and it gets out of control. This approach automatically detracts from the image that a print company would wish to project. The lack of control can quickly lead to rubbish, especially paper been blown onto adjacent properties, hazardous waste becomes mixed with non-hazardous waste and vice versa, the loss of valuable outside space and adverse customer perception. Information and best available techniques for dealing with hazardous and non-hazardous waste can be obtained from the **Waste Control guidance** (see section 15). This does assume that there is the provision of properly allocated storage areas that are clearly labelled.

pollution

Noise levels

Noise levels can be influenced by a number of factors; the background noise level in the vicinity of the plant, wind direction and the topography of the area.

Noise from a printing plant will occur from:

- Equipment such as printing presses, platen presses, guillotines, high pressure guns spraying water, stapling machines, compressors
- Ventilation and extraction machinery
- Transport in the form of lorries making deliveries and collections, fork lift trucks and public announcements
- Building work

There are a number of simple and practical ways of ensuring that the level of noise transmitted outside the plant boundary causes the minimal nuisance:

- Avoid or minimise noisy activities, especially at night; pay particular attention to traffic movements, reversing sirens, deliveries, external public address systems and radios.
- Where practical, schedule or restrict noisy activities to the normal working day (for example 8am to 6pm, Monday to Friday and 8am to 1pm on Saturday).
- Consider where noisy operations are done close to site boundaries and relocate them if possible further away, or make use of existing buildings/stockpiles/topography as noise barriers.
- Reduce noise levels outside the buildings by increasing insulation to the building fabric and keeping doors and windows closed.
- Ensure that any burglar alarms on the premises have a maintenance contract and a callout agreement.
- Consider replacing any noisy equipment and think about noise emissions when buying new or replacement equipment. Maintain fans and refrigeration equipment

Try to establish a good relationship with neighbours, particularly for transient effects likely to affect them. Advise them in advance if a particular operation, such as building work or installing new plant could cause a problem. If neighbours are kept informed they perceive the business as more considerate and are less likely to make a complaint.

5. Dust

The main area where dust is generated in a printing organisation is in the finishing and converting areas. There are a number of activities that generate fine dust that for health and safety reasons has to be removed from the working environment. Many types of dust have occupational exposure limits with respect to human exposure that need to be controlled. This dust is normally collected into filter bags rather than being extracted directly to atmosphere. Even under these arrangements some dust is emitted into the outside atmosphere especially if the filtration system is not working effectively. The dust can, under certain circumstances, absorb volatile organic chemicals that are subsequently released into the environment. The discharge of dust into the environment can easily be controlled by routine maintenance of the dust extractors and ensuring that the dust collection bags are changed regularly. The collected dust will sometimes be classified as hazardous waste.

6. Light

This subject will only be an environmental issue if the printing plant is sited adjacent to residential properties. It could involve excessive light directed onto the neighbouring property or loss of light because of high walls, fences or hedges. Often industrial premises have external lighting. This is to allow work to continue outside daylight hours and for reasons of site security. During the selection and the installing process of exterior lights consideration should be given to the neighbours.

Checks should be undertaken to ensure that stray light does not intrude onto adjacent properties and the level of light is not excessive especially in the low activity areas such as car/lorry parks.

The construction of high walls, fences and the growing of hedges should not unduly preclude light from entering adjacent properties especially if these are domestic premises.

12. hazardous substances

Information on the hazardous nature of substances used in the printing industry can be found in the following European Directives and Regulations.

pollution

Directive **67/548/EEC** Official Journal P 196 of 16.08.1967 on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances amended by:
Directive **71/144/EEC** Official Journal L 074 of 29.03.1971
Directive **1973/146/EEC** Official Journal L 167 of 25.06.1973
Directive **1975/409/EEC** Official Journal L 183 of 14.07.1975
Directive **79/831/EEC** Official Journal L 259 of 15.10.1979
Directive **92/32/EEC** Official Journal L 154 of 05.06.1992
Directive **96/56/EC** Official Journal L 236 of 18.09.1996
Directive **1999/33/EC** Official Journal L 199 of 30.07.1999
Regulation (EC) No **807/2003** Official Journal L 122 of 16.05.2003
Directive **1999/45/EC** Official Journal L 200 of 30.07.1999 concerns the approximation of the laws, regulations and administrative provisions of the Member States relating to the classification, packaging and labelling of dangerous preparations adapted for technical progress:
Directive **2001/60/EC** Official Journal L 226 of 22.08.20012001 adapting to technical progress
Directive **1999/45/EC**

Directive **2006/8/EC** Official Journal L 19 of 24.01.2006 amending, for the purposes of their adaptation to technical progress, Annexes II, III and V to Directive **1999/45/EC**
Regulation (EC) No **648/2004** Official Journal L 104 of 08.04.2004; corrigendum Official Journal L 328 of 15.12.2005 on detergents.
Regulation (EC) No **907/2006** Official Journal 168 of 21.6.2006
Regulation (EC) No **1907/2006** Official Journal L 396, 30.12.2006, corrigendum : Official Journal L 136 of 29.5.2007 of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive **1999/45/EC** and repealing Regulation (EEC) No 793/93 and Regulation (EC) No **1488/94** as well as Directive **76/769/EEC** and Directives **91/155/EEC**, 93/67/EEC, 93/105/EC and 2000/21/EC.

Directive **2006/121/EC** Official Journal L 396, 30.12.2006 amending Directive **67/548/EEC** on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances in order to adapt it to Regulation (EC) No **1907/2006** concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) and establishing a European Chemicals Agency.

Machinery

Directive **2002/96/EC** Official Journal L 37 of 13.02.2003of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment and Directive **2002/95/EC** Official Journal L 37 of 13.02.2003of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment amended by:

Directive **2008/34/EC** Official Journal L 81 of 20.3.2008
Directive **2008/35/EC** Official Journal L 81 of 20.3.2008

Toys

Directive **88/378/EEC** Official Journal L 187 of 16 07 1988 [corrigendum: Official Journal L 37 of 09.02.1991] on the approximation of the laws of the Member States concerning the safety of toys

Directive **93/68/EEC** Official Journal L 220 of 30 08 1993
Decision **1999/815/EC** Official Journal L 315 of 09.12.1999 of 7 December 1999 adopting measures prohibiting the placing on the market of toys and childcare articles intended to be placed in the mouth by children under three years of age made of soft PVC containing phthalates amended by:
Directive **2005/84/EC** Official Journal L 344 of 27.12.2005; corrigendum [Official Journal L 033 of 04.02.2006]; addendum [Official Journal L 068 of 08.03.2006]

The following is guidance:
Green Paper of 26 July 2000 - Environmental issues of PVC [**COM (2000) 469** - Not published in the Official Journal].

European Council of Paint, Printing Ink and Artists' Colours Industry (CEPE); Exclusion list for printing inks and related products – October 2006 **(http://www.foodcontactmaterials.com/materials/eupia.pdf)**

Acrylate Preference Criteria; Guide to the classification and labelling of UV acrylates **(http://www.radtech.org/health_safety/pdf_docs/Cefic%20document.pdf)**.

health, safety and environmental information

1. General
Any product that contains substances that have the following EU risk phrases **R40, R45, R46, R49, R60 and R61 or R50, R51, R54, R55, R56, R57, and R59** must be substituted immediately by products that avoid such substances.

2. Toxic metals and metal compounds
Cadmium, lead, chromium and nickel are often occurring as pigments for inks. They may also be present in inks as constituents of driers, catalysts etc. These are controlled by other legislation such as Directive **76/769/EEC** restricting the marketing and use of these and other pigments across the EU. Similar restrictions are applied under the Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment, etc. (RoHS).

The European Toys Standard EN 71-3 limits the use of pigments based on antimony, arsenic, barium, cadmium, chromium, lead, mercury, and selenium. Many purchasers of children's clothes require that the inks used must comply with EN 71-3 as such clothes can be sucked by children.

The discharge to a sewage system of any silver compounds should be controlled.

Many of these toxic metals and metal compounds degrade either slowly or not at all and therefore must be disposed of only as hazardous waste.

3. Plasticisers
Plasticisers are included in ink and photo-stencil emulsions as a means of producing the necessary flexibility in the product to avoid breakdown of such products under material stress. Such substances include a group of chemicals known as phthalate esters.

Phthalate esters e.g. di-ethyl phthalate and di-cyclohexyl phthalate have been assessed as having a high level of concern with respect to being an **endocrine disruptor**.

The endocrine system is a complex network of glands, hormones and receptors. It provides the key communication and control link between the nervous system and bodily functions such as reproduction, immunity, metabolism and behaviour. The main evidence suggesting that exposure to environmental chemicals can lead to disruptions of the endocrine function comes from changes seen in a number of wildlife species. Effects suggested as being related to endocrine disruption have been reported in molluscs, crustaceans, fish, reptiles, birds and mammals in various parts of the world.

There is a number of different phthalates that can and are used in printing formulations. Although there is insufficient evidence to determine whether none or all this entire group of chemicals are endocrine disruptors, many purchasers of print require their products to be phthalate-free.

4.Biocides
This group of chemicals is present in most water-based compositions. Their role is stopping the formation of bacteria that could cause the composition to malfunction after prolonged storage. Because the biocide stops the generation of living organisms; that degeneration will also occur if the composition containing the biocide is allowed to enter the environment through the sewage system. This can have an adverse effect on any sewage treatment plant. There is an EU approved list of substances that can be used as biocides.

5. Surfactants
Surfactants are used in water and solvent based cleaning preparations. Chemically surfactants often belong to the group of chemicals known as alkyl ethoxylate, alkyl phenol ethoxylates or sulphonate derivatives. These surfactants are included in detergents and other cleaning products in order to reduce the surface tension of liquids so that they can wet surfaces and clean them more effectively. Since the inclusion of a surfactant will increase the products biodegradability it will adversely affect the Chemical Oxygen Demand/Biological Oxygen Demand (COD/BOD) and the cost of the sewage treatment charge.

To reduce the impact of these surfactants with solvent based cleaning preparations avoidance of any discharge to the sewage system should be promoted by recycling of the product.

6. Resins
Resins are the essential constituent of any ink and act as the film former. The major area of concern is Polyvinyl Chloride (PVC). It is extremely difficult to degrade and therefore it presents problems if disposed of by landfill. Incineration of this resin gives rise to the production of chlorine, hydrogen chloride and possibly dioxins. All these chemicals are toxic to the person or the environment. Because of these reasons many print purchasers are requiring alternative film formers to be used especially with “T” shirt production.

Some acrylate based UV resins do have certain skin irritation properties. It is possible to limit this problem associated with such resins by using inks that have been formulated using the Acrylate Preference Criteria.

7. Monomers
Monomers are the non volatile solvent constituent of UV curing inks. They dissolve the resin film formers. During the curing process the UV light causes a chemical reaction that instigates the almost instantaneous polymerization of these chemicals.

Earlier UV curing compositions contained a chemical known as n-Vinyl-2-pyrrolidone (NVP) as the monomer. There is limited evidence that this chemical has carcinogenic properties and is subject to an EU Risk Assessment. It is currently assigned the EU risk phrase R40 – limited evidence of carcinogenic effect. A number of other monomers are known to cause allergic dermatitis; these can be avoided by using inks that have been formulated using the Acrylate Preference Criteria.

8. Solvents
The solvent is the chemical that dissolves the film former, in many cases aids the adhesion of the ink to the substrate and acts as a controlling influence on the rate of drying of the print. Because it dissolves the film former it is used as a cleaner to remove ink from the screen or digital print head. The vast majority of solvents used in screen and digital printing are volatile organic compounds (VOCs).

Solvents have an adverse effect on the environment. They have a deleterious impact upon the atmosphere, the aquatic environment and land if disposed of by landfill. Because of their solvency power they dissolve the essential protective skin oils and can cause dermatitis.

pollution

Reduction of the effect on the environment can be achieved by a number of ways:

- Using UV curing inks
- Using medium and high flashpoint cleaning agents also has some health and safety advantages, because the exposure of personnel to the evaporated solvents will be reduced.
- End-of-pipe technology
- Recycling units fitted to screen reclamation units
- Recycling or valorization of solvent based waste

For good health, safety and environmental practices the following solvents should be avoided:
2-Methoxyethanol, 2-Ethoxyethanol, 2-Methoxyethyl acetate, 2-Ethoxyethyl acetate, volatile chlorinated hydrocarbons, such as trichloroethylene, perchlorethylene and methylene chloride, volatile fluoro-chlorinated hydrocarbons, 2-Nitropropane and Methanol.

9. Dyes
This group of chemicals is only used for specialised applications and formulations containing the following should be avoided:

Auramine (Basic Yellow 2 - CI 41000), Chrysoidine (Basic Orange 2 - CI 11270), Fuchsine (Basic Violet 14 - CI 42510), Induline (Solvent Blue 7 - CI 50400) and Cresylene Brown (Basic Brown 4 - CI 21010).

impact of hazardous substances

For many years printers have had to be aware of the impact of hazardous products either from a health and safety or product liability standpoint. Many consumable products such as inks, digital ink cartridges, thinners, cleaners, etc. will have exhibited an EU warning label. Some electrical and electronic equipment may have shown a laser warning sign.

The European Union has extended their “Polluter Pays Policy” to include machinery, every type of chemical as well as imposing the rules that would prevent ‘significant environmental damage’ or rectify damage after it has occurred. Hence the Waste Electrical and Electronic Equipment (WEEE) and the Reduction of Hazardous Substances in electrical and electronic equipment (RoHS) Directives will require all suppliers of printing equipment to update their designs to incorporate these changes. The Environmental Agency in Seville has extended the rules applicable to chemicals specifically used in the printing process covered by the Integrated Pollution Prevention and Control Directive (IPPC). The Environmental Liability Directive has now been adopted and raises serious issues for companies on matters relating to insurance and risk.

Suppliers of consumables such as inks, cleaners etc. will have to meet the exacting standards laid down by the Registration, Evaluation, Authorisation and restriction of Chemicals Regulations (REACH). REACH will involve the testing of chemicals that have been used within the print industry for many years, chemicals that have to date been presumed to be safe to use. These chemicals will also be subject to rigorous testing as to their impact upon the environment. Any chemical that is considered to have carcinogenic, mutagenic, repro-toxic or bio-accumulating effects will require specific authorisation before they be used.

Many commercial organisations faced with these challenges are reviewing their purchasing policies. High on their buying requirements are environmental issues; their corporate responsibility is stated by every multinational company and this corporate responsibility includes sustainability and lower carbon emissions. These organisations are looking to their suppliers to help them improve their environmental performance and image. Printers supplying the toys and children's clothing market will be aware of the adverse financial consequences of failing to comply with these requirements. Millions of Mattel toys were scrapped because they were painted with inks containing lead. In the light of these events major companies are specifying that many hazardous chemicals must not be present in products supplied to them. **A typical example is the exclusion of polyvinyl chloride (PVC) plastisols on 'T' shirts. Phthalate plasticisers that are considered to be endocrine disruptors are often required to be excluded. Some print customers will even require compliance with certain voluntary codes.**

It is therefore necessary to review the chemicals used within the printing Industry to enable the printer to make an informed decision as to which products should be used and the necessary steps needed to meet today's health, safety and environmental requirements.

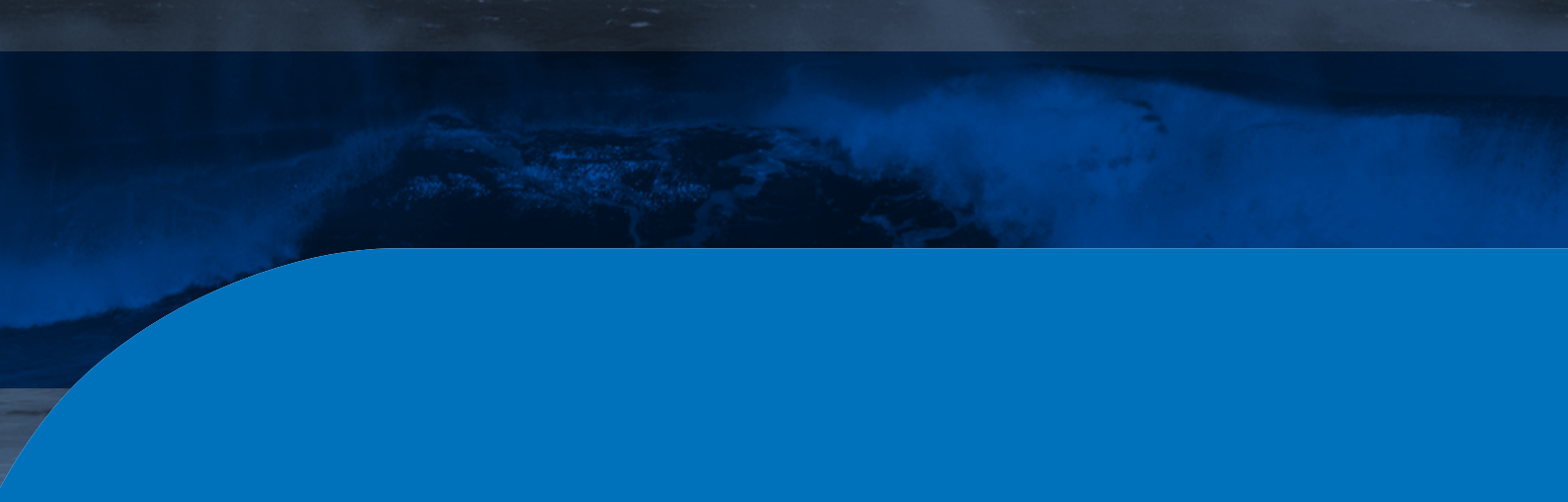
1. Responsibility

There are dual responsibilities in ensuring that the products used and produced by the printing industry meet the challenges of today's stricter health, safety and environmental requirements.

- The producer of consumables, inks both screen and digital, thinners, cleaners, photostencil emulsions and ancillary products, etc., properly label their products and supply safety data sheets that advise the user of all the hazards present.
- The printer must ensure that the necessary data is supplied by the producer of consumables. It is then necessary to review this information to determine whether it meets the clients' requirements.

2. Action Plan

- Determine all the hazardous substances that are used by examining the appropriate safety data sheets
- Contact the supplier if any products contain substances that are carcinogenic, mutagenic, repro-toxic or have bio-accumulating effects and request alternative products. These chemicals will have been assigned the EU risk phrases **R40, R45, R46, R49, R60 and R61 or R50, R51, R54, R55, R56, R57, and R59** on the label and/or safety data sheet.
- Review all other hazardous substances and ascertain from the data supplied under the heading "Health, Safety and Environmental Information" whether less hazardous alternatives could be used.



water

13. emissions to water

best available techniques (BAT)

1. avoidance of silver nitrate entering the sewage system
2. reduction of volume of water consumed
3. reduction of chemical oxygen demand/ biological oxygen demand (COD/BOD)
4. reduction of suspended solids (SS)
5. end-of-pipe treatment plants

water

Water is not a commercial product like any other but, rather, a heritage which must be protected, defended and treated as such. Its availability may be low temporarily, owing, for instance, to rainfall deficiency (drought), or low for a sustained period of time in which the demand for water exceeds the exploitable water resources (water scarcity). Water availability problems affect many regions in Europe and require combined action at EU level, and it is all the more necessary to take action given that sporadic or sustained water shortages are likely to persist due to climate change. The controls are usually placed in the hands of the local water provider and/or water treatment company. The actual limits specified will depend on localized conditions as well as individual EU Governmaents taking into consideration local topographical conditions. The control levels can vary substantially within a country and across Europe. This problem concerns primarily screen printing activities.

The liquid discharge from a printing plant comes mostly from the following activities:

- Effluents from the photo-lab and pre-press (preparation of positives)
- Rinsing of emulsions
- Cleaning of screens using solvents or water (aqueous systems in the textile print shops and printing with water based UV inks)
- De-coating of the screens
- Kitchens and toilets
- Surface water from roofs and yards

There are a number of chemicals used in the printing processes that have an adverse effect on the aquatic environment and these should be avoided or minimised wherever possible.

During the preparation of photographic positives silver salts as well as fixer and developer chemicals can be discharged. Silver and its compounds are strictly controlled under various EU Directives.

Rinsing emulsions; polyvinyl alcohol, polyvinyl acetate and acrylate based polymers present in the emulsions are highly biodegradable and are a major element for increasing the Biological Oxygen Demand/Chemical Oxygen Demand (BOD/COD). Limits on BOD/COD are often imposed by water treatment organisations. “Spotting out” filler is frequently based on polyvinyl alcohol and it has a similar effect. Acid stabilized diazonium salts are often used but these are present in extremely low concentrations.

Cleaning screens; the cleaner will typically contain aromatic hydrocarbons, alcohols, glycol and glycol esters, and ketones. All these chemicals are highly biodegradable. Some of these chemicals are insoluble in water and cause problems to sewage workers. Waterbased screen printing inks are often more difficult to remove and more aggressive solvents are required. In exceptional circumstances chlorinated

hydrocarbons are used. These are severe polluters to the aquatic environment. Some UV-based inks are cleaned using water and many of the constituents have a polluting effect on the discharge. Water from screen rinsing and reclaiming is often allowed to enter the sewage system without any agreement from the community or sewage treatment company.

De-coating screens: similar remarks to the above are applicable if the decoating operation is not undertaken automatically and/or in a closed circuit. The water coming from de-coating and rinsing of the screens is often discharged into the main sewage system. This contains pollution in the form of particles (ink residue, polymerised emulsions, etc.) together with organic and inorganic pollution coming from the de-coating products such as bleach, oxidising agents and strong alkalis.

The supply and treatment of water can be undertaken by either public authorities or commercial enterprises: in either case it will be the designated public authority that will set the limits for any discharges from sanitary and refreshment facilities. Water supplied and waste water discharged to and from a printer are chargeable activities for which the printer must pay. As EU Directives impose stricter controls on the water that is allowed to be discharged to rivers and the sea so the charges will increase. It is therefore important that the printer understands the factors that will affect the total water cost. There are two significant factors that affect these costs. These are the volume of water consumed and the pollution treatment charge. In many countries it is necessary to segregate discharges of surface water (from roofs and outside areas such as yards) from waste or contaminated water (from toilets and production processes such as screen cleaning). To calculate the pollution charge consideration is given to either the Chemical Oxygen Demand (COD) or the Biological Oxygen Demand (BOD) and the Suspended Solids (SS) found in the water discharged from the printer.

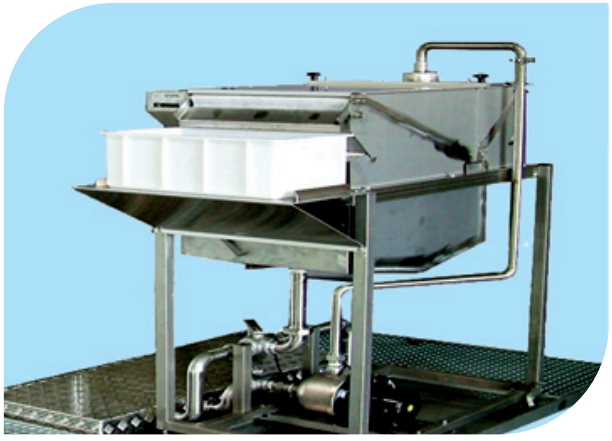
Volume of Waste Water: The waste flow is proportionate to the volume of activity (function, number and size of screens) It is possible to globally class the screen printing activities into 3 categories:

- **Small screen printing plant 1 m^3 per week**
- **Medium plant 1 to 2 m^3 per day**
- **Large plant 4 to 6 m^3 per day**

Digital printers will have little or no chemically contaminated discharge.

Both screen and digital will have further discharges.

Pollution charge: It varies between 5 and 15 grm of COD per litre according to the work habits in the plant. The relation COD/BOD is in the order of 3 weak biodegradable effluents. The SS varies generally between 200 – 500 mg/litre. The levels of COD, BOD and SS are compared against levels set by the water treatment plant. These levels can take into consideration the distance from the printing plant to the treatment plant and the biological loading on the plant. With the adoption of environmental friendly work practices, this same pollution level can be reduced considerably.



The distribution of the flow is around 40% for emulsion rinsing (screen preparation) and 60% for the screen reclamation process (30% for screen cleaning and 30% for de-coating). Of course this data is not applicable for those plants having automatic closed circuit cleaning and de-coating machines in place.

The characteristics of the effluent before disposal can contain components forming three main groups:

- SS of a size greater than 10 nanometres (ink residues for example) Colloidal materials are SS of the same origin but of a size less than 10 nanometres (residues of polymerised emulsion for example)
- Dissolved materials of less than a few nanometres, are generally cations and anions as well as organic components (diverse solvents and detergents)
- Sometimes sewage treatment organisations put a limit on the acidity/alkalinity (pH) of the discharge; it usually ranges from 6 to 8.

In some countries there is a legal requirement to obtain an authorisation from the sewage treatment plant to discharge industrially contaminated water to the sewer.

Responsibility

The responsibility for ensuring that the printing plant has the appropriate authorisation to discharge effluent into the sewer lies with the owner or chief executive of the business. Even if an authorisation is not required there is responsibility for ensuring that any effluent discharge does not exceed the limits imposed on certain chemicals covered by local and/or European-wide legislation.

Action Plan

- Determine whether an authorisation to discharge is required
- Ascertain the level of charges imposed by the water supplier/ treatment organisation
- Review the best available techniques (BAT) options for reducing the water consumption,discharge of contaminated water etc.

water emission

Water discharges from printing sites can enter numerous water courses. Emissions to water from printing sites are controlled either directly or indirectly by the following EU Directives and Regulations:

To have all the Directives and Regulations in detail, (go to page 38)

Best Available Techniques (BAT)

The suitability of the various BAT methods explained will be dependent upon the printing process that is being used and the production volume of the printing operation. The following could be used as methods to reduce emissions to water. They have been divided into five main categories dealing with the discharge of silver nitrate; the volume of water consumed; reducing the Chemical Oxygen Demand/Biological Oxygen Demand (COD/BOD); Suspended Solids (SS) and end-of-pipe treatment plants.

1. Avoidance of silver nitrate entering the sewage system

- **Silver treatment unit**

During the photographic process silver nitrate can enter the sewage system and it is toxic to the aquatic environment. There are a variety of on-site silver recovery technologies available. For small volume users, silver recovery using metallic replacement is recommended. These cartridges are simple to use and maintain. Used cartridges must be sent to a silver refiner for further treatment and recovery of metallic silver. Electrolytic silver recovery is the most efficient technique for removing silver from silver-rich photographic solutions. The type of electrolytic recovery unit chosen depends on the solutions being treated and the daily volumes requiring treatment. Often, metallic replacement cartridges need to be used entailing electrolytic recovery equipment to ensure compliance with local sewer discharge limits. These units are costlier than simple metallic replacement cartridges and rather more complex to set up and operate effectively.

Achieved environmental benefits:
Removal of a toxic chemical. Recovered silver can be sold. The process involves capital expenditure as well as the purchase of fixers and developers.

water

Directive **2000/60/EC** Official Journal L 327 of 22.12.2000 establishing a framework for Community action in the field of water policy covering: inland waters, surface water, groundwater, coastal water and river basin as amended by: Decision No **2455/2001/EC** Official Journal L 331 of 15.12.2001

Directive **2008/32/EC** Official Journal L 81 of 20.3.2008
Directive **80/68/EEC** Official JournalL 20 of 26.01.1980 on the protection of groundwater against pollution caused by certain dangerous substances for:

- direct discharge of substances in List I is prohibited. This list includes organo-halogen, organo-phosphorus and organo-tin compounds, mercury and cadmium and their compounds, and hydrocarbons and cyanides;
- discharge of substances in List II must be limited. This list includes certain metals such as copper, zinc, lead and arsenic, and other substances such as fluorides, toxic or persistent organic compounds of silicon, and biocides and their derivatives not appearing in List I.

Directive **2006/118/EC** Official Journal L 324, 27.12.2006 on the protection of groundwater against pollution and deterioration that establishes a framework for measures to prevent and control groundwater pollution and, in particular, measures for assessing the chemical status of groundwater and measures to reduce the presence of pollutants.
Directive **2006/11/EC** Official Journal L 64, 4.3.2006 on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community that considered:
Directive **82/176/EEC** Official Journal L 81 of 27.03.1982 on limit values and quality objectives for mercury discharges by the chloro-alkali electrolysis industry. This Directive was amended by Council Directive **91/692/EEC**.
Directive **83/513/EEC** Official Journal L 291 of 24.10.1983 on limit values and quality objectives for cadmium discharges. This Directive was amended by Council Directive **91/692/EEC**.
Directive **84/156/EEC** Official Journal L 74 of 17.03.1984 on limit values and quality objectives for mercury discharges by sectors other than the chloro-alkali electrolysis industry. This Directive was amended by Council Directive **91/692/EEC**.
Directive **84/491/EEC** Official Journal L 274 of 17.10.1984 on limit values and quality objectives for discharges of hexachloro-cyclohexane. This Directive was amended by Council Directive **91/692/EEC**.
Directive **86/280/EEC** Official Journal L 181 of 04.07.1986 on limit values and quality objectives for discharges of certain dangerous substances included in List I of the Annex to Directive **76/464/EEC**.
This Directive was amended by Council Directives **88/347/EEC**, 90/415/EEC and 91/692/EEC.
Directive **91/271/EEC** Official Journal L 135, 30.5.1991, concerning the collection, treatment and discharge of urban waste water and the treatment and discharge of waste water from certain industrial sectors. Its aim is to protect the environment from any adverse effects due to discharge of such waters and amended by Directive **98/15/EC** Official Journal L 67

• **Purchase positives from repro-labs**

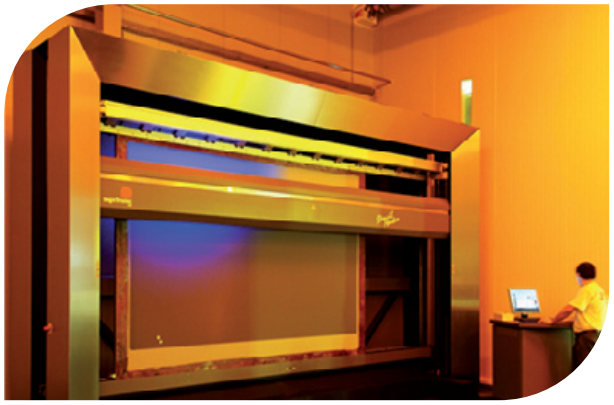
This avoids any in-plant environmental damage but does not resolve the total environmental issue as the supplier could have a problem.

Achieved environmental benefits:
Removal of a toxic chemical from site. No requirement to buy fixers and developers. There will be increased revenue cost and quality cannot be guaranteed.

• **Computer to screen**

Removes the need for positive and therefore silver chemicals are not needed.

Achieved environmental benefits:
No use of toxic chemicals



2. Reduction of volume of water consumed

• **Sanitary controls**

Programmable discharge: Considerable quantities of water are wasted because many systems supplying men's toilets discharge water when the cistern becomes full even though the urinals are not being used. This is particularly wasteful when the plant is not occupied. Sensors can be fitted that only activate the discharge of water whenever the urinal and hand washing facilities are being used. The latter facility can be used in female toilets.

Achieved environmental benefits:
A reduction in water usage; retro-fitting can involve costs and vandalism to the sensors can be a problem. It is better to fit such systems at the initial building stage or when a refurbishment is being undertaken.

Waterless urinals: There is no water consumption; low cleaning cost; no moving parts or flushing mechanism to go wrong; no water supply pipes; odour-free clean environment being bacteria free, due to absence of water; simple to retrofit as there is minimal maintenance with cartridge replacement.

Achieved environmental benefits:
A considerable reduction in water usage; easy retrofitting and improved environment makes this the preferred option. Does involve a continuing revenue cost as cartridges have to be replaced.

- **Recycle water during screen preparation.**

Divert discharge: A considerable volume of water is used in the wash-out stage of stencil preparation. After the initial wash-out stage, further water used during the washing out process can be diverted by means of a 'T' pipe fitted with a two-way valve to a holding tank. This lightly contaminated water (known as "grey" water) can be used for the initial stage wash-out for the following screen.

Achieved environmental benefits:
Measureable savings in water usage. It requires installing a tank; pump and a two-way valve. Savings are dependent upon the operator using the two-way valve to switch the discharge route.

To know more about "Automatic wash out" and the "Use of 'grey' water", (go to page 41)

3. Reduction of Chemical Oxygen Demand Biological Oxygen Demand(COD/BOD)

- **Minimise use of water soluble screen fillers**

Water soluble fillers are often used to "spot-out" screens and coat the unexposed areas between the stencil and the frame. Most water soluble fillers have a very high COD/BOD. To limit the usage it is possible to coat a 50mm border around the edge of the frame with the same adhesive that is used to attach the mesh to the frame. It is possible to use the sensitized photo-stencil emulsion in preference to the water soluble fillers to cover uncoated areas of the screen.

Achieved environmental benefits:
Noticeable reductions in COD/BOD. Easy to instigate procedures and there are purchase savings in water soluble screen fillers.

Automatic wash-out:
The more expensive option is to install an automatic stencil wash-out machine with recycling facility.

Achieved environmental benefits: Sizeable savings in water usage. Unlikely to be suitable option for smaller and some medium sized printers as the volume of screens and the capital expenditure could not be justified.

Use of "grey" water:
It is possible by using certain foul water treatment (see later under end-of-pipe treatment) to use the "grey" water created by these methods within the screen preparation, screen reclamation and toilet facilities of the printing plant.

Achieved environmental benefits: This is the best environmental option, but it does require considerable investment and a technical understanding of the treatment process.

- **Bore hole**

Some printing plants can be sited above aquifers. Providing authorisation is given, the sinking of a bore hole can provide a cheap or in some cases free source of water. There is the outlay to access the aquifer; the cost of pumping the water to a header tank; filtration of the water and there is still the charge for treatment of any discharge to the sewage system. This option would involve considerable capital investment and would only be viable for a printing plant that consumed a large volume of water.

Achieved environmental benefits: Large savings in the cost of supply. There are very limited opportunities for such an approach.

- **Minimise organic solvents entering the sewage system**

All organic solvents have a very high COD/BOD; some such as aromatic hydrocarbons can be banned from entering the sewage system by local authorities.

a. Print shop housekeeping:
Remove as much of the remaining product from the screen as possible before sending the screen for reclamation. All inks, varnishes and adhesives have a high COD/BOD which can have an adverse impact upon the screen reclamation process.

Achieved environmental benefits:
Improvement in COD/BOD levels and as well as a lower usage of screen reclamation solvents. Unclean screens can have hardened coatings that require extra solvent and operator time to remove the residual deposits.

b. Separate reclaiming booths:
The initial booth is used only for the removal of any contaminant on the screen by means of a cleaning solvent prior to decoating the stencil. The solvent is not permitted to enter the sewage system. This can be achieved by retaining the solvent in the bottom of booth, draining into a separate container or using a solvent recycling pump. The excess solvent on the screen is removed by means of a squeegee prior to transfer to the second booth.

Achieved environmental benefits:
Major reduction in COD/BOD levels, considerable savings in purchases of screen cleaning solvents. The savings in solvent purchases will fund any expenditure for the booth and/or recycling pump.

c. Automatic screen cleaning machine:
For medium and large companies.

Automatic screen cleaning machine: These machines are programmable to accommodate a wide selection of screen sizes and types of inks used. They produce an excellent result when maintained and operated correctly. The solvent is retained within the system and doesnot enter the sewage system.

Achieved environmental benefits: Considerable reduction in COD/BOD levels. There is a significant improvement in productivity. This type of equipment requires specialised solvent formulations, considerable capital expenditure and competent operatives.

4. Reduction in Suspended Solids (SS)

• Use of gravel trap
A pea gravel trap is fitted under the discharge point from the stencil removal booth. Some of the suspended solids generated from ink residues, polyvinyl acrylate and polyvinyl acetate resins and pigments from the photo-stencil emulsions are trapped. The water then passes into the sewage system.

Achieved environmental benefits:
Some reduction in SS is obtained. The equipment is cheap to purchase, install and operate. The gravel trap can easily become saturated without the operator being aware and thereby the system fails. Disposal of the contaminated pea gravel must subsequently be undertaken.

• Flocculation treatment
The treated discharge is subsequently filtered thereby removing the suspended solids. The filtrate can be discharged to the sewage system.

Achieved environmental benefits:
A measureable reduction in SS is obtained. The equipment is relatively cheap to purchase, install and operate. There is the necessary purchase of new flocculant. A substantial amount of materials from the filtration process require disposal.

• Automatic screen cleaning machine

5. End-of-Pipe Treatment Plants

• Reed Bed

The reed bed is an engineered method of treating pollutants using a biological planting containing typically the common reed, Phragmites australis. The reeds pass oxygen, absorbed by their leaf system, via their stems and rhizomes to their roots - the Rhizosphere. Polluted water passing around the roots is purified by the immense population of microorganisms living in the Rhizosphere.

Achieved environmental benefits: Removes almost all the pollutants. This is an excellent natural and attractive method of treating industrial organic liquid wastes. It is extremely cheap to operate. It does require time for the reed bed to become acclimatized to type of pollutant. There is a need for a sizeable area to set up the reed bed. The “grey” water produced can be reused in certain production areas. It will not tolerate wide fluctuations in the composition of the discharge.

• Reverse osmosis

Reverse osmosis is a separation process that uses pressure to force a solution through a membrane that retains the solute or particles on one side and allows the pure liquid to pass to the other side. The membrane here is semi-permeable. The membranes used for reverse osmosis have a dense barrier layer in the polymer matrix where most separation occurs.

Achieved environmental benefits: Removes almost all the pollutants. Water can be reused throughout the plant for industrial purposes and sanitation. The plant is expensive to purchase and requires technical support to operate. The membranes are expensive and can be adversely affected by certain solvents.

air

14. emissions to air

best available techniques (BAT)

1. eliminate VOCs in inks using UV curing inks
2. reduce VOCs in inks using water based inks
3. reduce overall VOC cleaning emission
4. reduce VOCs by managing exposure

air

Emissions to air will be organic solvents but also includes ozone and dust. The major element will be organic solvents. Organic solvents are referred to as Volatile Organic Compounds (VOCs) and these will have an adverse effect on the environment. These chemicals may not be harmful to the environment in their own right, but if they mix with nitrogen oxides (NOx) under the right conditions (presence of sunlight and warm temperatures) they can react to produce ground-level ozone that can have harmful effects on human health. Many VOCs degrade rapidly in the lower atmosphere which means that these VOCs do not cause any problems with the stratospheric ozone layer. There are some VOCs that don't degrade in the lower atmosphere, but do react in the stratosphere and thereby contribute to the formation of so-called ozone holes.

Severe restrictions are imposed for chemicals with the EU Risk Phrases **R40, R45, R46, R49, R60 and R61**. To be considered as a VOC a chemical must have a vapour pressure of 0.01 kilo Pascals (kPa) or more at 293.15K (20oC). UV curing ink monomers and most plasticisers used in inks, photo stencils etc. are not VOCs by this definition. The discharge of VOCs to the atmosphere from a printing plant can arise from the following process procedures: ink colour matching, mixing and storage; printing and drying the substrate; cleaning machinery parts and ancillary equipment such as screens. Discharges will take place from the extraction points of dryers, local exhaust ventilation (LEV) equipment and fugitive emissions (work place emissions through doors and windows).

Responsibility

The level of responsibility is determined by the quantity of VOCs that are discharged from a printing plant.

Where printing activities use more than 5 tonnes per year of VOCs the EU Solvent Emissions Directive 1999/13/EC (SED) is applicable to a wide range of printing activities and covers only airborne emissions. Individual countries within the EU can impose controls on printing processes other than those specified in the SED under the doctrine of subsiduarity.

Where printing activities use more than 150kg/hour or 200 tonnes per year of VOCs they are subject to the controls of the European Union (EU) Integrated Pollution Prevention and Control Directive 96/61/EC (IPPC). This covers all forms of emission including effluent, waste disposal and airborne emissions.

Action Plan

- Generate an inventory of all inks, cleaners, thinners and other chemicals used
- Obtain from the supplier the annual quantity of VOCs present in each item purchased
- Ascertain all the emission sources from the plant e.g. dryers, LEV points, etc.
- Review the best available techniques (BAT) options for reducing the emission levels e.g. replacement of solvent based inks, reduced extraction levels, etc.
- Undertake a Solvent Management Plan

air emissions

Emissions to air from printing sites are controlled by EU Directive 96/61/EC (IPPC) where the usage of VOCs exceeds 150 kilos/hour or 200 tonnes per year.
For further information – see box below

If the VOC emissions to air from printing sites are less than 150 kilos/hour or 200 tonnes per year but exceeds 5 tonnes per year they may be controlled by EU Directive **1999/13/EC** (Solvent Emissions Directive).
For further information – see box on page 48

Best Available Techniques (BAT)

The suitability of the various BAT methods explained will be dependent upon the printing process that is being used and the production volume of the printing operation. The following could be used as methods to reduce emissions to air:

1.- It has subsequently been amended by:
Directive **2003/35/EC** Official Journal L 156 of 25.6.2003
Directive **2003/87/EC** Official Journal L 275 of 25.10.2003
Regulation **(EC) No 1882/2003** Official Journal L 284 of 31.10.2003
(EC) No 166/2006 Official Journal L 33 of 4.2.2006
In order to receive a permit a printing installation must comply with certain basic obligations
In particular, it must:

- use all appropriate pollution-prevention measures, namely the best available techniques (which produce the least waste, use less hazardous substances, enable the recovery and recycling of substances generated, etc.);
- prevent all large-scale pollution;
- prevent, recycle or dispose of waste in the least polluting way possible;
- use energy efficiently;
- ensure accident prevention and damage limitation;
- return sites to their original state when the activity is over.

In addition, the decision to issue a permit must contain a number of specific requirements, in particular including:

- emission limit values for polluting substances;
- any soil, water and air protection measures required;
- waste management measures;
- measures to be taken in exceptional circumstances (leaks, malfunctions, temporary or permanent stoppages, etc.);
- minimisation of long-distance or transboundary pollution;
- release monitoring;
- all other appropriate measures.

2.- Council Directive 1999/13/EC has subsequently been amended by:
Regulation **(EC) No 1882/2003** Official Journal L 284 of 31.10.2003 and
Directive **2004/42/EC** Official Journal L 143 of 30.04.2003

The printers concerned can conform to the specified emission limits in either of the following ways:

- by installing equipment to reduce emissions to comply with the emission limit values and the fugitive emission values, or total emission limit values;
- by introducing a reduction scheme to arrive at an equivalent emission level, in particular by replacing conventional products which are high in solvents with low solvent or solvent-free products such as UV cured inks.

Solvents containing substances likely to have a serious effect on human health (carcinogens, mutagens, or toxic to reproduction), must be replaced, as far as possible, by less harmful substances within the shortest possible time. Stricter emission values are specified for harmful substances.

The emission limits vary for each printing process and annual VOC usage. These SED processes include coating, publication gravure, flexography, off-set litho, rotogravure and rotary screen. Some countries within the EU have included other forms of printing such as flat bed screen and digital printing using the permitted subsiduarity rule.

1. Eliminate VOCs in inks using UV curing inks

Radiation curing is based on resins and reactive diluents (monomers) which react together on exposure to, e.g. ultraviolet light (UV). The resins are generally polyesters, polyurethanes or epoxies, with acrylate or methacrylate functionality, though other coating chemistries may also be used. The formulations are liquid, but are solvent-free and curing can be very fast, just a few seconds, generally at ambient or slightly raised temperatures.

Achieved environmental benefits:
A complete elimination of solvent use in the system. There are normally no significant emissions during curing and the cured coatings no longer contain volatile components. There can be improved energy efficiency with flash curing. Minimal use of VOCs is needed as drying-in of screen or print heads is less likely to occur.

The added benefits are that the use of UV inks will substantially improve productivity, reduce capital expenditure on abatement equipment, actively support the Solvent Reduction Scheme advocated in the SED and could remove installations from the requirements of SED and/or IPPC.

2. Reduce VOCs in inks using water based inks

Water based inks are usually based on a co-solvent system that includes a water soluble VOC that acts as a “bridge” with the other non-aqueous constituents. They can be latex based and the technology allows for these inks to be used on a wide range of substrates. The level of VOC will vary dependent upon the type of water-based ink that is used.

Achieved environmental benefits:
A considerable reduction in the VOC content. Drying-in of screens and print heads is less likely to occur compared with conventional solvent based inks.

The added benefits are that the use of water-based inks will reduce capital expenditure on abatement equipment, actively support the Solvent Reduction Scheme advocated in the SED and could remove installations from the requirements of SED and/or IPPC.

3. Reduce overall VOC cleaning emissions

High boiling point solvents have a slower rate of evaporation than lower boiling point solvents. The use of higher boiling point solvents will lower the VOC concentration in the working environment. These higher boiling point solvents can be effectively used in the cleaning processes such as screen reclamation and digital print head cleaning.

Cleaning agents with a flashpoint of >40ºC: The evaporation speed of traditional solvents is significantly higher than the evaporation speed of solvents with a flashpoint of >40°C. Consequently, the evaporation during cleaning can be reduced by using medium flashpoint solvents. These solvents may be useful as an intermediate step when switching from volatile cleaning agents to less volatile cleaning agents.

Cleaning agents with a flashpoint of >55ºC: The evaporation speed of traditional solvents can be some 100 times higher than the evaporation speed of solvents with a flashpoint of >55ºC. Consequently, the evaporation during cleaning can be reduced dramatically by using high flashpoint solvents.

Achieved environmental benefits:
Reduction of VOC emissions to air depends on the situation at the start: changing from solvents with a flashpoint of <21ºC achieves a reduction of about 90%; changing from solvents with a flashpoint of 21-55ºC can result in a reduction of about 50%. Another advantage is that there is less risk of soil contamination. As less solvent evaporates, solvent consumption decreases.

Operational data: High flashpoint solvents may not be as effective and efficient in cleaning as traditional solvents, but with experience, the results tend to become acceptable.

Cleaning with high flashpoint solvents will require more time, although with training and experience this time loss will be reduced to an acceptable level.

4. Reduce overall VOCs by managing exposure

Wherever VOC solvents are used, the following general measures and principles can be applied to ensure they are kept in airtight (or nearly airtight) containers

- enclosure, e.g. using lids, of the sources of potential emissions
- re-lid partly emptied drums or cans of solvent to prevent vapour losses
- 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 vessels and reservoirs do not have proper covers, use plastic wrap or antistatic plastic covers, where necessary attached by elastic bands, tyre inner tubes or nylon hook and loop fasteners (where these materials are not dissolved by the solvent being covered). Such covers have the added advantage of keeping them from dust and debris
- store wastes containing solvents, e.g. contaminated wipes and solvent-based residues, in containers
- use measuring systems or controlled dosages to avoid excess material containing solvent being used, e.g. the use of pre-impregnated wipes can be effective for cleaning small parts.

Achieved environmental benefits:
Reduced amount of fugitive VOCs emitted to the air. In general this method of reducing VOCs is cheap to undertake but does require constant monitoring to ensure that the methodology is being followed.

The following are end-of-pipe techniques:

- Thermal oxidation
- Recuperative oxidation
- Catalytic oxidation
- Regenerative oxidation: 2 beds
- Regenerative oxidation: 3 beds
- Other oxidation techniques
- Regenerative carbon adsorption
- Polymer adsorption
- Condensation at ambient temperature
- Refrigerated condensation
- Cryogenic condensation
- Biological treatment

For larger companies to reduce VOC emissions by end-of pipe techniques

As waste gas treatment is generally expensive to install and operate any of the methods given below should only be considered in the event that the previously described techniques do not produce the necessary reduction in VOCs to comply with the local legal requirements.

• Thermal oxidation
Waste gases are heated by burning natural gas. There is no attempt at heat recovery for a reduction of energy consumption. It is the simplest oxidation technique with the lowest capital investment. It is an auto-thermic operation only at concentration levels over 25% LEL. It has the lowest electrical energy consumption for the main fan but the highest gas relative consumption.

As the simplest technique, thermal oxidation has relatively the lowest maintenance and least downtime. it has a rapid start up (0.5 – 1 h), but requires a stable operating temperature. Non-organic dust needs to be removed (to <3 mg/m³) before the oxidation unit, although this technique is more tolerant of dust than others.

It is suitable for intermittent use (a few days a week; very variable airflows; one shift system, etc.) and where the capital costs are much more relevant than operational costs or in combination with other abatement technologies for multi-purpose units or for air volumes <2000 m³/h. The method can be used for exhaust concentration ranges between 5 and 16g/m³, high inlet temperatures of the waste gas and in situations where gas flow and solvent concentrations are relatively constant. Operation at concentration levels above LEL is also possible.

• Recuperative oxidation

Similar to thermal oxidation but with a heat exchanger that preheats the incoming waste gases with the heat of the exhaust gases. This reduces gas consumption, but the heat exchanger requires a higher capital investment. With a heat exchanger of maximum efficiency (about 76 %), auto-thermic operations are possible at solvent concentrations approaching 10g/m³ or more; the auto-thermic concentration depends on the caloric value of the solvent. The electrical energy consumption for the main fan is higher than in the case of thermal oxidation but the gas consumption is lower.

It is a simple oxidation technique, but with a relatively high investment due to the large steel content. It has an almost immediate start up (0.5 – 1 h). The removal efficiency is restricted by the maximum operating temperature which is determined by the mechanical integrity of the heat exchanger. The heat exchanger has a limited lifetime and requires substantial maintenance due to corrosion and thermal stress. Heat exchangers may easily be blocked by accumulation of dust in the tubes, and efficiency will be reduced due to the partial fouling, increasing investment and running costs. However, the technique is more tolerant of dust than others, and there are techniques for clearing blockages.

The method is suitable for intermittent use (one or two shift systems), but should only be considered where the reduction of gas consumption warrants additional capital cost and electrical energy. It is applicable where auto-thermic operation is possible, but excess energy cannot be used in the installation as an alternative for regenerative oxidation.

• Catalytic oxidation

For this method the oxidation temperatures are lower, 280 – 450°C (instead of in the region of 800°C). It is often equipped with a heat exchanger. This reduces the gas consumption, but catalysts and heat exchangers lead to a higher investment. The catalyst may need maintenance and occasional replacement which adds to the operational cost and downtime. When equipped with an efficient heat exchanger (maximum possible some 87%), autothermic operations are possible at solvent concentrations of some 5g/m³ or over depending on the calorific value of the solvent. The maximum possible temperature of the catalyst limits the inlet concentration to some 8 g/m³. Electrical energy consumption for the main fan is higher than in the case of thermal oxidation. With solvent concentrations below 25% LEL, the gas consumption will be lower than in the case of recuperative oxidation. The catalyst makes this a less simple oxidation technique, but still with a relatively low investment. Almost immediate start up (1 h to preheat the catalyst), but shutting down too frequently may damage the catalyst carrier. The catalyst adds to the need for maintenance and increases downtime. Some solvents or dust particles poison the catalyst and lead to early replacement of the expensive catalyst. Catalyst and carrier need to be adapted to waste gas composition, required temperature and expected removal efficiency. A used catalyst may need to be disposed of as

hazardous waste, although the catalyst material can often be recycled. It is very sensitive to the presence of dust and droplets in the waste gases and changes in the inlet concentration.

The technique can be used only where all solvents that are to be oxidised are known not to poison the catalyst and where the inlet temperature is not too high for the catalyst. An autothermic operation is possible, but any excess energy cannot be used in the installation as an alternative for regenerative oxidation.

• Regenerative oxidation: 2 beds

The oxidising chamber is situated between two ceramic beds. The waste gas passes through one bed before entering the oxidising chamber and leaves through the other. The direction of waste gas flow is alternated every 1 to 5 minutes. One bed preheats the waste gases; the other accumulates the heat from the exhaust. During the changeover solvent-laden waste gases are emitted for a few seconds. This technique reduces fuel consumption drastically. It increases the need for electrical energy due to the higher air resistance in the ceramic beds. With a high heat exchanger efficiency (maximum possible 96 %), auto-thermic operations are possible from solvent concentrations of 2 g/m^3 and over (depending on the calorific value of the solvent, e.g. ethyl acetate 2.2 g/m^3). Preheating after periods of standstill may, however,account for considerable gas consumption.

Electrical energy consumption for the main fan is higher than in the case of other oxidisers because of the high pressure drop in the ceramic beds. Where the solvent concentration in waste gases is higher than the auto-thermic concentration, excess heat is produced. This may be recovered. Where excess heat is not permanently recovered and the concentrations are variable, the efficiency of the heat exchanger may need to be reduced to prevent overheating of the ceramic beds when high concentrations occur. This leads to a higher autothermic concentration and the need for adding natural gas in periods of low solvent concentrations. Because there are complicated sensors and large valves necessary to repeatedly change the direction of the airflow mean complex equipment and the need for skilled personnel. This leads to higher maintenance costs and more downtime than other oxidation techniques. Every one or two years there is a need for 2 to 3 days downtime for maintenance. The system needs preheating before start up since the ceramic beds cool down during standstill (After 36 hours of standstill, 1 to 2 hours are needed for preheating).

The removal efficiency is a few per cent lower than that of the 3 bed system (see below) due to emissions discharged during changeover of the direction of the waste gas stream. Where the end-of-pipe emission limits expressed in mgC/m^3 averaged over a short period of time apply, the emissions during changeover of the direction of the waste gas stream may lead to an average outlet concentration that exceeds the limit values if the inlet concentration is higher than about 3g/m^3. The regenerator blocks rapidly with dust. It is possible to run with some low dust concentrations, but the regenerative beds need a different structure (structured packing honeycomb instead of saddles) with different cost and efficiency.

This technique is specifically suitable in continuous or near continuous operations where most of the time the solvent concentrations in the waste gases are over the auto-thermic concentration and the solvent concentrations do not vary significantly. It is therefore unsuitable for most screen and digital printing where flexibility in substrate use and ink type may take place.

• Regenerative oxidation: 3 beds

In principle it is the same as the 2 bed system. The third bed serves to avoid the emission of solvent laden air during the change of the direction of the waste gas flow. Compared with the 2 bed system the capital investment is about 25 % higher than a 2 bed system. There are lower emissions. The preheating cost is higher. The system uses about 10 % higher electricity consumption due to a larger fan for purging purposes. The removal efficiency is a few per cent higher than that of the 2 bed system due to the prevention of emissions during changeover of the direction of the waste gas stream. It is possible to use burnout techniques for removing sticky particles.

Relative to the 2 bed system the 3 bed alternative is most suitable for concentrations from 1 – 12g/m^3 especially if there is a variation in the concentration over the production time. It is most suitable in large continuous operations with solvent concentrations in waste gases well above auto-thermic concentration particularly where the resulting emission reduction warrants the additional investment and operational cost.

• Other oxidation techniques

Process dryer: the waste gases to be treated are recycled to an existing heater (e.g. gas fired) as combustion air and a complementary fuel. The heater must be available and must be operating and able to receive all the waste gases at times when they are produced. Before installation it will be necessary to specify to the heater manufacturer the VOCs that are to be used as a supplementary fuel. Any such heater must comply with the necessary local and EU regulations when it is installed.

• Regenerative carbon adsorption

The low temperature waste gases are fed through a bed of activated carbon. The solvent adsorbs to the activated carbon. When the carbon is saturated the waste gas flow is switched to a second carbon bed. The saturated bed is desorbed through heating. The heat releases the solvents from the carbon in such a high concentration that it allows condensation of these solvents. Desorption must be done in an atmosphere with little or no oxygen. Steam, nitrogen or oxygen-free hot air may be used. After condensation of the solvent, complex techniques may be necessary to make the recovered solvents ready for re-use. These techniques depend on the solvent recovered.

Since the adsorption characteristics of solvents differ enormously, the size of the adsorbers (and therefore not only the investment but also the energy and inert gas consumption) is very much determined by the kind of solvent. Some solvents may react with the activated carbon and cause fire. Methyl ethyl ketone (MEK) is one of these, but techniques exist to prevent these reactions and recover MEK safely. Some low volatility solvents may adhere to the activated carbon permanently and quickly reduce the adsorption capacity with early replacement of the activated carbon as a result. Activated carbon also adsorbs water effectively. Waste gas streams with high moisture content (e.g. water based inks) are therefore not suitable.

Investment and operational costs are considerably higher than in the case of oxidation, therefore as an emission control method it is unlikely to be suitable for screen and digital printers. Electrical energy consumption for the main fan is higher than in the case of oxidisers because of the higher resistance of the beds of activated carbon. There is a requirement for high displacement with low airspeeds to prevent the VOC blowing out of the activated carbon. When used as an emission control technique the complex equipment requires specifically trained technical personnel.

This method is a reliable operation and very little downtime is the norm. However, it is possible to use small individual carbon filters as a means of local exhaust ventilation that assist with compliance in meeting local health and safety regulations.

The high cost in comparison to oxidation and with the low market value of recovered solvents necessitates

the re-use of the solvents in the same installation in order to make solvent recovery a viable option. Breakeven point between oxidation and recovery evidently depends on the price of the solvent recovered and the techniques necessary. For xylene, the recovery may be cheaper than oxidation starting at a solvent consumption of 100 tonnes per year. For ethyl acetate, MEK and ethanol, breakeven with oxidation was calculated to be possible starting at approximately 500 to 1000 tonnes per year.

The technique does not work with high inorganic dust concentrations. It should only be considered when the recovered solvent can be re-used in the installation or be sold against the market value of 'fresh' solvents. (The sale of recovered solvent brings no more than 50 % of its original price).

• Polymer adsorption
The low temperature waste gases are fed through a moving bed of grains of a special polymer. The solvent adsorbs to the polymer. The saturated polymer is desorbed through heating. The heat releases the solvents from the polymer in such a high concentration that it allows condensation of these solvents. Desorption is done with hot air. The concentrations are above the higher explosion limit in order to prevent accidents.

Since the polymer is the most costly part of the equipment (10 to 20 times the cost of activated carbon); this technique is known to be suitable for only very few solvents and unlikely to be of use for screen and digital printers.

• Condensation at ambient temperature
Waste gases are cooled down to a temperature above freezing point. The low volatility solvents condense. High volatility solvents such as those used in screen printing are not condensed effectively. The equipment is very simple and not expensive. There are no known examples of successful application in industries in the scope of this document.

• Refrigerated condensation
The waste gas is cooled to a temperature below 0°C. Icing occurs and regular de-icing is necessary. For that purpose there are usually two condensers. A condensation step above 0ºC upstream reduces the water content of the waste gas.

The running costs are high and increase if a lower condensation temperature is necessary. It is applicable mostly for the recycling of higher cost solvents where there are low airflows with high concentrations.

• Cryogenic condensation
Condensation is undertaken at very low temperatures usually with liquid nitrogen. It is used mostly for the recycling of higher cost solvents with low airflows with high concentrations.

• Biological treatment
The waste gas is blown through a bed of organic material (often referred to as a reed bed) in which the VOCs are adsorbed and destroyed (metabolised) by bacteria. The equipment is simple and not expensive, but needs a lot of space in the case of large airflow. Bacteria are easily killed by changing the composition of the waste gas or by lack of feed in the holiday season. This affects the filter efficiency.

The system works well with a waste gas stream with a low concentration of VOCs that are biodegradable and preferably water soluble. There can be odour problems

Achieved environmental benefits: VOCs emitted to the air are virtually eliminated.

waste

15. waste control

Hazardous waste
best available techniques (BAT)

Non hazardous waste
best available techniques (BAT)

waste

The generation of any waste has an immediate adverse effect upon the profitability of a company. Few companies have adequate knowledge as to the quantity or the cost of disposal of the waste that is generated. Therefore it is essential to undertake a review of the total waste generated over a reasonable period of time.

Responsibility

The municipal authority has no statutory commitment to collect any waste coming generated from a commercial enterprise. No waste produced by a company can be assimilated into domestic waste. The communal services are free to set limits on what they will collect. The producer of the waste has the responsibility for ensuring the correct disposal of waste continues until the final stage of recycling and disposal.

Action plan:

- Assign a senior member of the workforce to be responsible for all matters relating to the control of waste.
- Each type and quantity of waste must be categorized.
  - **Segregation** is paramount. Waste falls into two main categories; hazardous and non-hazardous. Putting polluted waste together with a non-hazardous waste makes the whole collection hazardous waste
  - **No hazardous waste** can be thrown in the sewage system or dumped on land.
  - **Clearly label** each waste type and store separately before collection.
- Select a company authorized to handle the various types of hazardous waste generated by your enterprise.

Review the procedures used by the selected company including visiting the site where the final disposal takes place especially with respect to hazardous waste. If the waste centre is classified following national and/or local rules, it must conform to the terms of use.

  - Retain documentary evidence concerning each collection.
- Monitor the weight and cost of each waste type.
- Review each BAT technique to determine which are suitable.
  - Select those BAT techniques that will produce the greatest saving or best environmental impact.
  - Report the savings and/or environmental impact.

hazardous waste

Hazardous waste is described and controlled by the following European Directives. To obtain these directive in details, see box on page 60.

Hazardous waste can take many forms; waste ink, thinners, cleaners, dirty wipes and rags, used ink and solvent containers, spent developer and fixer, used reclaiming chemicals and some adhesives. It will have been assigned a **European Waste Catalogue code number**. For example waste inks are assigned the code number **08 03 12** and the description **"waste ink containing dangerous substances."** Another example is photo-stencil emulsions containing acrylates are assigned the code number **09 01 99** and described as **"wastes not otherwise specified."** Details should be found in Section 13 Disposal considerations in the Material Safety Data Sheet.

Other wastes that are of concern to the printer include lamps containing mercury, electrical and electronic equipment and batteries.

Exposure lamps and fluorescent tubes are hazardous waste and must be disposed of accordingly. Unless the electrical or electronic equipment is immovable it **will be subject to the WEEE Directive if purchased after 1 July 2006**. There are a number of types of equipment that are excluded, however; the printer must be sure that any new equipment purchased must comply with this directive. **The RoHS Directive** imposes on the machinery manufacturer restrictions on the use of hazardous substances such as lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBBs) and polybrominate diphenyl ethers (PBDEs).These must be replaced by other materials in electrical and electronic equipment with certain exceptions.

Batteries Directive: The Implementation of the Batteries and Accumulators and Waste Batteries and Accumulators Directive **(2006/66/EC)** applies especially to the machinery manufacturers and suppliers.It covers the complete range of battery sizes (including button size in computers) and incorporates the producer responsibility principles of recycling and recovery. It sets recycling and recovery targets: restricts the use of many heavy metals currently used; requires labelling and controls disposal.

Hazardous Waste Directive 91/689/EEC (HWD) amended by Directive 94/31/EC European Waste Catalogue 2000/532/EC (EWC) amended by:

Decision **2001/118/EC** [Official Journal L 47, 16.2.2001]
Decision **2001/119/EC** [Official Journal L 47, 16.2.2001]
Decision **2001/573/EC** [Official Journal L 203, 28.7.2001]

Waste Electrical and Electronic Equipment Directive **2002/96/EC** (WEEE) amended by Directive **2003/108/EC** and exemptions applicable to lead, mercury, cadmium and hexavalent chromium Decision **2005/618/EC** - Official Journal L 214 of 19.08.2005

Decision **2005/717/EC** - Official Journal L 271 of 15.10.2005
Decision **2005/747/EC** - Official Journal L 280 of 25.10.2005
Decision **2006/310/EC** - Official Journal L 115 of 28.04.2006
Decision **2006/690/EC** - Official Journal L 283 of 14.10.2006
Decision **2006/691/EC** - Official Journal L 283 of 14.10.2006
Decision **2006/692/EC** - Official Journal L 283 of 14.10.2006

Restriction of certain Hazardous Substances in electrical and electronic equipment Directive **2002/95/EC** (RoHS) and Directive **2006/66/EC** of the European Parliament and of the Council of 6 September 2006 on batteries and accumulators and waste batteries and accumulators.

Best available techniques (BAT)

The following could be used as methods to reduce waste:

• Automated mixing systems

Computerized Pantone matching systems or programmable scales are available. Depending on the quantity of ink consumed automated ink delivery from 200 litre containers and colour matching can be utilised; smaller printers can use computerized matching systems that can prepare much smaller colour matches. These techniques can produce a reduction in waste materials and saving of resources.

Achievable environmental benefits:
During manual mixing, losses of 1 or 2% of solvents can occur. These can account for 15 % of the total VOC emissions. Automated mixing in enclosed machines reduces most of these emissions. Also, less cleaning agent is needed. In printing, the amount of waste ink may be reduced by 75 % depending on the number of times that inks are mixed and the amounts involved. The automated technique permits a perfect dosage so that no colour correction is necessary, so therefore, only the exact quantity of ink is prepared.

• Re-use of returned inks

Solvent and water-based returned inks can be re-used if they are not diluted too much and are not contaminated with cleaning agents where these differ from the solvent used as thinner. Water-based inks polluted with cleaning agents cannot be reused at all. UV curing inks can be re-used if the ink has not been left exposed to daylight for excessive periods. To avoid contamination of the unused ink, the residual ink on the screen must to be returned to the container before the machine is cleaned.

Achievable environmental benefits:
There is a lower consumption of fresh ink and less waste. The technique is applied when standard colours are used. When non-standard colours are used, computer-based colour matching is needed to be able to use the mix as a source for a new mix.

• Solvent recovery

Solvent based waste such as inks and screen reclamation cleaners can be distilled to recover the solvent and to reduce the amount of hazardous waste. Special purpose distillation equipment exists that is capable of handling as little as 25 litres. The distillation equipment must be installed and operated with care. Cleaning agents with a high flashpoint generally also have a high boiling point. For these solvents, only vacuum distillation equipment can be applied in these situations.

Achievable environmental benefits:
The amount of hazardous waste is reduced and the solvent can be re-used, e.g. for cleaning, however; frequently a regenerant has to be added.

• Solvent reuse

Some contaminated solvents can be utilised as a fuel for other industrial applications such as cement manufacture.

Achievable environmental benefits:
The amount of hazardous waste is reduced.

waste

• Handling and use of solvents and solvent based inks in production areas.

Where products contain VOCs such as thinners, cleaners and solvent based inks are used,the following general measures and principles can be applied to ensure they are kept in airtight (or nearly airtight) containers:

- enclosure, e.g. using lids, of the sources of potential emissions
- re-lid partly emptied drums or cans of solvent and inks to prevent vapour losses
- keep solvent containers away from sources of heat and draughts to minimise evaporation
- store wastes containing solvents, e.g. contaminated wipes and solvent-based residues, in containers
- use solvent safety containers to avoid excess material containing solvent being used especially when using wipes

Achievable environmental benefits:
Reduced amount of VOCs emitted to the air.

• Disposable cleaning wipes

Cleaning can be done with disposable wipes.Once dirty, the disposable wipes are thrown away and treated as hazardous waste. This normally implies incineration. Disposable wipes are generally made of synthetic fibres. Per unit of weight, they can contain many times more cleaning agent and dirt than re-usable wipes. After use, they are incinerated together with their contamination. Since disposable wipes are light, the incineration of the sludge from the cleaning of re-usable wipes offers little advantage over incineration of completely disposable wipes. Disposables have far better adsorption properties than re-usable wipes thus less weight and volume is needed. The amount of transportation involved is, consequently, also much smaller.

• Re-usable cleaning wipes

Cleaning can be done with re-usable wipes. Once dirty, they are returned to the rental company,where they are washed and put back into circulation. Re-usable wipes are made of natural textile fibres. After use, they are washed with solvents and then dried. The contaminated solvent is distilled and the sludge is incinerated as hazardous waste. The washing, drying and distillation processes for re-usable wipes give rise to solvent emissions. Since re-usable wipes are far less adsorbent than disposables, a far greater weight and volume is needed. The amount of transportation involved is consequently larger for the same amount of cleaning. However, re-usable wipes generate less waste than disposable wipes.

Achieved environmental benefits:
There is no clear environmental difference between reusable and disposable wipes. An important factor in the choice for disposable wipes is the damage that may occur to very sensitive surfaces such as screens and digital print heads by a re-usable wipe that is not completely free of contamination from previous uses.

• Re-usable containers

Some inks and varnishes are supplied in re-usable containers, such as standard 200 litre metal drums, etc. These containers can be returned for re-use or re-used for containing solvents. Incorporation of a liner that is un-reactive to the contents and can be disposed of and eliminate the damage to the 200 litres open top drum and make re-use easier.

Achievable environmental benefits:
Reduced waste

non hazardous waste

For industrial enterprises the non hazardous waste is mainly controlled by the Packaging and Packaging Waste Directive **94/62/EC** (PPW) amended by Directives **2004/12/EC** and **2005/20/EC**. Each EU member state has a responsibility for reducing the level of packaging materials that are disposed of under the PPW. The method of meeting the requirements of the PPW may vary from country to country. The PPW sets the level of reuse,re-cycling and recovery. The Member States must introduce systems for the return and/or collection of used packaging to attain the following targets:

60% Recovery or incinerated to generate energy
55 – 80% Recycled which will include:
60% glass
60% paper and board
50% metal
22.5% plastic
15% wood

These recovery and recycling rates are to be achieved by 31 December 2008.It includes all domestic, commercial and industrial non hazardous waste. The non hazardous waste will typically be unprinted paper, board and plastic, off-cuts from printed substrate, packaging materials including pallets, office waste excluding copying toner and fluorescent tubes. New levels are planned for 2009 - 2014.

The system can be related to turnover, consumption etc. and can exclude certain enterprises. Each country within the EU is permitted individual schemes to meet the targets shown above.

Any metal or plastic containers that were used to supply inks, some toner cartridges and bottles, thinners, cleaners, fixers, developers, emulsions etc. must be treated as hazardous waste and must not be mixed with other packaging materials.

waste

Best available techniques (BAT)

The following could be used as methods to reduce waste:

• Segregation

All non-hazardous materials should be segregated into separate clearly identified containers. Mixed waste is extremely difficult to recycle or valorize; incineration can also prove difficult. Whilst it may not be possible to re-use waste in your business, it may be useful to others. Make use of a waste exchange scheme to advertise your waste and make it available for use by others, either for sale or free collection. The exchange schemes cater for a wide range of materials and include difficult wastes that may not have recognised markets,brokers or dealers.

Achievable environmental benefits:
Increased level of recycling can be achieved leading to lower usage of virgin raw materials.

• Sorting paper waste

During the finishing and converting processes unprinted off cuts are produced. It is easier to recycle such paper and many waste collection/treatment companies are prepared to pay for such material.

Achievable environmental benefits:
Higher levels of recycling are achieved and financial savings can be obtained.

• Returnable packaging

Where regular and large volumes of paper, board or plastic are purchased from one or more suppliers negotiate the use of returnable packaging. Segregate this packaging to return to the supplier using their transport.

Achievable environmental benefits:
High levels of re-use are achieved and financial savings can be obtained.

• Digital ink toner cartridges

Some producers offer a reverse logistics to their customers; examples include Ricoh, Konica Minolta and Canon. The appropriate labelling and collection/ shipping instructions are frequently available on the suppliers' web site. Some toners contain dangerous substances and must be treated as hazardous waste at the end of their life. This may not stop it being collected for recycling, but the necessary legal requirements must be complied with to ensure that the waste is transferred correctly and safely.

Achievable environmental benefits:
High levels of re-use are achieved

• Install compactor

Packaging waste is usually very bulky. Waste collection costs are frequently based on the volume collected; compacting reduces the apparent volume by displacing air within the waste.

Achievable environmental benefits:
Reduced levels of transport and resulting carbon emissions and financial savings.

• **Outgoing packaging**

For key clients with frequent orders, offer returnable packaging or take back of used packaging (only if it is your own). Avoiding using polystyrene chips. Use cardboard inserts or balled/shredded paper instead of plastic protection as this is readily recycled. Use a paperbased wrapping tape rather than a plastic tape.

Achievable environmental benefits:
Reduced level of usage of raw materials leading to cost savings.

• **Re-utilise pallets**

Good quality second-hand pallets can be used for shipping to customers or they can be sold to a company who will use them or sell them on to others.

Achievable environmental benefits:
Reduced level of usage of raw materials leading to cost savings..

energy

energy management

Energy consumption

best available techniques (BAT)

1. lighting
2. heating, ventilation and air conditioning systems (HVAC)
3. compressed air systems
4. electrical motor driven sub-systems

energy

Apart from consumables such as substrate, ink, thinners etc., energy is probably the printer's next highest non-payroll expenditure. Within the European Union (EU) the paper and printing industry consumes 11% of the total industrial energy usage. With the continued industrial and economic expansion in countries such as China and India the availability of sources of energy worldwide will be under severe strain. This in turn will probably lead to a continual increase in the cost of all forms of energy.

In 2001, the energy structure of the EU remained heavily dependent on fossil fuels (79 % of the gross inland consumption), including a significant proportion of imported oil and gas. The EU imports over 50 % of its energy supplies, and this is expected to rise to more than 70 % in the next 20 - 30 years. There is little doubt that the cost of energy will follow this upward trend. Aside from the very strong incentives to reduce the consumption of these vital commodities there is the need to avoid polluting the environment through the burning of fossil fuels. However, a powerful driver in addressing energy management is economic. To remain competitive the printer must make the most efficient use of the energy resource needed to run the business.

The majority of print businesses will consume energy in a number of activities. These can be grouped under the following headings:

- Lighting
- Heating, ventilation and air conditioning systems
- Compressed air systems
- Electrical motor driven subsystems for equipment such as printers, dryers, guillotines platen presses, etc.

These topics will be reviewed taking into consideration new installation requirements as well as upgrading and the maintenance of current equipment and plant. Addressing this topic will ensure that the printer remains competitive as well as exhibiting a positive attitude towards environmental issues.

Responsibility
Everyone within the organisation has a responsibility and role to play in the reduction in the energy consumed as a proportion of the cost of the product sold.

Action Plan
- Review the total annual spend on energy
- Encourage all members of staff to participate in energy reduction activities
- Conduct a survey using a lux meter of all areas of the plant
- Discuss with staff their needs for each area and modify the lighting levels accordingly
- Survey all areas of the plant to determine the current temperature settings for winter and summer
- Examine the appropriate BAT to reduce the energy requirements for heating/cooling as well as when installing new ventilation equipment or reviewing the current installation
- Check all compressed air systems for leaks etc
- Review BAT when making purchases of new electrical motors
- Check the means of transmission from electrical motors and the repair and maintenance

energy consumption

Apart from the Integrated Pollution Prevention and Control Directive **96/61/EC** amended by **2003/87/EC** there are no specific European Union Directives or Regulations relating to energy consumption and management. There is the Commission Communication on the Climate Change Programme and a number of world-wide and European Accords relating to energy and the impact on the environment. These include the Berlin Declaration of March 2007; "We intend jointly to lead the way in energy policy and climate protection and make our contribution to averting the global threat of climate change."Many sectors have considerably improved energy efficiency over the past 20 years.Dominant market drivers are productivity, product quality and new markets. The steps which industry has taken have largely been voluntary and usually driven by cost.

Best Available Techniques (BAT)

The suitability of the various BAT methods explained will be dependent upon the printing process, the finishing activities that are being used, the location and age of the premises and its equipment and the production volume of the printing operation. The following could be used as methods to reduce the level of energy consumed:

1. Lighting

Tackling this topic is the easiest means of saving energy at the least expense and should be a priority of every printer. It will achieve an immediate saving. Artificial lighting accounts for a significant part of all electrical energy consumed worldwide. In offices, from 20 to 50 per cent of the total energy consumed is due to lighting. Most importantly, for some buildings over 90 per cent of lighting energy consumed can be an unnecessary expense through over-illumination. There are several techniques available to minimise energy requirements in any building:

- **Identification of lighting requirements for each area**

This is the basic concept of deciding how much lighting is required for a given task. Lighting types are classified by their intended use as general, localised, or task lighting,depending largely on the distribution of the light produced by the fixture. Generally the energy expended is proportional to the design illumination level.

General lighting is intended for the general illumination of an area, a lighting level of 800 lux (lumen per square metre) might be chosen for a work environment encompassing meeting rooms, whereas a level of 400 lux could be selected for building corridors. Outdoors, general lighting for a parking area may be as low as 10-20 lux since pedestrians and motorists already accustomed to the dark will need little light for crossing the area.

Task lighting is mainly functional and is usually the most concentrated, for purposes such as reading or inspection of materials may require task lighting levels up to 1500 lux, and some inspection tasks procedures require even higher levels.

- **Analysis of lighting quality and design**

The purpose of this analysis is:

- the integration of space planning with interior design (including choice of interior surfaces and room geometries) to optimize the use of natural light. Not only will greater reliance on natural light reduce energy consumption, but this will favorably impact on human health and performance,
- planning activities to optimize the use of natural light,
- consideration of the spectral content required for any activities needing artificial light selection of fixtures and lamp types that reflect best available technique for energy conservation.

Characteristics and efficiency of different light types

Name	Optical spectrum	Nominal efficiency (lm/W)[1]	Lifetime (MTBF) (hours)	Colour temperature[2] (Kelvin)	Colour	Colour rendering Index[4]
Incandescent light bulb	Continuous	12-17	1000-2500	2700	Warm white (yellowish)	100
Halogen lamp	Continuous	16-23	3000-6000	3200	Warm white (yellowish)	100
Fluorescent lamp	Mercury line + phosphor	52-100	8000-20000	2700-5000	White (with a tinge of green)	15-85
Metal halide lamp	Quasi-continuous	50-115	6000-20000	3000-4500	Cold white	65-93
High pressure sodium	Broadband	55 - 140	10000-40000	1800-2200[3]	Pinkish orange	0-70
Low pressure sodium	Narrow line	100-200	18000-20000	1800[3]	Yellow, virtually no colour rendering	0
Sulphur lamp	Continuous	80-110	15000-20000	6000	Pale green	79
Light emitting Diodes		20-40	100000		Amber and red light	
		10-20			Blue and green light	
		10-12			White	

[1] 1 lm = 1 cd-sr= 1 lx-mj. [2] Colour temperature is defined as the temperature of a black body emitting a similar spectrum. [3] These spectra are quite different from those of black bodies. [4] The colour rendering index (CRI) is a measure of the ability of a light source to reproduce the colours of various objects being lit by the source.

The most efficient source of electric light is the low pressure sodium lamp. It produces an almost monochromatic orange light, which severely distorts colour perception. For this reason, it is generally reserved for outdoor public lighting usages. Low pressure sodium lights generate light pollution that can be easily filtered, contrary to broadband or continuous spectra.

Data on options, such as types of lighting, is available via the Green Light Programme (http://www.eu-greenlight.org/). This is a voluntary prevention initiative encouraging non-residential electricity consumers (public and private), referred to as 'Partners', to commit to the European Commission to install energy efficient lighting technologies in their facilities when (1) it is profitable, and (2) lighting quality is maintained or improved.

• Management of lighting

This role is to:
- emphasize the use of lighting management control systems including occupancy sensors, timers, etc. aiming at reducing lighting consumption
- training of building occupants to utilise lighting equipment in the most efficient manner
- maintenance of lighting systems to minimise energy wastage.

Achieved environmental benefits:
Energy savings. It should be remembered that certain types of lamps, e.g. mercury vapour, fluorescent, contain toxic chemicals such as mercury or lead. At the end of their useful life, lamps must be recycled or disposed of correctly.

2. Heating, ventilation and air conditioning systems (HVAC)

A HVAC system can comprise of heating or cooling equipment, pumps and/or fans, piping networks, chillers and heat exchangers transferring or absorbing heat from a space or a process. Studies have shown that about 60 % of the energy in an HVAC system is consumed by the chiller/heat pump and the remaining 40% by peripheral machinery. Since there are considerable differences in the climatic conditions across Europe and the need for ventilation for health and safety and/or workforce comfort the BAT advice will be split into two segments namely: space heating and cooling and ventilation.

• Space heating and cooling

In printing companies there are a wide range of space heating and cooling activities. The application and use depend on the sector and the location in Europe, and are used:
- to maintain satisfactory working conditions
- to maintain product quality (e.g. cold rooms)
- to maintain input material quality and handling characteristics.

The systems can be localised (e.g. IR space healers for equipment in storage areas) or centralised (e.g. air conditioning systems in offices).

The consumption of energy in space heating/cooling is considerable. In some countries it represents nearly 10% of fuel consumption. It is quite common to have high heating temperatures in industrial buildings that could easily be reduced by 1 or 2 °C; conversely, when cooling, it is common to have temperatures that could be increased by 1 or 2 °C without degrading the comfort. These measures imply a change for the employees and they should be implemented following an information campaign.

Energy savings can be achieved in reducing the heating/cooling needs by:
- building insulation
- efficient glazing
- air infiltration reduction
- automatic closure of doors
- lower temperature settings during non-production periods (programmable regulation)

To lower the temperature set point of 1°C for heating, and raising it by 1°C for air conditioning can reduce energy consumption about 5 -10 %, depending on the average temperature difference between indoors and outdoors. Generally, raising air conditioning temperatures saves more, as the temperature differentials are generally higher. These are generalisations,and the actual savings will vary according to the climate, on a regional basis.

Limiting heating/cooling during non-production periods can save 40 % of electrical consumption for a plant working on an 8 hours per day basis. Limiting heating coupled with a permanent reduced temperature in unoccupied areas and localised heating in occupied areas, can generate nearly 80 % energy savings depending on the percentage of occupied areas. It should be remembered that temperatures may be set by other criteria, e.g. regulatory minimum temperatures for staff, maximum temperatures to maintain product quality etc.

The heat losses through the walls of the combustion system can occur and are determined by the diameter of the pipe and the thickness of the insulation. An optimum insulation thickness which relates energy consumption with economics should be found in every particular case.

Efficient thermal insulation to keep heat losses through the walls at a minimum is normally achieved at the commissioning stage of the installation. However, insulating material may progressively deteriorate, and must be replaced after inspection following maintenance programmes. Some techniques using infrared imaging are convenient to identify the zones of damaged insulation from outside while the combustion installation is in operation in order to plan repairs during shutdown.

Regular maintenance and periodical control is important to check the absence of hidden leaks in the system (below the insulations). In negative pressure systems, a leakage can cause an increase of the amount of gas in the system and a subsequent demand of electrical power at the fans.

• New ventilation system

A ventilation system is essential for many industrial installations to function well. It protects staff from pollutant and heat emissions within premises and maintains a clean working atmosphere to protect product quality.

A ventilation plant is a system consisting of many interacting parts. It can include the air system (intake, distributor, transport network); the fans (fans, motors, transmission systems); the ventilation control and regulation systems (flow variation, centralized technical management (CTM), etc.); energy recovery devices; air cleaners and the different types of ventilation system chosen (general ventilation, specific ventilation, with or without air conditioning, etc.).

It is essential to have a clear idea of the requirements for a ventilation system to make the right choices and to decide on the right design. These may be clean air intake; maintenance of environmental conditions (temperature, pressure, humidity, etc.), for either improving comfort or health within working areas or for product protection; extraction of dust, humidity and hazardous products.

The following types of ventilation system can be used:

general ventilation: these systems are used to change the air in large volume working areas. Several types of clean air ventilation systems are possible, depending on the premises to be ventilated, the pollution, and whether or not air conditioning is required. Airflow is a major element influencing energy consumption; the lower the flow-rate, the lower the energy consumption.

specific ventilation: these ventilation systems are designed to remove emissions as close as possible to the source. They are directed at localised pollutant emissions, using specific intakes, and preventing them from being propagated throughout the work area.

They have the following advantages:

- **preventing any contact with their occupants**
- **avoiding the renewal of all the air in the work area.**

In both cases, extracted air may require treatment prior to discharge to the atmosphere (see section 14).

It is estimated that 10 % of the electricity consumption in companies is by ventilation systems. Where there is also air conditioning, ventilation and air conditioning can take up an **even larger share of the business energy budget**.

There are two critical issues that need to be addressed:

1. Fans: They are the principal source of electricity consumption in the installation. Their type, size and controls are major factors from the point of view of energy. When designing or modifying an installation, key issues are:

- a fan with a high efficiency rating: the maximum efficiency of fans is generally between 60 and 85 % depending on the type of fan. Manufacturers are developing ranges of even more efficient fans
- a fan designed to operate as close as possible to its optimal rate: with a single fan efficiency can vary according to its operating rate. It is therefore essential to choose the correct size of fan for the installation, so that it operates as close as possible to maximum efficiency.
- Note that choosing a high efficiency fan of the correct size may mean that a smaller fan can be chosen and savings on the purchase price can be obtained

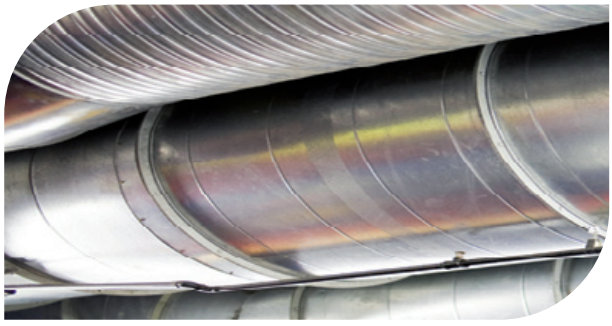
2. The air system: The design of an air system must meet certain conditions in order to be energy efficient:

- ducts must be sufficiently large in diameter (a 10 % increase in diameter can produce a 72 % reduction in the power absorbed)
- circular ducts, which offer less pressure loss, are better than rectangular ducts of an equal section
- avoid long runs and obstacles (bends, narrower sections, etc.)
- check that the system is airtight, particularly at joints
- check that the system is balanced at the design stage, to make sure all "users" receive the necessary ventilation. Balancing the system after it has been installed means that single leaf dampers have to be installed in some ducts, increasing losses bn pressure and energy.

• Improving an existing ventilation system within an installation

An existing ventilation system can be improved by introducing maintenance and a monitoring plan for the installation.

Knowledge of the installation is an essential precursor to improving its performance. A diagnosis of the installation enables the following: evaluation of the performance of the current ventilation system; detection of any malfunctions and if necessary, the selection of a new installation of the correct size.



The energy consumption of a ventilation system increases over time for an identical performance. To maintain its efficiency, it is necessary to monitor the system and when necessary carry out maintenance operations, which will produce substantial energy savings whilst increasing the lifetime of the system. These operations may consist of:

- **conducting leak detection and repair campaigns** on the air duct system
- **changing filters regularly**, particularly in the air cleaning devices, because:
  - loss of pressure increases very rapidly with a worn out filter
  - the filter's efficiency at removing particles deteriorates over time
- **check compliance** with health and safety standards associated with pollutant removal
- **measure and record** regularly the key values for the installation (electricity consumption and pressure loss in devices, airflow).

The following immediate action can be taken:

- stop or reduce ventilation where possible. The energy consumption of a ventilation installation is directly linked to rate of airflow. Airflow is determined by:
  - the presence of operators
  - the number of sources of pollution and types of pollutants
  - the rate of and distribution of each source of pollution replace clogged filters
- fix leaks in the air system
- if the air is conditioned, check settings and ensure they suit specific needs

Achieved environmental benefits: Energy saved after optimising all the parameters of the ventilation system will produce, on average, a reduction of the order of 30 % of the energy bill associated with its operation.

3. Compressed air systems

There are three major areas where savings can be achieved; these are reducing compressed air system leaks, filter maintenance and feeding the compressor(s) with cool outside air.

4. Reducing compressed air system leaks

The reduction of compressed air system (CAS) leaks has by far the highest potential gain on energy savings. Leakage is directly proportional to the system pressure. Leakages are present in every CAS and they are effective 24 hours a day, not only during production. The percentage of compressor capacity lost to leakage should be less than 10 % in a well maintained large system. For small systems, leakage rates of less than 5 % are recommended. The amount of leakage in a poorly maintained CAS can be up to 25%.

Preventive maintenance programmes for compressed air systems should therefore include leak prevention measures and periodic leak tests. Once the leaks are found and repaired, the system should be re-evaluated.

Leakage reduction: stopping leaks can be as simple as tightening a connection or as complex as replacing faulty equipment such as couplings, fittings, pipe sections, hoses, joints, drains, and traps. In many cases, leaks are caused by badly or improperly applied thread sealant. Equipment or whole parts of the system no longer in use should be isolated from the active part of the CAS.

Several methods exist for leak detection; searching for audible noise caused by larger leaks, applying soapy water with a paint brush to suspect areas and ultrasonic acoustic detector. While leakage can occur in any part of the system, the most common problem areas are; couplings, hoses, tubes, and fittings, pressure regulators, open condensate traps and shut-off valves, pipe joints, disconnects, and thread sealants and compressed air tools. An additional way to reduce leakage is to lower the operating pressure of the system. With lower differential pressure across a leak, the leakage flow-rate is reduced.

Achieved environmental benefits: Energy savings. In addition to being a source of wasted energy, leaks can also contribute to other operating losses. Leaks cause a drop in system pressure, which can make air tools function less efficiently, which decreases productivity.

5. Filter maintenance

Pressure losses can be caused by badly maintained filters, either through inadequate cleaning or disposable filters not being replaced frequently enough.

Achieved environmental benefits: Energy savings, reduced emissions of oil mist and/or particles. It will involve increased use of filters, and discarding as waste.

6. Feeding the compressor(s) with cool outside air

Often the main compressor station is placed near the main equipment demanding compressed air, to decrease the pressure drops along the lines. It is not uncommon to find them placed in inner rooms inside the plant. In such cases, there is normally a lack of fresh air to feed the compressors, and the motors are compelled to compress the ambient air, which is generally at a temperature higher than the outside air temperature. For thermodynamic reasons, the compression of warm air requires more energy than the compression of cool air. Each increase of 5°C of inlet air temperature at the compressor causes an increase of about 2 % of the power needed. This energy can be saved simply by feeding the compressed air station with outside air, especially in cold seasons, when the difference between outside and inside temperatures can be several times greater than 5°C, depending on the location. Where possible a duct should be installed connecting the outside and the intake of the compressor. The outside intake should be placed on the north side of the plant, or at least in the shade for most of the time.

Reducing the compressors inlet air temperature by feeding cool air from the outside is always possible. Sometimes it is sufficient to open a circular hole in a wall, and install a duct connecting the outside intake with the compressor intake. When the CA station is located in a situation where access to the outside is difficult, the ventilation of the room should be improved. It is estimated to be applicable in 50 % of cases.

The reduction of the temperature of the air entering the compressor involves economic advantages such as: the cold air fed is free; the reduction of running use of compressors (savings of kWh); the reduction of electric power supply (savings of kW).

Achieved environmental benefits: Less consumption of primary energy resources. Due to the presence of the large amount of heat released by the compressor, whether it is recovered or not, the room temperature in CA stations is always high. It is not uncommon to find room temperatures of 30 - 35 °C, even in winter. Obviously, the greater the difference of outside – inside temperatures, the greater the power savings achievable.

7. Electrical motor driven sub-systems

An electric motor driven sub-system converts electric power into mechanical power. In most industrial applications, the mechanical work is transferred to the driven machine as rotational mechanical power (via a rotating shaft). Electric motors are the prime movers behind most printing industry machinery: pumps, fans, compressors, mixers, printing and platen presses, guillotines, etc.

The electricity consumption of motor systems is influenced by many factors such as; motor efficiency, proper sizing, motor controls: stop/start and speed control, power supply quality, mechanical transmission system, maintenance practices and the efficiency of end-use device.

In order to benefit from the available savings potential, the users should aim to optimise the whole system that the motor sub-system is part of, however, many of these topics concern the actual motor design and will not be considered under this BAT heading. Advice should be sought from the equipment manufacturer on such matters as energy efficient motors, proper motor sizing and variable speed drives. Three topics that could affect the energy consumption are transmission losses, motor repair and rewinding..

8. Transmission losses

Transmission equipment including shafts, belts, chains, and gears should be properly installed and maintained. The transmission system from the motor to the load is a source of losses. These losses can vary significantly, from 0 to 45 %. When possible, use synchronous belts in place of V-belts. Cogged V-belts are more efficient than conventional V-belts. Helical gears are much more efficient than worm gears. Direct coupling has to be the best possible option (where technically feasible), and V-belts avoided

9. Motor repair

Motors above 5 kW can fail and are often repaired several times during their lifetime. Laboratory testing studies confirm that poor motor repair practices reduce motor efficiency of typically between 0.5 and 1 %, and sometimes up to 4 % or even more for old motors.

To choose between repair and replacement, electricity cost/kWh, motor power, average load factors and the number of operating hours per year will have to be taken into account. Proper attention must be given to the repair process and to the repair company, which should be recognised by the original manufacturer (an energy efficient motor repairer, EEMR).

Typically, replacement of a failed motor through the purchase of a new EEM can be a good option in motors with a large number of operating hours. For example, in a facility with 4000 hours per year of operation, an electricity cost of EUR 0.06/kWh, for motors of between 20 and 130 kW, replacement with an EEM will have a payback time of less than 3 years.

10. Rewinding

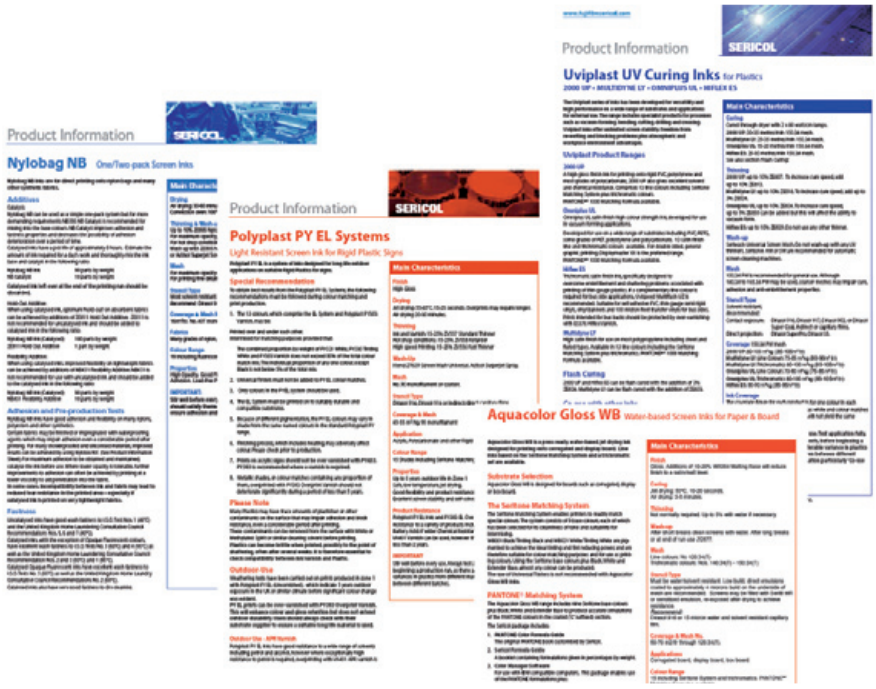
Rewinding a motor is carried out widely in industry. It is cheaper and may be quicker than buying a new motor. However, rewinding a motor can permanently reduce its efficiency by more than 1 %. Proper attention must be given to the repair process and to the repair company, which should be recognised by the original manufacturer (an energy efficient motor repairer, EEMR). The extra cost of a new motor can be quickly compensated by its better energy efficiency, so rewinding may not be economic when considering the life-time cost.

Achieved environmental benefits: The table below shows potentially significant energy savings measures which might be applicable to a motor driven sub-system. Although the values in the table are typical, the applicability of the measures will depend on the specific characteristics of the installation.

Driven sub-system energy savings measure	Typical savings range
System installation or renewal	
Energy efficient motors (EEM)	2-8%
Correct sizing	1-3%
Energy efficient motor repair (EEMR)	0.5-2%
Variable speed drives (VSD)	4-50%
High efficiency transmission/ reducers	2-10%
Power quality control	0.5-3%
System operation and maintenace	
Maintenance, Lubrication, adjustments, tuning	1-5%

techniques

17. environmental management techniques



Within the European Union, many organisations have decided on a voluntary basis to implement environmental management systems based on EN ISO 14001 or the EU Eco58 management and audit scheme (EMAS). EMAS includes the management system requirements of EN ISO 14001, but places additional emphasis on legal compliance, environmental performance and employee involvement; it also requires external verification of the management system and validation of a public environmental statement. Many larger organisations are stipulating that products will be preferentially purchased from companies that have an accredited environmental system.

Medium and smaller printing companies

Many of the principles enunciated within this part of the FESPA Planet Friendly Guide can be used without attempting to conform to the rigours of a formalized environmental management system.

It should be noted that the information published within this section of the Guide does not contain all the requirements for compliance to EN ISO 14001 and EMAS but covers those topics raised within the Guide. Companies wishing to comply with either EN ISO 14001 or EMAS should acquire the necessary standards from the appropriate organisations.

Larger printing companies

An Environmental Management System (EMS) is a tool that printers can use to address the design, construction, maintenance, operation and decommissioning issues in a systematic, demonstrable way. An EMS includes the organisational structure, responsibilities, practices, procedures, processes and resources for developing, implementing, maintaining, reviewing and monitoring the environmental policy. Environmental management systems are most effective and efficient

Responsibility

It is essential that the Chief Executive Officer of the company is wholly committed to the successful operation of the EMS. There is a need to specify the roles and responsibilities of staff including the appointment of one specific management representative. This representative will oversee the implementation and continual improvement of the company's environmental performance. The company management must ensure that all staff are kept informed and trained in their roles to meet the standards laid down to meet the applicable EMS that has been selected.

The senior management will have to define the environmental policy and undertake regular reviews of the company's environmental performance.

Action Plan

- Appoint a senior management representative to implement the EMS
- Define the environmental policy
- Plan and establish agreed objectives and targets
- Implement the necessary operational procedures
- Institute checking and corrective action
- Conduct routine management reviews
- Prepare a regular environmental statement
- Obtain validation by a certification body or external EMS verifier
- Review design considerations for end-of-life plant decommissioning
- Development of the use of cleaner technologies
- Benchmark the company's performance

environmental management techniques

An EMS can take the form of a standardised or non-standardised ('customised') system. Implementation and adherence to an internationally accepted standardised system such as EN ISO 14001:1996 can give higher credibility to the EMS, especially when subject to a properly performed external verification. EMAS provides additional credibility due to the interaction with the public through the environmental statement and the mechanism to ensure compliance with the applicable environmental legislation. However, non-standardised systems can in principle be equally effective provided that they are properly designed and implemented.

Further details on Regulation (EC) No 761/2001 Official Journal L 114, 24/4/2001 allowing voluntary participation by organisations in a Community eco-management and audit scheme (EMAS), can be obtained from
http://europa.eu.int/comm/environment/emas/index_en.htm

Information on EN ISO 14001:2004 can be obtained from
http://www.iso.org/iso/home.htm

Best Available Techniques (BAT)

An environmental management system can provide a number of advantages, these are:

- improved insight into the environmental aspects of the company
- improved basis for decision-making
- improved motivation of personnel
- additional opportunities for operational cost reduction and product quality improvement
- improved environmental performance
- improved company image
- reduced liability, insurance and non-compliance costs
- increased attractiveness for employees, customers and investors
- increased trust of regulators, which could lead to reduced regulatory oversight
- improved relationship with neighbours and environmental groups.

The following key issues need to be considered to achieve an accredited EMS or improve the environmental performance of the printer.

For the medium and smaller printer who does not have the manpower resource to implement EMS it is possible to pick applicable parts of the BAT shown below to achieve both environmental and financial benefits.

• Environmental policy

The senior management is responsible for defining an environmental policy for the company and ensuring that it is appropriate to the nature, scale and environmental impacts of the activities of the company. It must include a commitment to pollution prevention and control as well as the need to comply with all relevant applicable environmental legislation and regulations, and with other requirements to which the organisation subscribes. This could include the compliance with the EN 71-3 Toy Standard where it is applicable. It must provide the framework for setting and reviewing environmental objectives and targets and is documented and communicated to all employees as well as available to the public and all interested parties.

• Planning

There needs to be procedures to identify the environmental aspects of the installation, in order to determine those activities which have or can have significant impacts on the environment, and to keep this information up-to-date. There are also requirements for procedures to identify and have access to legal and other requirements to which the organisation subscribes and that are applicable to the environmental aspects of its activities.

It is necessary to establish and review documented environmental objectives and targets, taking into consideration the legal and other requirements and the views of interested parties such as neighbours and customers.

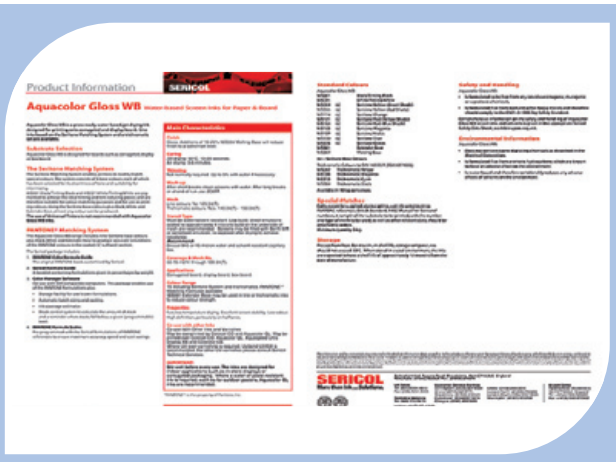
There is need to establish and regularly update the environmental management programme, including the designation of responsibility for achieving the objectives and targets at each relevant function and level as well as the means and timeframe by which they are to be achieved.

• Implementation and operation of procedures

It is important to have systems in place to ensure that procedures are known, understood and complied with, therefore effective environmental management includes:

- Structure and responsibility
- Training, awareness and competence
- Communication
- Employee involvement
- Documentation
- Efficient process control
- Maintenance programme
- Emergency preparedness and response

For more details, go to box on page 84-85


Product Information

Aquacolor Gloss WB

SERICOL

• Structure and responsibility

This includes defining, documenting and communicating roles, responsibilities and authorities, and particularly the appointment of one specific management representative to oversee the implementation and continued adherence to the desired standard (in large companies).

The provison that resources essential to the implementation and control of the environmental management system are available, including human resources and specialised skills, technology and financial resources.

• Training, awareness and competence

There is a requirement to identify training needs to ensure that all personnel whose work may significantly affect the environmental impacts of the activity are aware of the implications.

• Communication

It is necessary to establish and maintain procedures for internal communication between the various levels and functions of the company as well as procedures that foster a dialogue with external interested parties and receiving, documenting and, where reasonable, responding to relevant communication from external interested parties. These interested parties could include customers, neighbours, local and state authorities.

• Employee involvement

A critical matter is getting the employees involved in the process to achieve a high level of environmental performance by using appropriate forms of participation such as the suggestion-book system, project-based group works or environmental committees.

• Documentation

It is essential to establish and maintain up-to-date information, in paper or preferably electronic form, to describe the core elements of the management system and their interaction and to provide direction to related documentation.

• Efficient process control

There must be adequate control of processes under all modes of operation, i.e. preparation, start-up, routine operation, shutdown and abnormal conditions. There is a need to identify the key performance indicators and methods for measuring and controlling these parameters (e.g. airborne solvent emissions, water quality, waste levels and energy consumption).

A system for documenting and analysing any abnormal operating conditions is required so as to identify the root causes and then address them to ensure that these events do not recur (this can be facilitated by a 'no-blame' culture where the identification of causes is more important than apportioning blame to individuals).

• Maintenance programme

It is important to establish a structured programme for maintenance based on the technical descriptions of the equipment, norms etc. as well as any equipment failures and consequences. Such a system will support the maintenance programme by appropriate record keeping systems and diagnostic testing clearly allocating responsibility for the planning and execution of maintenance.

• Emergency preparedness and response

An essential topic is the establishment and the maintenance of procedures to identify the potential for and response to accidents and emergency situations, and for preventing and mitigating the environmental impacts that may be associated with them.

• Checking and corrective action

As with any part of the printing process it is necessary to check a system and institute corrective measures if the necessary standard is to be maintained. It is therefore essential that the key subjects are measured and monitored, recorded and the corrective action taken. An EMS is no different and the following sub-headings give guidance on this topic:

- Monitoring and measurement
- Corrective and preventive action
- Records
- Audit
- Periodic evaluation of legal compliance

For more details, go to box on page 86-87

For those companies undertaking the formalized approach will require compliance to the following procedures:

- Management review
- Preparation of a regular environmental statement
- Validation by certification body or external EMS verifier
- Design considerations for end-of-life plant decommissioning
- Development of cleaner technologies
- Benchmarking

For more details, go to box on page 87-88

• Monitoring and measurement

It is necessary to establish and maintain documented procedures to monitor and measure, on a regular basis, the key characteristics of operations and activities that can have a significant impact on the environment, including the recording of information for tracking performance, relevant operational controls and conformance with the site's environmental objectives and targets (e.g. Plant Friendly Emissions to air on solvent emissions)

There is a need to establish and maintain a documented procedure for periodically evaluating compliance with relevant environmental legislation and regulations. These can be reviewed by examining the various subjects such as emissions to air, emissions to water, waste control that are covered within the Planet Friendly Guide.

• Corrective and preventive action

There is a requirement for establishing and maintaining procedures that define the responsibility and authority for handling and investigating non-conformance with permit conditions. There is also the need to cover other legal requirements as well as objectives and targets. A system needs to be in place for taking action to mitigate any impacts caused and for initiating and completing corrective and preventive action that are appropriate to the magnitude of the problem and commensurate with the environmental impact encountered.

• Records

Records are an essential part of any EMS. Without such the system will collapse. Therefore there is a need to establish and maintain procedures for the identification, maintenance and disposition of legible, identifiable and traceable environmental records, including training records and the results of audits and reviews.

• Audit

The audit is the critical means of determining the company's compliance with the EMS. Therefore there is a need to establish and maintain a programme and procedures for periodic environmental management system audits that include:

- discussions with personnel, inspection of operating conditions and equipment and reviewing of records and documentation and that results in a written report, to be carried out impartially and objectively by employees (internal audits) or external parties (external audits), covering the audit scope, frequency and methodologies, as well as the responsibilities and requirements for conducting audits and reporting results, in order to determine whether or not the environmental management system conforms to the planned arrangements and has been properly implemented and maintained,

- completing the audit or audit cycle, as appropriate, at intervals of no longer than three years, depending on the nature, scale and complexity of the activities, the significance of associated environmental impacts, the importance and urgency of the problems detected by previous audits and the history of environmental problems (more complex activities with a more significant environmental impact are audited more frequently),

- having appropriate mechanisms in place to ensure that the audit results are followed up.

• Periodic evaluation of legal compliance

It is necessary to review compliance with the applicable environmental legislation and the conditions of the environmental permits held by the company as well as evidence on the documentation of the evaluation.

• Management review

The review carried out by the senior management demonstrates the commitment to improving the environmental performance of the organisation. It should be carried out at intervals that it determines to ensure the continuing suitability, adequacy and effectiveness of the environmental management system. There must be in place adequate documentation for the review ensuring that the necessary information is collected to allow management to carry out this evaluation in a meaningful and pertinent manner.

• Preparation of a regular environmental statement

The preparation of an environmental statement is required to pay particular attention to the results achieved by the installation against its environmental objectives and targets. It is regularly produced usually once a year or less frequently depending on the significance of emissions, waste generation etc. It considers the information needs of relevant interested parties and it is publicly available (e.g. customers, share holders, trade associations, libraries etc.).

When producing a statement, the operator may use relevant existing environmental performance indicators, making sure that the indicators chosen:

- give an accurate appraisal of the installation's performance
- are understandable and unambiguous
- allow for year on year comparison to assess the development of the environmental performance of the installation
- allow for comparison with sector, national or regional benchmarks as appropriate
- allow for comparison with regulatory requirements as appropriate.

- **Validation by certification body or external EMS verifier**

Having the management system, audit procedure and environmental statement examined and validated by an accredited certification body or an external EMS verifier can, if carried out properly, enhance the credibility of the system. With some major companies an external verified system is necessary before they are willing to make a purchase.

- **Design considerations for end-of-life plant decommissioning**

It is prudent to give consideration to the environmental impact from the eventual decommissioning of the unit at the stage of designing a new plant, as forethought makes decommissioning easier, cleaner and cheaper. This is because decommissioning poses environmental risks for the contamination of land (and groundwater) and generates large quantities of solid waste.

- **Development of cleaner technologies**

Environmental protection should be an inherent feature of any process design activities carried out by the printer, since techniques incorporated at the earliest possible design stage are both more effective and cheaper. Giving consideration to the development of cleaner technologies such as UV curing inks can often produce productivity gains as well as environmental improvements. Further examples can be located within the various sections of this Guide such as Emissions to air, Emissions to water, Waste control, Hazardous substances and Energy management.

- **Benchmarking**

It is possible to carry out systematic and regular comparisons with sector, national or regional benchmarks, including for energy efficiency and energy conservation activities, choice of input materials, emissions to air and discharges to water (using for example the European Pollutant Emission Register, EPER), consumption of water and generation of waste. This enables the printer to compare the environmental performance of other similar companies.

18. best practices for screen printers

Just a reminder to think, while you are setting your workflow, about a few crucial points where you have to take care of some environmental concerns.

1. At Prepress

(a) Graphic base	Direct projection reduces the silver intermediaries, economises on products and energy. Care must be taken to recycle all silver from photographic work. The use of thermal and digital is possible for some types of work. Using CTS (from computer to screen) can also reduce waste and energy consumption.
(b) Type of fabric	Polyester or Nylon (polyamide) mono filament.
(c) Tension of screen	Self-stretching frames or mechanically stretched saves energy. The best operation is the pneumatic stretching.
(d) Glues for fabrics	Self-stretching frames are economical with products and eliminates emissions from solvents. The cyano-acrylate adhesives have a smaller impact on health and environment, but a more restrictive use. No instructions for safe use.
(e) Preparation of fabric	Aqueous moistening agents work best.
(f) Stencilling, Emulsion, Indirect, Capillary, Direct/indirect	Choose products without phthalates (some are reputably dangerous as endocrine disruptors) and surfactants such as nonyl phenol ethoxylates. Be sure the sensitisers are free of dichromate. Recycle and treat water to eliminate the solids in suspension and dissolved products. If the capillary system is chosen, recycle the film base (polyester PET based substrate)
(g) Fillers	Better to use an aqueous based product: Choose the products not containing phthalates and nonyl phenol ethoxylates.
(h) Health at work	With the above choices, some stencilling products can be irritants – look for data on the composition showing risks of side effects (do they have an allergic reaction?) The adhesives can cause allergies: protect the skin and insure good ventilation. Always protect the eyes and skin when using chemicals.

2. On Press

(a) Substrates	Avoid products whitened with chlorine; try to use the recycled products, when possible. Avoid substrates that contain phthalate based plasticizers, as they can be dangerous, or heavy metals. The dosage of heavy metals must not exceed the level specified in the Rule for toys EN71 & the Directive for packaging 94/62/EC when possible.
(b) Ink, diluters and retarders	Naturally, choose UV or aqueous inks. If you have to use solvent inks, make sure the aromatic hydrocarbons content is as low as possible. Also make sure that the pigments and additives present a minimal level of risk. Check the content of heavy metals using the same rule and directive as above. Select inks and thinners that are not designated toxic and preferably not harmful.
(c) Screen cleaners	Not needed with UV inks. If needed with solvent inks, use as little as possible and try to use products containing only a small amount of aromatic hydrocarbons.
(d) Dryers/Energy	UV - Make sure, when possible, there is minimal ozone production and energy consumption. Evaluate the efficiency of the dryer. The IR and jet-air dryers must be tested and evaluated for solvent and aqueous inks. It is better to use jet-air dryers instead of open racks.
(e) Emissions/Reduction	Emissions do not exist with UV inks and they are considerably less with water-based inks when compared to solvent inks. Avoid producing ozone in the work place by using a good extractor system in the UV reactor.
(f) Health in the work place	With the above choices, UV inks before curing can sometimes cause skin irritation. Wherever possible only use products that comply with the Acrylate Preference Criteria Protect the skin by using nitrile rubber gloves. Solvents can be both dangerous and cause allergies. Check the OES/MAK etc. levels by consulting the data sheets. Measure the level of and extraction is in place and working properly. Always protect the skin and the eyes when using inks and chemicals.

3. At Post-Press

(a) Screen cleaning	With inks that are water-based/co-solvents, water can be used, but you must make sure the local authorities accept the waste water. If the inks are solvents, choose products containing low volatility. Use an enclosed cleaning machine whenever possible. Verify the flash-point of the solvents for the antiexplosive equipment of the machine. It is preferable to choose products with a high flash-point. N.B. Higher flash-point increases the drying time of the inks.
(b) De-coating	Products with a periodic acid base are recommended, but at less than 2% concentration. A flow of pressurised water increases the efficiency when tanks are used. Make sure the residues are treated before discharge to the sewer or alternatively by an authorised company. In some cases, it might be necessary to cut the screen fabric and eliminate it as waste.
(c) Traces/ghost images	Favour the alkaline systems. The HP gun reduces the use of chemicals; take care with splashes. It is sometimes necessary to neutralise the residue before disposal. If you use systems containing chlorides, make sure to have the lowest possible grade of chlorine.
(d) Treatment of liquid waste	Collect and treat the solids, reduce the SS and colloidal materials in suspension. Verify that the pH stays between 6-8.
(e) Ink rejects	Many UV inks can be classified as H4 irritants when uncured. Solvent ink can be combustible H4/5. Identify waste using a code of 6 digits. Ink waste is classed 080312 (dangerous) or 080313 (non-dangerous). A computerised system of ink preparation can reduce waste materials.
(f) Cutting scraps, packaging and off-cuts	Paper or cardboard can be collected for recycling. Separate the plastics to recycle if possible, into different categories : PVC, PET, PMMA, PR, PS etc.
(g) Solvent wastes	Solvents can have a danger level of H3 “flammable” or H4 “Irritant”. They are classified under items 40603 or 200113.

safety data sheets

Finally, learn how to read the safety data sheets, your suppliers and manufacturers are obliged to give you. These sheets, according to the European Directive are divided into 16 sections and must contain the following information:

1. Name of product/supplier
2. Identification of dangerous components
3. Identification of risks
4. First Aid in case of accident or wrong use
5. Measures to be taken against fire
6. Measures to be taken for accidental spills and leaks
7. Handling rules and storage
8. Controls on exposure & protection of staff
9. Chemical and Physical properties
10. Stability and reactivity
11. Toxicological information
12. Ecological information
13. Collecting waste
14. Information on shipping rules
15. Information about the supply if dangerous
16. Additional data

To find what you need to know, follow the 4 recommendations below:

1. **Verify that the risk identification corresponds to the product label**
2. **Verify dangers (Section 3) if there are none then store as usual using good industrial hygiene (Section 7)**
3. **Should the product present a danger, then follow the rules given for storage**
4. **Make note of the duties for personal protection (Section 8) and safe conditions of use (Section 8 to 10)**

Make sure **the instructions for work are read** and keep the safety data sheets in an easily accessible place in case of emergencies so that First Aid can be administered in the correct manner (Section 4), fire (Section 5), spills (Section 6) illness through toxics (Section 11),waste disposal (Section 12 & 13) and any legal considerations (Sections 1, 2,14 and 15)

annexes

A) Replacement of the volatile cleaning solvents

The European Union's position for the management of volatile solvents follows a tendency to focus on the points below:

- To reduce emissions of volatile hydrocarbons
- Prohibit the use of di/tri-chloro ethane in cleaning solvents and chemicals that have carcinogenic, mutagenic or repro-toxic effects.
- To discourage the use of solvents with noxious smells in the neighbourhood, such as toluene, methyl iso-butyl ketone, xylene.
- To restrict the use of highly volatile solvents where the flash point is lower than 21ºC (group 1) soon to be 50ºC (group 2)
- To recommend the use of solvents from group 3 (C3 flash point between 50ºC & 100ºC) better still group 4 (HBS flash point above 100º)

Directive **67/548/EEC** relating to the classification of dangerous substances is applicable – with the exception of Xi (irritating) in combination with R36/37/38 (irritating for the eyes, the lungs and the skin). This will be replaced by **REACH EC 1907/2006**.

This pressure is actually peculiarly strong in Denmark, Netherlands, Germany and France. However, starting from the principle that EC politics is always based on the requirements of one of the most stringent member states, we can soon expect a general application of these rules.

Many products available are based on mixtures and users should examine **the safety data sheet** to ascertain whether any of the constituents present are group 1 or 2 substances. A list of frequently used solvents is supplied here in an **addendum**. Most of them are directly or indirectly, available in Europe. Users should be aware that there are different methods for determining the flash point of a chemical that can result in slight variances in the temperature that is quoted. The addendum lists each chemical with its **CAS©** (Chemical Abstract Service) number. The CAS number is an internationally accepted means of identifying a substance. It's given as an individual chemical can appear under different names (trivial, IUPAC or commercial description) in the safety data sheet.

To see this list on the addendum, see page 94

B) General terms, abbreviations, acronyms and substances

We often read many abbreviations and acronyms, without knowing their real meaning! That is why it was evident for us that such a listing as the one here under would be very useful for our readers. To see those terms, abbreviations, acronyms and substances, see page 95 onwards

Addendum

Group 1 (F Pt <21ºC)
- Acetone (CAS 67-41-1)
- n-Butyl acetate (CAS 123-86-4)
- iso-Butyl acetate (CAS 110-19-0)
- Cyclohexane (CAS 110-82-7)
- Ethyl acetate (CAS 141-78-6)
- Tetrahydrofuran (CAS 109-99-9)
- Toluene (CAS 108-88-3)
- Methyl iso-butyl ketone (CAS 108-10-1)
- Methyl ethyl ketone (CAS 78-93-3)
- Propan-1-ol (CAS 71-23-8)

Group 2 (F Pt 21 - < 50ºC)
- Amyl acetate (CAS 628-63-7)
- Solvent Naphtha (CAS 64742-95-4)
- Solvent Naphtha (CAS 64742-95-5)
- Butan-1-ol (CAS 71-36-3)
- 2-Butoxyethanol (CAS 111-76-2)
- 1-Ethoxy propan-2-ol (CAS 1569-02-4)
- 1-Propoxypropan-2-ol (CAS 1569-01-3)
- Trimethyl benzene (CAS 108-67-8)
- Ethyl lactate (CAS 97-64-3)
- 2-Methoxy ethanol (CAS 109-86-4)
- 2-Methoxy ethyl acetate (CAS 110-49-6)
- 1-Methoxypropan-2-ol (CAS 107-98-2)
- 1-Methoxy-2-propyl acetate (CAS 108-65-6)
- Stoddard Solvent (CAS 64742-82-1)
- Xylene (CAS 108-36-3)

Group 3 (F Pt 50 – 100ºC)
- 2-Butoxyethyl acetate (CAS 112-07-2)
- Cyclohexanone (CAS 108-94-1)
- Diacetone alcohol (CAS 123-42-0)
- Diethylene glycol mono-butyl ether (CAS112-34-5)
- Diethylene glycol mono-ethyl ether (CAS 111-90-0)
- Diethylene glycol mono-methyl ether (CAS 111-77-3)
- Dipropylene glycol mono-ethyl ether (CAS 34590-94-8)
- 1-Ethoxy-2-propyl acetate (CAS 54839-24-6)
- n-Methyl pyrrolidone (CAS 872-50-4)

Group 4 (F Pt > 100ºC)
- Benzyl alcohol (CAS 100-51-6)
- Diethylene glycol ethyl ether acetate (CAS 112-15-2)
- Ethylene glycol (CAS 107-21-1)

TERM	MEANING
Acid	a proton donor: a substance that liberates hydrogen ions in water
Aerobic	a bliological process that occurs in the presence of oxygen
alkali (base)	a proton acceptor. A substance that liberates hydroxide ions in water solution
anaerobic	a biological process which occurs in the absence of oxygen
AOX	adsorbable organic-halogen compounds. The total concentration in milligrams per litre, expressed as chlorine, of all organic halogen compounds (except fluorine) present in a sample of water that are capable of being adsorbed on activated carbon
BAT	best available techniques
biodegradable	that can be broken down physically and/or chemically by microorganisms. For example, many chemicals, food scraps, cotton, wool and paper are biodegradable products
BOD	biochemical (or biological) oxygen demand: a measure of the content of organic matter in water and wastes. It is the amount of dissolved oxygen required by micro-organisms in order to decompose organic matter. The unit of measurement is mg O_2/l. In Europe, BOD is usually measured after 3 (BOD3), 5 (BOD5) or 7 (BOD7) days.
b.p	Boiling point
BREF	BAT reference document
CAS	Chemical Abstract Service
CEN	European Committee for Standardization
CMR	carcinogenic, mutagenic and repro-toxic: applied to substances that have all or some of these hazardous properties
COD	chemical oxygen demand: the quantity of oxygen absorbed chemically (by a sample). The test conditions are strongly oxidising using potassium dichromate that oxidises virtually all organic compounds. The unit of measurement is mg O_2/l
containment, contained area	(secondary) containment refers to additional protection against storage tank releases over and above the inherent protection provided by the tank container itself. There are two major types of secondary containment for leakages, namely those that are part of the tank construction, such as double tank bottoms (only for above ground tanks), double skinned and double walled tanks and impervious barriers which are placed upon the soil surface below the tanks
cross-media effects	the calculation of the environmental impacts of water/air/soil emissions, energy use consumption of raw materials, noise and water extraction (i.e. everything required by the IPPC Directive)
DIN	Deutsche Industry Norm
EC	European Commission

effluent	physical fluid (water together with contaminants) forming an emission
EFTA	European Free Trade Association
EIPPCB	European IPPC Bureau
ELY	emission limit values: the mass, expressed in terms of certain specific parameters, concentration and/or level of an emission, which may not be exceeded during one or more periods of time
EMAS	environmental management and audit scheme
emission	the direct or indirect release of substances, vibrations, heat or noise from individual or diffuse sources in the installation into the air, water or land
EMS	environmental management system
'end-of-pipe' technique	a technique that reduces final emissions or consumptions by some additional process but does not change the fundamental operation of the core process. Synonyms: 'secondary technique', 'abatement technique'. Antonyms: 'process-integrated technique', 'primary technique' (a technique that in some way changes the way in which the core process operates, thereby reducing raw emissions orconsumptions)
environmental footprint	a measure of the burden or impact that a product, operation or business places on the environment. For IPPC, this will be: • the consumption of energy, raw materials and water • emissions to air, water, groundwater, and soil; and as waste • damage to material property and the impairment or interference with amenities and other legitimate uses of the environment. IPPC includes a consideration of noise and vibration, dust and odour. It does not include aspects such as life cycle analysis of products
EQS	environmental quality standard
EU	European Union
EUA	European Union Allowance: the term used for the trading units for the EU carbon trading scheme in EUR per tonne CO_2
existing installation	an installation in operation or, in accordance with legislation existing before the date on which a Directive is brought into effect, an installation authorised or in the view of the competent authority the subject of a full request for authorisation, provided that installation is put into operation no later than one year after the date on which this Directive is brought into effect
flocculation	waste water treatment involving gentle stirring whereby small particles are chemically attached to substances such as bentone to create larger particles so their weight causes them to settle to the bottom of the treatment tank

footprint	a company's environmental impact determined by the amount of depletable raw materials and non-renewable resources it consumes to make its products, and the quantity of wastes and emissions that are generated in the process
fugitive emission	in this document, the SED definition is used: any emissions not in waste gases of VOCs into air, soil and water as well as (unless stated in the SED) solvents contained in products. They include uncaptured emissions released to the outside environment via windows, doors, vents and similar openings (conversely, see also waste gas)
HBS	high boiling solvents
IBC	intermediate bulk container
IDOP	integrated downwind ozone production: a measure of the reactivity of a solvent in creating tropospheric ozone
installation	a stationary technical unit where one or more activities listed in a specific Directive are carried out, and any other directly associated activities which have a technical connection with the activities carried out on that site and which could have an effect on emissions and pollution
IPA	iso propyl alcohol
IPPC	integrated pollution prevention and control
K1, K2 and K3	an indication of flammability used in the Netherlands and Belgium, according to flashpoint: • K1:<21°C • K2:21-55°C • K3: >55 °C
LCA	life cycle assessment
LEL	lower explosion level
MEK	methyl ethyl ketone
monitoring	process intended to assess or to determine the actual value and the variations of an emission or another parameter, based on procedures of systematic, periodic or spot surveillance, inspection, sampling and measurement or other assessment methods intended to provide information about emitted quantities and/or trends for emitted pollutants
ODP	ozone depletion potential: a relative index indicating the extent to which a compound may cause ozone depletion
OEL	occupational exposure limit
OEM	original equipment manufacturer
OFP	ozone-forming potential

operator	any natural or legal person who operates or controls the installation or, where this is provided for in national legislation, to whom decisive economic power over the technical functioning of the installation has been delegated
ozone depletion	destruction of the stratospheric ozone layer, which can be caused by the phototytic breakdown of certain compounds containing chlorine and/or bromine (e.g. chlorofluorocarbons), which catalytically decompose ozone molecules
PBTs	persistent, bio-accumulative and toxic substances
pH	Measure of acidity and alkalinity
POCP	photochemical ozone creation potential pollutant individual substance or group of substances which can harm or affect the environment
POP	persistent organic pollutants
ppm	parts per million (by weight)
RH	relative humidity
secondary	see end-of-pipe technique
SED	Solvent Emissions Directive
SME	small and medium enterprises
specific emission	emission related to a reference basis, such as production capacity,or actual production (e.g. mass per tonne or per unit produced)
STP	standard temperature and pressure
TLV	threshold limit values: guidelines (not standards) prepared by the American Conference Governmental Industrial Hygienists, Inc (ACGIH) to assist industrial hygienists in decisions regarding safe levels of exposure to various hazards found in the workplace. A TLV® reflects the level of exposure that the typical worker can experience without an unreasonable risk of disease or injury. TLVs® are not quantitative estimates of risk at different exposure levels or by different routes of exposure
TOC	total organic carbon: a test to assess the amount of organic carbon in a sample
VOC	volatile organic compounds
waste gas	in this document, the SED definition is used: the final gaseous discharge containing VOCs or other pollutants, from a stack or abatement equipment into the air.
WFD	Water Framework Directive: Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for water use.

Common units, measurements and symbols

TERM	MEANING
normal atmosphere	(1 atm = 101325 N/m^2)
bar	bar (1.013 bar = 1 atm)
billion	thousand million (10^9)
°C	degree Celsius
cm	centimetre
d	day
g	gram
h	hour
K	kelvin(0°C = 273.15K)
kg	kilogram (1 kg = 1000 g)
kPa	kilopascal
kWh	kilowatt-hour (1 kWh = 3600 kJ = 3.6MJ)
L	litre
m	metre

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