Flexography and packaging gravure

Process description: Flexography

Flexography has now become the dominant relief printing process, a position previously held by letterpress printing. Flexographic printing employs direct rotary printing using resilient relief plates such as rubber or, more likely these days, photopolymers and fast-drying solvent or water-based inks.

Flexography is almost exclusively a reel or web-fed process. It is very much an in-line process, the printing operation being linked to other production processes so that, from the basic reel of paper, board, cellophane or plastic, a finished product such as sealed paper, plastic bag or flat-finished carton, is produced.

Specially designed flexo presses now produce a wide range of printed products. It is particularly suitable for long-run web printing, but is very adaptable to a wide range of substrates - from thin paper to heavy corrugated board, thin cellophane to thick flexible sheeting, vinyls and foils. Web printing is available in single colour and multicolour with more than eight colours-but sheet-fed presses are used for heavy board.

The process’ main applications are flexible packaging, cartons for liquids, a few newspapers, paperback books, labels, paper/plastic bags, cartons/packaging and wall coverings.

Of course, opportunities are being sought to use water-based inks wherever possible, and they are being used successfully on paper sacks and corrugated cartons in particular. As the quality of the process improves, more (higher quality) products can be printed, but these will mainly use solvent-based inks, at least to start with.

Process description: Gravure

Gravure is an intaglio process, that is, the image is recessed into the surface of the plate or cylinder. In this process, the cylinder is flooded with ink, and the surface scraped clean to leave ink only in the recessed, image areas.

Gravure, like flexo, uses low-viscosity inks, nearly all of them being solvent based. The inks used do, however, vary depending on whether they are being used to print publications or packaging. Publication inks rely totally on toluene, whereas packaging inks, like flexo inks, use a variety of, mainly, aliphatics. Water-based gravure inks have not yet proved very successful. Because of the solvent inks used, all gravure presses are fitted with dryers.
General Introduction

‘Flexo and packaging gravure’ includes the technically very similar processes of solvent-based laminating and varnishing. This is in conformity with the definitions in the VOC directive.

Instead of solvent-based inks, varnishes and adhesives, water-based products or products which are otherwise solvent free, may be used. These products are however difficult to apply in packaging gravure, they are not fit for all of the many different substrates used for the manufacture of flexible packaging materials, and they cannot meet all of the many complicated demands which may be put to these packaging materials.

Some examples of the complex demands which may be put to flexible packaging materials:

- Flexible packaging materials may be required to be resistant against acids, solvents, fats or oils coming from the food which is to be packed.
- The varnish may be required to have a certain resistance against slip in order to accommodate for the specifics of the packaging machines.

The varnishes or adhesives may need specific sealing qualities to make the packaging material impregnable.

Although there are limitations to the application of water-based products; there are some fields in which they are very successful.

- All sheetfed flexography on board and all flexo printed newspapers are printed with water-based inks.
- Most webfed flexo for paper packaging materials can be printed with water-based or UV curing inks.
- Many complex laminates can be produced with two component solvent free adhesives.

The environmental implications of water-based printing are different from printing with solvent-based products. They are treated not treated here.

Trend

The general demand for lighter and smaller packaging materials increases the demand for flexible packaging materials.

In printing on paper and board, there is a trend towards using water-based inks. In lamination, there is a trend towards using two-component solvent free adhesives.

Thresholds

- Very small solvent input: < 15 tons per year
- Small solvent input: 15 – 25 tons per year
- Large solvent input: > 25 tons per year

These thresholds are the same as the thresholds in the VOC directive.

Introduction to the recommendations

Introduction

Solvent-based inks, varnishes and adhesives as used in flexography and packaging gravure are very liquid. In their press ready state, they contain some 80% solvent. The other 20% is solid matter, which will ultimately compose the dry ink.
Once the ink, adhesive or varnish has been applied, the substrate is fed through a dryer. There it is heated and large volumes of air are blown over the substrate (temperature depending on substrate, 40 – 180 °C; the highest temperature for aluminium foil only). The solvent evaporates and is removed with the airflow. In the unabated situation, the solvent laden air is exited through stacks.

The airflow volume is to a large extent determined by the need to avoid fire and explosions. Additionally in the manufacture of packaging materials for food, the need to limit the residual solvent to mere micrograms per m², also makes for large airflow.

Most of the solvent will evaporate inside the dryers. Some will however not evaporate under these contained conditions. Mixing of inks, make-ready at the press, evaporation from the printed material before it has reached the dryer, cleaning of presses and press materials etc. give rise to evaporation outside the dryers. If no action were taken, all this non contained evaporation would escape to the environment via windows, doors, vents etc.

Several different measure are taken to limit the proportion of this uncontained evaporation to become fugitive emissions. The dryers generally take a large proportion of their air requirement from the direct surroundings of the press. During make ready and press cleaning, a part of the dryer ventilation is left on. Ink mixing area and washing machines have local extraction.

Not very much is known about the proportion of the solvents that is emitted fugitively. Neither is much known about the most effective ways in which to reduce these emissions when necessary. Until recently, not much attention was paid to this subject.

The actual amount of the fugitive emissions is believed to run as high as a third of the solvent input. The attainable level has been estimated based on information from more or less comparable publication gravure plants. The estimated attainable levels of the packaging gravure plants were roughly adjusted for the numerous differences between publication gravure and flexible packaging printing.

More will be known in the near future, when national legislation in several Member States will demand the annual determination, and if necessary a reduction of the fugitive emissions. The most frequently used solvents in flexible packaging printing are:

- Ethyl acetate
- Ethanol
- Methyl ethyl ketone

In addition, some small amounts of other solvent will be found such as propylacetate, butylacetate, isopropanol and butanol. These are generally added in small amounts for specific purposes, such as slowing down the evaporation process slightly.

Where the same processes are used for another purpose than producing packaging materials for foodstuff, other solvents than those mentioned above may be found.

**Unabated situation**

In the unabated situation, no solvent-based ink, varnish or adhesive will have been substituted, and there is an uncontrolled emission of all the solvents, which are used.

Widely differing estimations of the total potentially unabated emissions from ‘Printing in flexography & packaging gravure: solvent-based’ can be found in several sources. The order of magnitude seems to be some 300 to 400 kTons per year. (Based on an extrapolation of Dutch statistics and an estimation based on the EU ink consumption for packaging materials)
It is estimated that the printing plants which presently (1998) already control their emissions account for roughly half of the EU solvent consumption in this part of the industry.

**Abated situation**

In the abated situation a combination of controls may be in place. Some solvent-based products may have been substituted, the dryer exhaust will be led to an incinerator or a solvent recovery installation and fugitive emissions will kept to a minimum through many different means.

The result of this abatement effort will vary with plants size, available machinery and the kind of products that are made. The efficiency of end of pipe equipment is known to be 95% or higher. The remaining fugitive emissions are estimated to no more than 20 and 25% of solvent input, where the higher figure will apply to smaller plants. The industry average can be expected to be lower than those figures.

In total, it is very roughly estimated that, industry wide, in the abated situation some 20% of the unabated emissions will remain. Better estimations can only be given once more is known about fugitive emissions and the possibilities of controlling these.

<table>
<thead>
<tr>
<th><strong>Recommendations</strong></th>
<th><strong>Applicable to</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1: Reduce solvent emissions with a flexible and plant specific combination of substitution, end-of-pipe abatement and avoidance of fugitive emissions.</td>
<td>All plants</td>
</tr>
<tr>
<td>2: Reduce total solvent emissions to no more than 30 or 25 % of the unabated solvent input</td>
<td>Small and large plants respectively</td>
</tr>
<tr>
<td>3: Reduce dryer airflow up to a maximum solvent concentration of either 25 or 50% of LEL</td>
<td>In case of incineration. See provisions.</td>
</tr>
<tr>
<td>4: End of pipe abatement designed for average rather than maximum airflow. (Peakshaving)</td>
<td>In case of end of pipe abatement equipment</td>
</tr>
<tr>
<td>5: Annual solvent balances</td>
<td>All plants</td>
</tr>
</tbody>
</table>

**Not recommended**

| 7: Reduce solvent emissions to no more than qq % of the unabated solvent input. | Very small plants |
| 8: Reduce end of pipe solvent emissions to no more than xx mg/Nm³ |

### 1: Reduce solvent emissions with a plant specific combination of substitution, end-of-pipe abatement and avoidance of fugitive emissions.

**Description**

There are in principal four practical methods of reducing solvent emissions.

- **Substitution:** Solvent-based inks, varnishes or adhesives may in some cases be substituted by products that contain little or no solvent. There are three main categories of substitutes:
products that dry through the evaporation of water, products that dry through polymerisation by UV curing and two component products that dry mainly through a chemical reaction.

- **Incineration**: The exhaust air from the dryers, which is laden with solvents, is led through an incinerator or oxidiser. There the solvents are destroyed. The solvent concentrations do not suffice to support a straightforward incineration process. Heat exchangers and catalysts are needed reduce the need for fuel drastically.

- **Solvent recovery**: Solvents may be recovered from the drying air. Modern methods allow dry recovery of solvents that mix with water, as those used in flexible packaging printing. After distillation, a large proportion can be re-used in the printing process, the excess can be sold. Both investment and running costs are higher than those of incineration are. Break even between incineration and solvent recovery lies between a consumption of 500 and 1000 tons of solvent per year.

- **Reduction of fugitive emissions**: Reduction of fugitive emissions is aided by avoiding useless evaporation of solvent (for example by keeping all solvent containers well closed), by increasing the capture efficiency (for example point extraction where inks are mixed and machine parts are cleaned) and by extraction of uncaptured evaporated solvents from the factory and leading those towards the dryers. But little quantitative information is available, and experience is yet limited.

**Flexibility**: The most suitable approach is generally a combination of two or three of the methods mentioned above. Very large plants may combine solvent recovery with introduction of solvent free adhesives and a reduction of fugitives. In medium sized plants the variety in production techniques, substrates and product specifications may be such that the need for flexibility makes incineration the only sensible solution. Very small plants printing only paper in flexography may be able to avoid investments in abatement equipment and aim exclusively for substitution.

The variation in needs and possibilities is such that a flexible, plant specific approach is needed.

**Cost**

- **Substitution**: It is difficult to compare the costs of water-based or otherwise solvent free inks, varnishes and adhesives with the traditional solvent-based products. It must however be kept in mind that the solvent content of solvent-based products accounts for less than 10% of the cost: the other ingredients are far more important.

  For water-based inks it can be said that the price per kg as delivered is higher, but dilution with water is cheaper than with solvents. Also the area covered with each kg is larger, but the energy consumption for drying the ink is somewhat higher. More waste is generated and the cost of disposal is higher. The overall cost per m² of printed material will generally be somewhat higher than the cost of solvent-based inks.

  For varnishes and adhesives, no general valid statement can be made.

- **Incineration**: The investment in an incinerator varies with the required capacity. Regenerative incinerators are generally suitable. The investment can be estimated with the following rule of thumb: minimum 200,000 € for a capacity between zero and 10,000 m³/h, plus 10 to 15 € for each additional m³/h above 10,000. This does include a simple centralised collection duct, but not the cost for optimisation of the airflow. The fuel demand can be low, so the electric fan mainly determines the running costs. The running costs are some 15,000 € per year for each 10,000 m³/h.
• **Solvent recovery:** The investment in solvent recovery will be 0.5 to 1 million € over the investment in an incinerator. The running costs are between 0.15 and 0.25 € per recovered kg of solvent. Where the solvent consumption is less than 500 tons per year, it is very unlikely that solvent recovery will be an economically attractive alternative to incineration.

Solvent recovery in flexible packaging printing is complex, because of the mixture of solvents that are generally used. Most of these solvents form azeotropic mixtures both with water and with each other. Complex dehydration and distillation are necessary. Even then, a part of the recovered solvents will unavoidably reappear as a mixture and will have only limited use. The proportion of the recovered solvents which is not reusable in house and which needs to be sold, depends largely on the ratio between the amounts of ethanol and ethyl acetate that are used in the production process. This ration in turn depends on the processes in use and the products that are made. Generally where ethyl acetate makes over 90% of the total, the re-usable amount may be such, that the plant becomes almost self sufficient and no longer needs to buy ethyl acetate for dilution purposes.

• **Reduction of fugitive emissions:** To reduce useless evaporation of solvents does not require large investments or substantial running costs. Point or floor extraction in themselves are not overly expensive, but feeding the extracted air to abatement equipment increases the needed capacity and thus the investment and running costs of that equipment. Extraction of the air for the dryers from the factory is generally a normal procedure. In many cases this airflow is enough to prevent exceedence of the occupational exposure limits in the plant. Increasing that airflow however beyond what is needed for drying purposes increases the needed capacity of abatement equipment beyond reason.

Reduction of fugitives also reduces the smell

**Provisions**

Recommendations 3 & 4 (Reduce dryer airflow up to a maximum solvent concentration of either 25 or 50% of LEL & End of pipe abatement designed for average rather than maximum airflow) are essential in finding a plant specific economically possible solution.

Recommendation 2: ‘Reduce total solvent emissions to no more than 30 or 25% of the unabated solvent input’ describes the level of emission reduction that should be regarded as BAT for different plant sizes.

**2: Reduce total solvent emissions to no more than 30 or 25% of the unabated solvent input**

**Description**

Flexibility is needed to allow the most cost effective reduction option to be found for each plant. Where this flexibility is given, some kind of reference is needed to determine what emission reduction should be regarded as BAT. In annex IIb of the VOC directive a method for determining such a reference is given. The same method is proposed in this document.

The reference is an emission reduction in the most straightforward, but not necessarily the most cost effective, way: incineration and control of fugitive emissions, but no substitution. The remaining emissions will consist of the fugitive emissions and some end of pipe emissions which have escaped incineration. The maximum allowed total remaining emissions are expressed as a percentage of the unabated emissions. (In the VOC directive this ‘unabated emissions’ is called the ‘reference emission’)
Where no substitution has taken place, the unabated emissions are equal to the solvent input. Where some substitution has taken place however, the unabated emissions need to be estimated. The method in annex IIb of the VOC directive can generally be retained for this purpose. The average solvent content of press ready inks, varnishes and adhesives in packaging gravure and flexo is approximately 80%. The solid matter in these products accounts for 20% of the total weight, and thus ¼ of the solvent weight. The unabated emissions (‘reference emission’) can be estimated by multiplying the weight of all the solids, of both solvent-based and water-based products, by four.

In large plants, where less than 50% of the solvents have been substituted, this method can however be very imprecise. Small variations in actual solvent content in the remaining solvent-based products can make for vastly differing emission reductions that need to be achieved. In these cases it is more precise to equate the unabated emissions to the actual solvent input (both through solvent-based and water-based products) plus four times the solid weight in the water-based products.

The possibilities for emission reduction improve with the size of the plant. Not only does the investment in abatement equipment get proportionally smaller, but it is also easier in large plants to control uncaptured evaporation and thus avoid fugitive emissions.

Consequently, the remaining emissions as a percentage of the unabated emissions that must be regarded BAT differs with plant size. The figures are given in the table below. For comparison the comparable figures from Annex IIb of the VOC directive are given.

<table>
<thead>
<tr>
<th>Plant size</th>
<th>Threshold</th>
<th>% of unabated</th>
<th>Comparable figure from Annex IIb VOC directive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very small</td>
<td>&lt; 15 t/a</td>
<td>See below</td>
<td>Not in scope</td>
</tr>
<tr>
<td>Small</td>
<td>15 – 25 t/a</td>
<td>30%</td>
<td>30%</td>
</tr>
<tr>
<td>Large</td>
<td>&gt; 25 t/a</td>
<td>25%</td>
<td>25%</td>
</tr>
</tbody>
</table>

**Very small plants:**

For very small plants no figure is given. For these plants, substitution is the only economically possible option: even the smallest end of pipe abatement equipment far exceeds their possibilities for investment. Where in these plants substitution is technically possible, it should be implemented. But where substitution is technically not possible, leaving the situation unchanged is BAT.

**Remarks**

Finding and implementing the most cost effective emission reduction method takes time. Testing and introducing water-based products, reducing airflows, drawing up the specifications for incinerators and recovery installations, adapting working methods to reduce fugitive losses, all take time.

Printing plants should be given time for these preparations. On the other hand, printing plants should also start their preparations well before the date on which the emission reductions must have been achieved.

**Cost**

See previous recommendations.

**Provisions**
See previous recommendations.

3: Reduce dryer airflow up to a maximum solvent concentration of either 25 or 50% of LEL

**Description**

Both the investment and running costs of end of pipe abatement equipment are largely determined by the maximum airflow that needs to treated. Each additional m³/h that needs to be treated, increases the investment with some 10 to 15 € for incineration and 15 to 20 € for solvent recovery.

In order to keep end of pipe abatement equipment affordable, the maximum airflow to be treated needs to be reduced as much as is safely possible. The reduction of the airflow is however limited by the need to avoid risks of fire and explosions: the smaller the airflow, the higher the solvent concentration and thus the greater the danger of fire and explosions.

For safety reasons the ventilation rate in the dryers is designed in such a way that the maximum solvent concentration that can possibly occur does not exceed a certain percentage of the lower explosion limit of the solvents concerned.

Where the cost of the abatement equipment is not an issue, large safety margins are often employed. These however need to be re-evaluated when an investment in abatement equipment is necessary. The safety margin determines the maximum air flow and therefore the minimum size of the abatement equipment.

Solvent concentrations are expressed as a maximum percentage of the ‘Lower Explosion Limit’. (% LEL)

The following % LEL should be considered safe, in order to keep end of pipe abatement equipment an economically possible option.

<table>
<thead>
<tr>
<th>Situation</th>
<th>Maximum % of LEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dryers heated by open flame or electricity.</td>
<td>25%</td>
</tr>
<tr>
<td>Dryers heated by open flame or electricity with extensive safety features</td>
<td>50%</td>
</tr>
<tr>
<td>Dryers heated by thermal oil or steam</td>
<td>50%</td>
</tr>
</tbody>
</table>

The indications above are in conformity with the provisional EU standard on dryers prEN 1539

**Remarks**

In flexo or packaging gravure plants, where no measures have been taken to reduce the airflow, the average solvent concentration in the exhaust air may be no more than 1 to 2 g/m³.

For solvents like ethanol, ethylacetate or MEK, the LEL at the relevant operating temperatures is somewhere near 50 g/m³. A level of 25% LEL will be some 10 or 12 g/m³. This will be the maximum concentration in each individual dryer, and this concentration cannot be reached in all the dryers at the same time. Where measures have been taken to reduce the airflow, the average solvent concentration can rise to 4 to 6 g/m³.

The ‘extensive safety features’ which are necessary to allow 50% LEL will include continuous measurement of the % LEL in potentially dangerous places in the dryer and automatic stoppage of the presses when the allowed maximum is reached.
Cost
The cost of increasing solvent concentrations and reducing the airflow depends not only on the age and build of the presses, but also the size of the reduction which is achieved.

Where end of pipe abatement is to be installed, it is generally wise to reduce airflow until the marginal cost of further reductions become equal to the marginal cost of additional capacity of abatement equipment. This is for incinerators approx. 10 to 15 € per m³.

Reduction of airflow also reduces the energy consumption. As less air is used, less needs to be heated. Since however the drying temperatures are low (40 to 60 °C), these savings in themselves do not generally warrant the investment.

4: End of pipe abatement designed for average rather than maximum airflow.
(Peakshaving)
Description
Packaging gravure and flexographic presses have dryers on each colour unit. Each dryer is capable of drying a 100% coverage of ink or varnish at maximum press speed. But at maximum only two out of mostly eight units actually do provide this coverage. The other units provide ink to cover only a small proportion of the substrate or are not used at all. For safety reasons however, the maximum airflow from the press is equal to the sum of all the maximum airflows of the respective print units.

In most printing plants there are several different presses, laminating machines and varnishing units. All have a certain maximum airflow. But very rarely do all these machines operate at once. Even when a factory is working to full capacity, machines stand still for some 50% of the time for make ready. Almost never will the maximum airflow of the whole plant be used.

Where the capacity of abatement equipment is smaller than the maximum airflow of the plant, some of the time, some of the solvent laden air will need to be bypassed. This is called ‘peakshaving’.

Peakshaving can in most flexible packaging plants be regarded to be BAT. Bypassing on an annual basis a few percent of the solvent emissions, may reduce the capacity need, and thus both investment and running costs, by up to 50%. It is cheaper to reduce fugitive emissions by an extra few percent than to design the abatement equipment for the full ventilation capacity.

Remarks
To what extent peakshaving makes practical sense, needs to be established at plant level. A computer simulation can quickly show the influence of peakshaving on both the emissions and the costs.

Where in the VOC directive Annex IIb applies, end of pipe emission limit values do not apply. This implies that peakshaving in these cases is condoned, as long as the prescribed emission reduction is actually achieved.

Where drying air volumes are reduced in order to reduce the required capacity of an incinerator or recovery installation, it may be found that the factory ventilation is no longer adequate. In such a case, the presses do no longer extract enough air from the factory to guarantee compliance with prevailing occupational exposure limits. In such a case additional factory ventilation will be needed. This in turn will increase the fugitive emissions.

Where peakshaving is allowed, it may be possible to reduce the dryer airflows slightly less than technically possible without needing extra abatement capacity. In doing so the need for
additional factory ventilation may be prevented, and an increase of fugitive emissions may also be prevented.

**Cost**

Peakshaving prevents investment and running costs of end of pipe abatement equipment from becoming excessive.

Simulations were done at a model flexible packaging plant with a solvent input of circa 1,000 tons per year and a maximum airflow of 80,000 m³/h.

Each step in the table below represent a change in capacity of 2,000 m³/h and a marginal additional investment of circa 20 to 30,000 €.

<table>
<thead>
<tr>
<th>Incineration capacity as % of maximum airflow</th>
<th>Tons solvent bypassed per year</th>
<th>Marginal €/kg in case of abatement</th>
</tr>
</thead>
<tbody>
<tr>
<td>92.5 – 95.0</td>
<td>0.24</td>
<td>24,00</td>
</tr>
<tr>
<td>90.0 – 92.5</td>
<td>0.99</td>
<td>5,80</td>
</tr>
<tr>
<td>87.5 – 90.0</td>
<td>1.29</td>
<td>4,47</td>
</tr>
<tr>
<td>85.0 – 87.5</td>
<td>2.27</td>
<td>2.56</td>
</tr>
<tr>
<td>82.5 – 85.0</td>
<td>4.04</td>
<td>1.45</td>
</tr>
<tr>
<td>80.0 – 82.5</td>
<td>6.19</td>
<td>0.95</td>
</tr>
<tr>
<td>77.5 – 80.0</td>
<td>9.04</td>
<td>0.67</td>
</tr>
</tbody>
</table>

**Provisions**

In the VOC directive, application of annex IIb is reserved for emission reduction methods, ‘other’ than those assumed in Annex IIa (i.e. other than a simple combination of end of pipe abatement and some control on fugitives). The directive does not prescribe what exactly are ‘other’ methods. For the purpose of this document, it is necessary that reducing fugitive emissions further than required by Annex IIa is regarded as an ‘other’ method. This allows the proposed exchange between some end of pipe emissions and this reduction of fugitives.

**5: Annual solvent balances**

**Description**

With solvent balances a plant should keep track of its solvent emissions. Compliance with goals, plans and regulations must be checked with these balances. They also provide an instrument to determine if and where in the plant, the emissions are larger than intended.

Solvent balances whose function it is to prove compliance to regulations or environmental permits should be drawn up annually. This frequency is however not good enough to prevent plants from not complying. For that purpose, they need to keep track of solvent input and emissions more frequently. Except in very simple cases, monthly solvent balances are a minimum requirement for several years, until the plant has established a record of accomplishment of faultless balances.

The annual balance should not be the mere sum of all the monthly balances. It should be made separately, from original data, as far as possible. This annual balance should than be compared to the sum of the monthly balances. The causes of discrepancies should be found.

**Remarks**
Annex III of the VOC directive provides guidance on the possible content of solvent management plans. Simplified versions dedicated to specific kinds of printing plant, can be expected to be put forward by industrial federations in the industry.

**Cost**

Once a proper routine is established and where necessary adequate flow meters are introduced, drawing up the monthly solvent balances in large plants will take one or two man days.

Though in principal the same thing, the annual solvent balances will take some days more due to the checking of discrepancies with the sum of the monthly balances.

**Provisions**

Evidently making solvent balances is only a useful exercise in packaging gravure and flexo plants where solvent-based inks, varnishes or adhesives are used.

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**6: Recovery of excess heat produced by incinerators.**

**Description**

Modern regenerative incinerators can be designed to work without the addition of fuel when the solvent concentration in the air to be treated, is some 2 g/m³. In flexo and packaging gravure plants with modern equipment, average concentrations of 4 to 6 g/m³ are attainable when the airflow has been optimised. Under these circumstances, incinerators can be designed to produce excess heat, which can be recovered and used in production processes.

There are however serious limitations to the applicability of this recommendation:

- To recover and transport the excess heat requires additional investment. This investment is such that it can only be recovered with lower energy costs, if all the excess heat can actually be used and if no additional investments are necessary to be able to use this heat.
- In the average flexo and packaging gravure printing plant, the amount of excess heat is larger than can be utilised. The main heat consumers are the dryers on the presses. Incinerating one gram of solvents can heat one m³ of air by circa 25°C. There are circa 3 to 4 g/m³ available: enough calories to heat each m³ by 75 to 100°C. The needed temperature rise for the drying air is however on average only some 30°C. More than half the recovered heat can not be used if the dryers are the only large energy consumers.
- The recovered heat needs to be transported. For this purpose, steam or thermal oil are suitable. Most dryers in the industry however operate with an open gas flame or electricity. Using the excess heat from the incinerator for the dryers would imply replacement of all the dryers: an investment that could never be recovered with the decrease of the energy costs.

**Cost**

Investments in energy recovery should, just as energy saving measure, show a return in order to be recommended as BAT.

**Provisions**

Considering the above, the requirements that need to be met for energy recuperation from incineration to be recommended, are the following:

- The plant needs to have more large energy consuming processes than only the dryers on the presses.
• The energy demand must be in the form of steam or thermal oil

**7: Reduce solvent emissions to no more than qq % of the unabated solvent input. (Very small plants) (NOT RECOMMENDED)**

*Description*

Packaging gravure and flexographic printing plants with an annual solvent input of less than 15 tons per year, are extremely small. Although in most small plants solvent-based inks can be substituted by either water-based or by UV curing inks, this is not always be the case.

In cases where substitution is not possible, investment in end of pipe abatement should not be demanded of these small plants.

**8: Reduce end of pipe solvent emissions to no more than xx mg/Nm³ (NOT RECOMMENDED)**

*Description*

Restricting solvent emissions by limiting the concentration of solvents in the exhaust air, takes away the much needed flexibility. It does not allow an exchange between substitution and reduction of fugitives and end of pipe abatement.
FURTHER INFORMATION

The information above was provided by Intergraf and Euroflex in June 2001. It is based upon ‘Printing and the Environment’, the award winning document providing guidance on Best Available Techniques in Printing Industries.

This document covers all the existing printing processes and considers over 200 different candidates for Best Available Techniques. It is available in English, Spanish and Polish.

Contact Intergraf, Euroflex or National Printing Federations for further information.

ADDRESS

<table>
<thead>
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<td>E-mail: <a href="mailto:AMDeNoose@Intergraf.org">AMDeNoose@Intergraf.org</a></td>
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