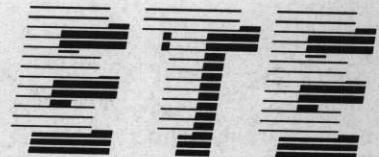


~~21/8/08~~ 21/8/08 - FROM THE ORIGINAL APP. SO CIRCA  
1993, BUT INTERESTING TO COMPARE  
WITH THE MARCH 2008 A2 PERMIT.

## AIR POLLUTION FROM PRINTWORKS

### 'ALTERNATIVE ANSWERS'

Presented at the British Printing  
Industry Federation 'Printer &  
the Environment' conference by Ron  
Constantine, Managing Director of  
pollution control specialists,  
ETE Limited

The logo for ETE Limited, consisting of the letters 'ETE' in a bold, stylized font. Each letter is formed by multiple horizontal lines of varying lengths, creating a sense of motion or a digital, layered appearance.

## INTRODUCTION

The recent introduction of the Environmental Protection Act establishes a new regime of legislation and controls designed to restrict the contamination of the environment by industry.

Without exception, all companies and processes which generate prescribed waste products will be forced to curb the creation of pollutants and to implement treatment regimes which comply with standards established by Her Majesty's Inspectorate of Pollution. Within the printing sector, it is those processes which generate as a waste by-product exhaust air emissions containing a high concentration of volatile organic compounds (VOC's) which will be most affected by the new controls.

Specific emission standards for individual printing processes are currently being drafted, and recommendations made on the type of abatement systems which need to be deployed in order to meet the levels specified. In order to promote the use of pollution control techniques which are in themselves environmentally benign, it is likely that the emission levels are to be banded with higher emission limits permissible with control systems, which are essentially energy-efficient and which generate no secondary contaminant by-products.

There is no single control system which can be recommended for all applications, with the final choice dependant upon the type of printing process, the different substrates and inks used and the drying techniques applied. Selection of an optimum system for each plant requires an inherent knowledge of these variables, complemented by an understanding of the new emission limits, and the costs - both financial and environmental - associated with the use of the many emission control techniques now available.

### 1. PRINTING TECHNIQUES

The major printing techniques likely to be the subject of impending air pollution control legislation include:-

- offset
- rotogravure
- flexographic
- screen printing

These different techniques are utilised for a range of substrates and require a variety of ink formulations and drying techniques. Each of these variables will contribute towards the type and quantity of volatile organic compound emitted to atmosphere.

Consequently, careful consideration will be required to ensure that the most suitable air pollution control technique is selected for each particular application.

### 2. INK CHARACTERISTICS AND DRYING TECHNIQUES

#### 2.1 Ink Characteristics

The composition of ink varies depending upon:-

- the type of printing process
- the drying technique
- the type of substrate to be printed
- the technical printing specification required (i.e. resistance to light, transparency, heat resistance etc.)

Inks are composed of:-

- resins or binders dissolved in solvents
- solvents controlling the fluid properties of the ink
- colour pigments

- additives

The types of ink utilised can be broadly categorised as viscous inks and liquid inks. The viscous inks are of high viscosity, and low volatility with boiling points generally in excess of 230°C. Liquid inks are of low viscosity and high volatility, with a high concentration of low boiling point (75°C - 135°C) hydrocarbons.

#### 2.2 Drying Techniques

The techniques utilised for the drying of these inks affects the degree of VOC emissions.

Liquid inks are dried by forced evaporation of the solvents using hot air at temperatures of between 75°C and 135°C.

Viscous inks are dried by a variety of techniques:-

- Evaporation (forced) at high temperature - typically using hot air at 200°C - 300°C.
- Absorption of inks into the substrate.
- Oxidation at ambient temperature (reaction between atmospheric oxygen and resins to give a solid)
- Chemical reaction (polymerisation) of solvents under UV light or electron beam).

### 3. EMISSION CHARACTERISTICS OF THE DIFFERENT PRINTING PROCESSES

#### 3.1 Offset

The following presses, inks and methods of drying are encountered:-

- Cold set web offset is used for printing newspapers, magazines and books with absorbent papers. Viscous inks are used containing typically 60-70% of paraffinic hydrocarbons with boiling points of between 270-360°C. Inks dry by oxidation at ambient temperatures aided by adsorption on porous material.

These inks do not give rise to VOC emissions; however, cleaning solvents and dampening solutions which may contain up to 15% of alcohol (typically isopropyl alcohol) can produce fugitive VOC emissions.

- Heat set web offset is used for printing magazines, catalogues, and books with non-absorbent papers. Viscous inks containing typically 40-65% of hydrogenated hydrocarbons with boiling points of 230-270°C are utilised. A very rapid drying of the inks is achieved by forced evaporation of solvents at high temperature with thermal dryers.

Heat set web offset processes, operating at temperatures of up to approximately 300°C, emit VOC's which may be different from the solvent components in the ink - caused by cracking of solvents at the high temperature. Dryers are designed to evaporate approximately 85-90% of the solvents contained in the inks deposited on the substrates to be printed. The remaining 10-15% of solvents are absorbed into the paper and will evaporate slowly due to their very low vapour pressure at ambient temperature. For heat set web offset installations without abatement devices, an emission factor of 0.35 kg VOC per kg of ink used can be estimated. This will be reduced to less than 0.02 kg VOC per kg of ink with an abatement device fitted.

It has been estimated (in 1989) that 100% of heatset web offset presses in Germany are fitted with abatement devices; 70% in Italy; 60% in U.K; and 20% in France.

- Sheet fed offset used for printing magazines, advertisements, posters, metallic substrates etc. The viscous inks typically comprise 20-30% hydrogenated hydrocarbons with boiling points of between 270°C and 340°C. Depending

upon the substrate, the inks dry by oxidation and/or absorption on porous material.

These inks do not give rise to VOC emissions; however, cleaning solvents and dampening solutions which may contain up to 15% alcohol can produce fugitive VOC emissions.

### 3.2 Rotogravure

Rotogravure is used for printing publications and packaging on absorbent (various types of paper) and non-absorbent substrates (plastic, cellulose, metals etc.).

Rotogravure inks are characterised by a very low viscosity (liquid inks) and high volatility.

For publications, printing inks with 50% of solvents are used comprising aliphatics (boiling points 100-120°C) or mixtures of aliphatics and toluene. Accordingly, the VOC components will comprise mainly toluene and low boiling aliphatic hydrocarbons. Due primarily to the high toluene content, all rotogravure printing machines in this sector are equipped with solvent recovery equipment. A VOC emission factor of 0.1 kg of solvent per kg of undiluted ink has been estimated for modern systems.

For packaging/decorative printing, inks with 60% of solvents with low boiling points (75-135°C) such as; esters (ethyl acetate); alcohols (ethyl alcohol); ketones (methyl ethyl ketone); aliphatic hydrocarbons (boiling point 100-120°C); and glycols (ethoxypropanol) are utilised.

Drying of the ink is achieved by forced evaporation using hot air at 80-120°C and is a major source of VOC emissions. A VOC emission factor of 1.6 kg of VOC per kg of undiluted ink has been estimated for installations without abatement equipment.

### 3.3 Flexographic

Flexographic printing is used on absorbent substrates (different types of paper) and on non-absorbent substrates (cellulose, plastic and metal).

Flexographic inks are characterised by a very low viscosity (liquid inks) and high volatility. They have the same characteristics as rotogravure inks used for packaging/decorative printing and are dried by forced evaporation using hot air at 80-120°C.

Flexographic printing of paper, plastics, aluminium, etc. are, therefore, a major source of VOC emissions. A VOC emission factor of 1.6 kg of VOC per kg of undiluted ink has been estimated for installations without abatement equipment.

In certain instances, water based inks containing up to 15% alcohol content are utilised.

### 3.4 Screen

Screen printing is used for a wide variety of substrate - including paper, cardboard, plastic, wood, glass, textile etc.

The screen inks have a variety of compositions. Typically, they contain 50% of solvents including aromatic and aliphatic hydrocarbons (boiling points 160-180°C) and glycols. The ink is often dried by heat although UV drying is also used.

Screen printing inks represent only a small percentage of the total ink consumption. Although screen printing inks may contain up to 50% of medium-high boiling point solvents; the total VOC emissions are low and spread over a large number of small printing plants.

## 4. E.E.C. - VOC EMISSIONS

A study conducted in 1988 estimated VOC emissions arising from printing activities in the European Community, as

follows:

Printing type	VOC emission (tonne)	% of total
Heat set web offset	8,550	4.90
Publication rotogravure	7,750	4.50
Packaging/Decorative	151,700	87.20
Others, miscellaneous	6,000	3.40
	<u>171,000</u>	<u>100.00</u>

The above estimate is based on the following assumptions:

- 1) All rotogravure printing lines in publications are equipped with activated carbon adsorbers.
- 2) Heat set web offset installations are fitted with abatement systems - 100% in Germany; 70% in Italy; 60% in U.K. and 20% in other member states.
- 3) In packaging, 22% of ink consumption is water based.

Total VOC emissions arising from printing activities in the U.K. is estimated at 37,000 tonne per annum.

## 5. FUTURE U.K. LEGISLATION - AIR POLLUTION CONTROL - PRINTWORKS

The recent introduction of the Environmental Protection Act establishes a new regime of legislation and controls designed to restrict the contamination of the environment by industry.

Final emission limits have yet to be confirmed, however, from the latest draft document it is apparent that emissions from Printworks will be dealt with on a process to process basis and set at different levels to reflect the type of abatement equipment utilised.

The emission concentration limits contained in the latest draft are:-

Emissions of solvents from:-

- i) Heat set web offset (lithographic)
  - Total carbon content when solvent recovery system used 150mg/m<sup>3</sup>
  - Total carbon content when using incineration 50mg/m<sup>3</sup>
- ii) Flexographic (except food & medical)
  - (to be decided)
- iii) Flexographic (food & medical)
  - Above 5% aromatics 50mg/m<sup>3</sup>
  - Less than 5% aromatics
    - solvent recovery 200mg/m<sup>3</sup>
    - biological degradation 125mg/m<sup>3</sup>
    - incineration 75mg/m<sup>3</sup>
- iv) Gravure/Intaglio
  - Total carbon content when solvent recovery systems used 100mg/m<sup>3</sup>
  - Total carbon content for other arrestment systems 50mg/m<sup>3</sup>
- v) Others - laminating, di-isocyanates
  - (To be decided)

## 6. VOC EMISSION REDUCTION TECHNIQUES

The following techniques of VOC emission reduction can be used:

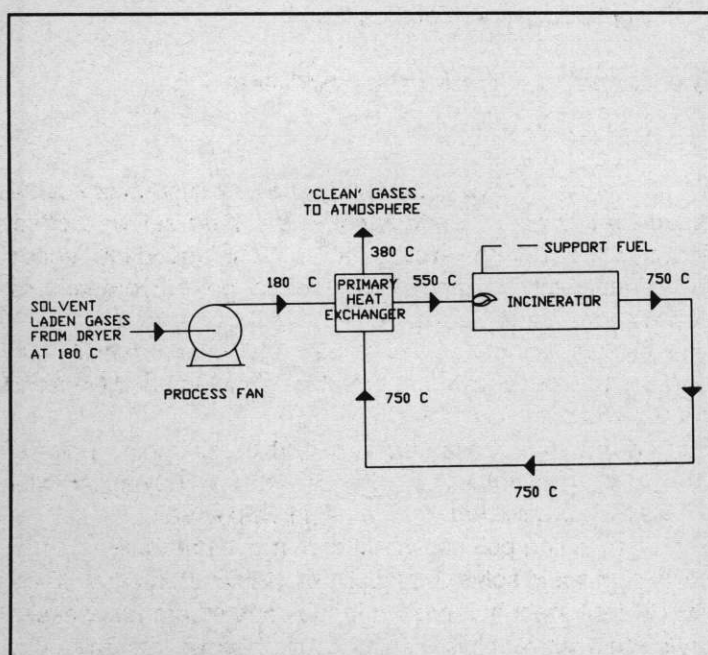
Destructive	:	thermal incineration
	:	catalytic incineration
	:	biological degradation
Non-Destructive (ie Solvent Recovery)	:	carbon adsorption
	:	condensing filtration
	:	absorption (oil scrubbing)
Substitution	:	water based inks
	:	radiation curable inks

The emission control techniques most commonly in use in the printing industry are thermal and catalytic incineration, carbon adsorption and condensing filtration. Each of these systems has advantages and disadvantages when applied to the exhaust emissions arising from the different printing processes.

### 6.1 Thermal Incineration

In thermal incineration techniques the dryer exhaust gases are raised in temperature to approximately 750°C. They are held at this temperature for a specific time in the presence of sufficient oxygen and turbulence to enable oxidation of the organic components in the exhaust stream to carbon dioxide and water vapour.

This technique is capable of achieving VOC emission reduction of between 90% and 99.5%. However, its major drawback is one of extremely high auxiliary fuel input in its basic form and it is likely that the incineration system would be provided, as a minimum, with a primary heat exchanger to preheat the dryer exhaust gases prior to entry into the incinerator combustion chamber.



**TYPICAL 'THERMOKLEEN' INCINERATION SYSTEM - WITH ENERGY RECOVERY**

## Thermal Incineration

### Advantages

- \* Wide range of applications
- \* High efficiency
- \* Multiple solvent capability

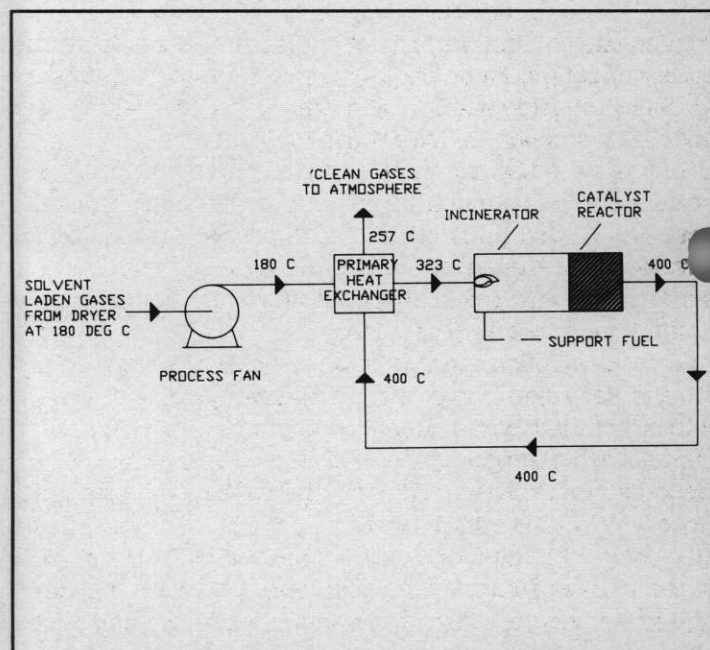
### Disadvantages

- \* High start-up costs
- \* High operating costs
- \* NO<sub>x</sub> and CO<sub>2</sub> generation
- \* High useage of natural resources (ie. oxygen and natural gas)

### 6.2 Catalytic Incineration

The incorporation of a catalyst with an incinerator provides a system suitable for the oxidation of organic components to carbon dioxide and water vapour at a much lower temperature than is necessary with a thermal incineration system.

The figure below illustrates the layout of a typical catalytic incinerator system. The catalyst bed usually comprises precious metal (typically platinum or palladium) or base metals dispersed on base metal supports, such as spherical pellets, ceramic rods, and ceramic/metal honeycomb. The efficiency of a catalytic incinerator is affected by:- operating temperature, space velocity, concentration and type of VOC, and catalyst characteristic. For systems operating in the printing industry typical operating temperatures for say heat set web offset emissions would be 350-420°C to achieve a VOC reduction efficiency of 95%.



**TYPICAL 'TWINKLEEN' CATALYTIC INCINERATION SYSTEM - WITH ENERGY RECOVERY**

## Catalytic Incineration

### Advantages

- \* Lower operating costs than thermal incineration
- \* Multiple solvent capability
- \* Less NO than thermal incineration system

### Disadvantages

- \* Limited applications due to poisons
- \* Particulates must be filtered out to avoid blinding of catalyst
- \* Maximum solvent concentration level
- \* Aging of catalyst. Efficiency reduces with time.
- \* Catalyst needs regular replacement.

## 6.3 Carbon Adsorption

Carbon adsorption removes VOC from an exhaust gas stream by adsorption of these VOC's onto the surface of the activated carbon.

Activated carbon distinguishes itself from other adsorbents by two main characteristics. Firstly, it has a high surface to volume ratio (approximately 10 m<sup>2</sup>/kg) and a pore diameter range of 10-20 micron. The surface adsorption is therefore supplemented by capillary adsorption. An order of magnitude capacity of adsorption results in 5 to 20 gm of VOC per 100 gm of activated carbon.

Carbon adsorption, usually involves two main steps:- adsorption and regeneration. However, for simplified operations with very low VOC concentrations it is possible to operate with non-reusable carbon.

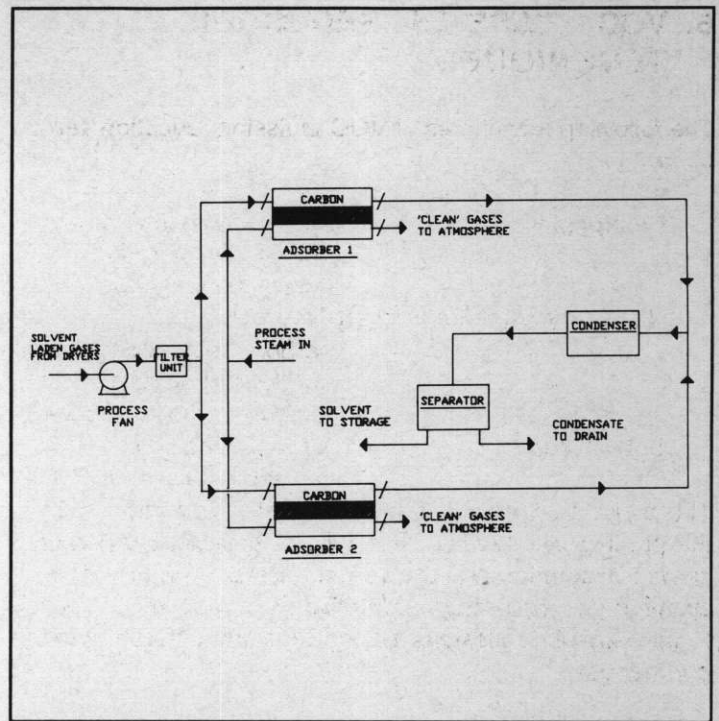
The adsorption cycle involves the passage of the solvent laden air through the bed of granular activated carbon. The solvent vapours are selectively extracted from the air and accumulate on the surface of the inner passages of the carbon (adsorption) or are trapped in the myriad capillaries (capillary consideration). The air leaves the carbon unit effectively stripped of solvent contaminants.

Eventually the carbon granules will become saturated with solvent and will require to be regenerated to restore the activated carbon to its original adsorptivity. Desorption refers to the liberation of the solvent vapours from the adsorbed state in order to effect their recovery and is accomplished during the regeneration.

Several desorption techniques may be utilised to regenerate the saturated carbon including desorption with steam, with a hot inert gas, and with a low pressure vacuum. A typical desorption technique is described below:-

Desorption with steam - Regeneration of a carbon bed saturated with VOC is most often accomplished with steam. The efficiency of this desorption cycle is a function of the amount of steam used during the regeneration cycle, of its temperature and pressure, of the type of compound adsorbed on the carbon and on the operating capacity of the carbon.

The steam/VOC mixture is then passed to a condenser and for water insoluble components (such as benzene, toluene, hexane) is separated by decantation. For water soluble components (such as ethanol and acetone) distillation is necessary for separation.



## 'ODORKLEEN' SOLVENT RECOVERY SYSTEM - WITH STEAM DESORPTION

### Carbon Adsorption

#### Advantages

- \* Recovery of solvent
- \* High efficiency
- \* Lower operational costs than incineration

#### Disadvantages

- \* Efficiency decreases with use
- \* Carbon requires regeneration
- \* Complex control functions
- \* Susceptible to auto-combustion

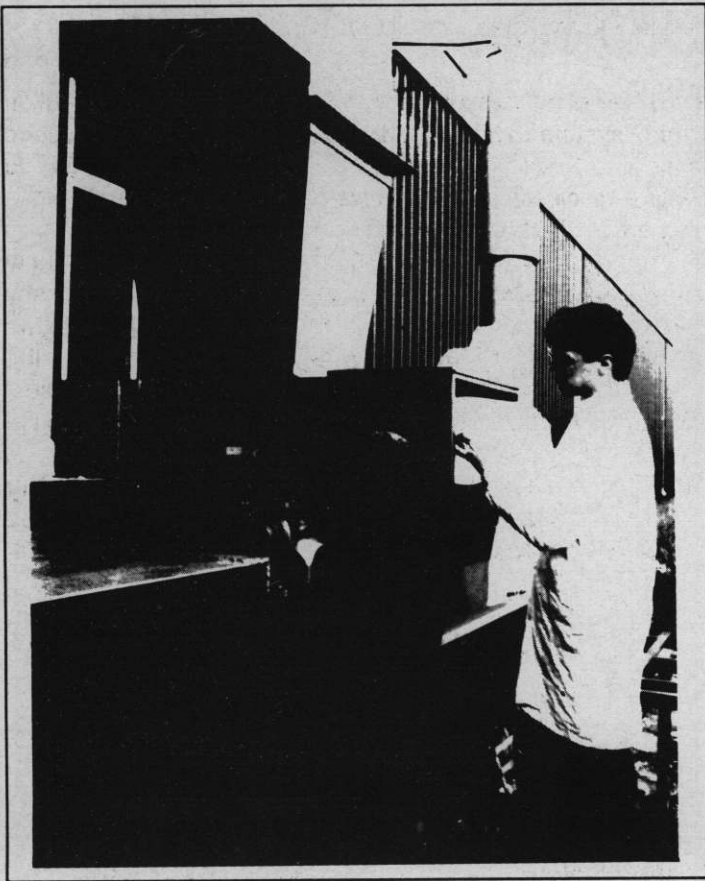
## 6.4 Condensing Filtration Solvent Recovery System

The condensing filtration solvent recovery system is a technique rapidly gaining popularity in the heat set web offset sector of the printing industry. It is a technique ideally suited for the efficient removal of high boiling point hydrocarbons from exhaust air streams.

The system comprises three main elements: a high efficiency condensation unit; a 'Printkleen' moving bed filter and a mist eliminator unit.

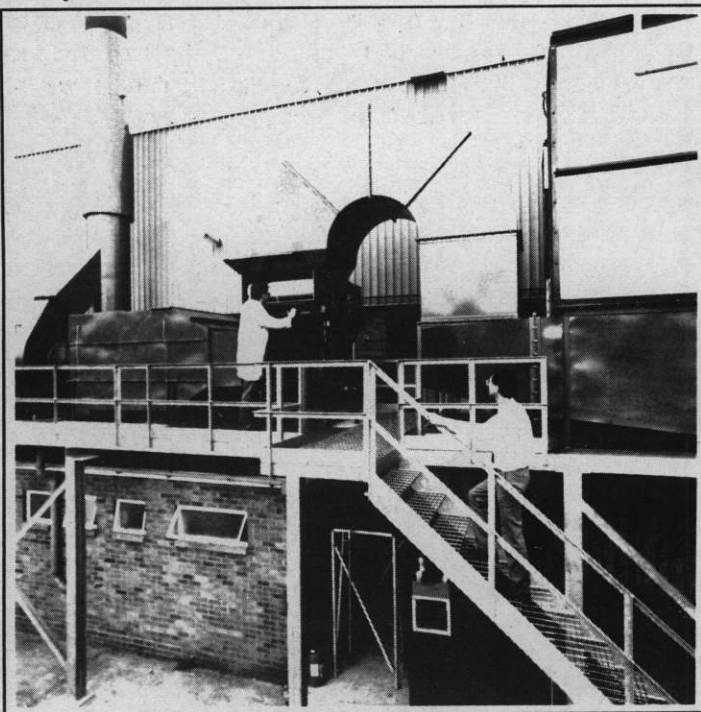
The dryer exhaust gases at 160-180°C, containing the solvent in the gaseous phase, enters the condensation unit where they are cooled to 40°C using ambient air.

The high boiling point solvents condense and form an aerosol mist of liquid solvent droplets. Approximately 60% of this liquid component is removed in the condensers and passes to a liquid solvent filtration unit (for removal of any solid contaminants) and into a solvent/water separator where the oil is separated from any water present by floatation techniques. The water is passed to the effluent drain whilst the solvents are passed to the main solvent storage tank for re-usage.



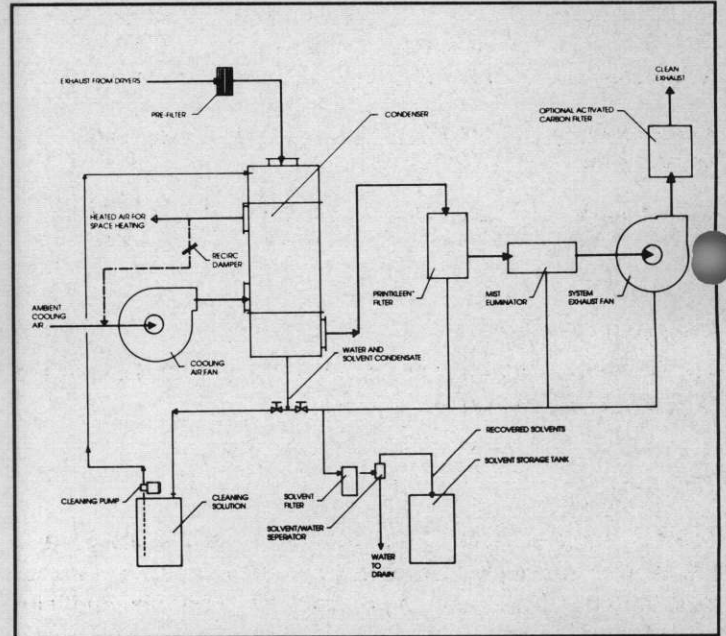
## REPLACING THE FILTER ROLL ON A 'PRINTKLEEN' EMISSION CONTROL AND SOLVENT RECOVERY SYSTEM

The exhaust air stream containing the aerosol of solvent droplets is then passed into the moving bed 'Printkleen' filtration unit where agglomeration of the droplets occurs in the filter media. Any solids, together with the aerosol solvents are removed from the exhaust stream. The liquid solvents collected are passed to the solvent filtration unit and solvent/water separator prior to entering the solvent storage tank. The 'Printkleen' filter unit will automatically advance on a new section of filter utilising a differential static pressure controller to maintain optimum performance efficiency.



**DESIGNED TO CLEAN THE CONTAMINATED GASES LEAVING THREE ROCKWELL PRESSES AT THE WORKS OF E T HERON (PRINT), THIS 'PRINTKLEEN' EMISSION CONTROL AND SOLVENT RECOVERY SYSTEM COSTS JUST £16,000 PER YEAR TO RUN**

The exhaust air now leaves the 'Printkleen' filter unit and is drawn into the mist eliminator where any remaining aerosol droplets of solvent are trapped, collected and passed to the liquid solvent treatment system. The exhaust gases are then passed to atmosphere via the main system exhaust fan.



## 'PRINTKLEEN' CONDENSING FILTRATION SOLVENT RECOVERY EMISSION CONTROL SYSTEM

The major benefits of this system can be summarised as follows:

### \* *Solvent and Energy Recovery*

Solvents are collected from all three stages of the condensing filtration system. The condensed solvents that are recovered from the condenser, auto-filter and mist eliminator are cleaned through a solvent filter, dewatered and stored in a solvent storage tank. These solvents can be used for certain ink reformulation or utilised as fuel in boilers and hot air heaters.

In addition, whilst the exhaust gases are cooled in the condenser units; heat is recovered by the condensers to provide a substantial supply of heated air for return to the dryers or for use as space heating in the warehouse and loading area.

### \* *Low Operating and Maintenance Costs*

The annual operating costs are limited to electricity for the exhaust and cooling air fans; filter rolls and detergent costs. The system requires no warm up or idling cycle and maintenance is restricted to 4-6 filter roll changes and 2 condenser cleaning cycles per year.

The financial benefits which can be derived from the use of condensing filtration solvent recovery systems as opposed to other abatement techniques is illustrated graphically by considering the costs for running a 'Printkleen' system at the works of Essex-based colour printers E.T.Heron (Print), comparing these with equivalent incinerators:

**OPERATIONAL COST ANALYSIS -  
E T HERON (PRINT)  
PRINTKLEEN SOLVENT RECOVERY V  
DIRECT THERMAL INCINERATION**

	PRINTKLEEN	THERMAL INCINERATION	THERMAL INCINERATION WITH HEAT RECOVERY
Annual Cost	£15,650	£271,247	£114,363
Annual Operating Costs/Savings	£40,750 SAVINGS	£271,247 COST	£114,363 COST
5 Year Analysis	£203,750 SAVING	£1,365,235 COST	£571,815 COST

\* High Efficiency

The system is guaranteed to meet existing and proposed U.K. and E.E.C. emission legislation.

\* Flexibility

The system is suitable for outdoor or indoor installation and because of relatively low weight is usually suitable for roof installations. The system is designed to be provided with an optional activated carbon unit for use where low boiling hydrocarbons are present in the exhaust gas stream.

\* Environmentally Friendly

The system guarantees no additional NO<sub>x</sub> or CO<sub>2</sub> emissions. As an indication of the potential damage caused by the use of thermal incinerators the following points should be considered:

The combustion of 1 therm of natural gas:  
 consumes ..... 16.95 lbs of oxygen  
 produces ..... 11.65 lbs of carbon dioxide

At E T Heron (Print) an incinerator with heat recovery facility would consume natural gas at the rate of 47 therms/hour resulting in:

- \* the production of 1589 tonnes of carbon dioxide per year.
- \* the consumption of 2311 tonnes of oxygen per year.
- \* the destruction of 30.55 million cubic feet of natural gas.

**CONCLUSION**

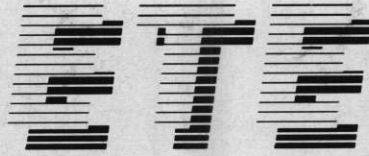
It will be seen that when deciding upon the type of pollution control system to install, a diverse variety of factors must be taken into account. Principal among these is the need to comply precisely with the emission standards established in the new Environmental Protection Act.

Economic constraints are always a priority, even more so at a time of recession, and the long-term operating costs of any system proposed should be analysed closely in order to ensure that it provides an optimum balance between the initial capital cost and the on-going operating expenses, taking into account such factors as the energy consumption and the requirement for maintenance.

Based on our experience of servicing the printing industry within the UK and overseas over a period of 20 years, we would recommend that the following techniques are considered:

- \* Heat set web offset - Condensing filtration solvent recovery
- Thermal incineration
- Catalytic incineration
- \* Rotogravure - Carbon adsorption
- (magazine/publication)
- \* Rotogravure/Flexographic
- (flexible packaging)
- Flow rates « 10,000 Nm<sup>3</sup>/hr - Catalytic/thermal incineration
- Flowrates » 10,000 Nm<sup>3</sup>/hr - Carbon adsorption
- Catalytic/thermal incineration

If you should have any questions about the new legislation and its impact upon your company, or the abatement measures available, then ETE's experienced engineers will be only too pleased to tender the necessary assistance.



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