

**Guidance on VOC Substitution and Reduction
for Activities Covered by the
VOC Solvents Emissions Directive
(Directive 1999/13/EC)**

Guidance 1: Heatset web offset printing

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1 Introduction

This guidance addresses heatset web offset printing and the related cleaning of equipment, presenting options to substitute or reduce the use of VOC and its resulting emissions.

Table 1: Scope definition of the VOC Solvent Emission Directive (SE Directive)

SE Directive – Scope definitions (Annex I)

Printing is defined by the Directive as ‘any reproduction activity of text and/or images in which, with the use of an image carrier, ink is transferred onto whatever type of surface. **It includes associated varnishing, coating and laminating techniques.**’

Heatset web offset is defined as ‘a web-fed printing activity using an image carrier in which the printing and non-printing area are in the same plane, where web-fed means that the material to be printed is fed to the machine from a reel as distinct from separate sheets. The non-printing area is treated to attract water and thus reject ink. The printing area is treated to receive and transmit ink to the surface to be printed. Evaporation takes place in an oven where hot air is used to heat the printed material.’

Varnishing is defined as ‘an activity by which a varnish or an adhesive coating for the purpose of later sealing the packaging material is applied to a flexible material.’

Coating is defined as ‘any activity in which a single or multiple application of a continuous film of a coating is applied.’

Laminating associated to a printing activity is defined as ‘the adhering together of two or more flexible materials to produce laminates.’

Other common printing techniques like sheet fed offset printing, cold set offset printing, digital printing, letter set printing or sheet fed screen printing do not fall under the scope of the SE Directive.

The following printing activities, covered by the SE Directive, are addressed in separate guidance documents: publication rotogravure see guidance 2, packaging printing using flexography or gravure printing and rotary screen printing see guidance 3.

The SE Directive lays down the following activity specific emission limit values for heatset web offset printing:

Table 2: Emission limit values of the SE Directive

SE Directive – Emission limit values (ELVs) (Annex II A – activity No. 1)				THE SE DIRECTIVE APPLIES TO HEATSET WEB OFFSET PRINTING IF A SOLVENT CONSUMPTION OF 15 TONS PER YEAR IS EXCEEDED.
Activity	Solvent consumption threshold [tonnes/year]	ELVs in waste gases [mg C/Nm³]	Fugitive emission values [% of solvent input]	
Heatset web offset printing	> 15 - 25	100	30 (1)	
	> 25	20	30 (1)	
Special provisions: ⁽¹⁾ Solvent residue in finished product is not to be considered as part of fugitive emissions				

Instead of complying with the above ELVs, operators may choose to use a reduction scheme, following the specifications of Annex II (B) of the SE Directive.

According to the SE Directive, a VOC shall mean any organic compound at 293.15 K (20°C), a vapour pressure of 0.01 kPa or more, or having a corresponding volatility under the particular conditions of use.

For heatset web offset the second part of the VOC definition is relevant because ink oils are heated in the dryer and under those conditions have a similar volatility as substances with a vapour pressure ≥ 0.01 kPa at 20°C.

Specific requirements apply for VOCs classified as CMR substances¹ as well as for halogenated² VOCs that are assigned the risk phrases R40 or R68³. There is a general obligation to replace CMR substances – as far as possible – by less harmful substances or preparations within the shortest possible time. In the case of a mass flow ≥ 10 g/h for VOC classified as CMR substances or ≥ 100 g/h for halogenated VOC with R40 or R68 the emission limit values in waste gases are 2 and 20 mg/Nm³ respectively, and these also apply when a reduction scheme is being used.

However, heatset web offset printing normally does not use VOC classified as CMR substances or halogenated VOC with the risk phrases R40 or R68.

National legislation may define lower thresholds for solvent consumption, stricter ELVs or additional requirements.

¹ CMR substances – carcinogenic (R45, R49), mutagenic (R46), or toxic to reproduction (R60, R61)

² Halogenated organic solvents are hydrocarbons with one or more of the following halogens: fluorine, chlorine (e.g. trichloroethylene), bromine or iodine.

³ After the implementation of the SE Directive a revision of the R-phrase R40 took place. The original wording of R40 was: 'Possible risk of irreversible effects'. The new wording is: 'Limited evidence of a carcinogenic effect'. In the 'old' version mutagenicity (cat 3) was included. This mutagenic effect is now covered separately under R68: 'Possible risk of irreversible effects'. This new risk phrase does not include carcinogenicity. The 'new' version of R40 is obviously less restrictive than the old version. Until the SE Directive is adapted to reflect this change a final decision on which version applies can only be given by the European Court

2 Summary of VOC substitution/reduction

The main sources of VOC emissions are the ink drying process and the use of solvents (usually isopropanol) in the dampening solution and for cleaning the machinery.

Emissions can be minimized by reducing the proportion of isopropanol in the dampening solution system, by using low-volatility or non-volatile cleaners and by deploying efficient waste gas treatment for VOC emissions from inks (substitutes for VOC emitting inks are under development).

When isopropanol is substituted in the dampening solution, personnel training may be required in order to avoid printing errors that occur when the isopropanol level is low (< 3 vol.-%).

The reduction of the volatility of the cleaning products leads to reduced VOC emissions. VOC-free cleaning products can be used for automatic roller cleaning systems and for manual cleaning of rollers and ink reservoirs.

Regular machine cleaning can be done with VOC-free systems.

VOC EMISSION REDUCTIONS CAN BE ACHIEVED BY SUBSTITUTION OF SOLVENTS FROM THE DAMPENING SOLUTIONS AND CLEANING SYSTEMS AS WELL AS BY USING EFFICIENT WASTE GAS TREATMENT

3 Description of the activity and related industry sector

Heatset web offset printing is used throughout Europe, mainly for printing products with a circulation of over 10,000 copies. About 50 % of all catalogues and 40 % of all magazines are produced by heatset printing (the remainder being produced by publication rotogravure printing) [ERA 2008]. Other typical products of heatset printing are travel brochures, advertising material and coloured books.

Heatset printing machines are able to print from 8 to 40 magazine pages per revolution. The press prints on both sides (resulting in up to 80 magazine pages per revolution), using the four standard inks: black, blue, yellow and magenta. In some machines additional colours (e.g. for brand marks) and varnishes can be applied.

In Europe, 2144 heatset web offset machines are installed [KBA-1 2008] with the following distribution of size (pages per revolution on one or both sides):

TYPICAL HEATSET PRINTING IS DONE WITH FOUR STANDARD INKS.

Table 3: Size distribution of heatset offset machines in Europe

8 pages	11.0 %	32/40 pages	15.9 %
16 pages	54.4 %	48 pages	9.6 %
24 pages	3.6 %	64-80 pages	5.5 %

[KBA-1 2008]

Ink consumption data of the graphical printing sector (here illustrated with data from Germany) show the sector is dominated by the use of publication gravure printing technique (~50 %), followed by heatset web offset (~25 %), coldset offset (~15 %) and sheet fed offset (~10 %). [Germán EPA 1999]

AFTER PUBLICATION ROTOGRAVURE, HEATSET PRINTING IS THE MOST IMPORTANT PRINTING TECHNIQUE FOR THE PUBLICATIONS SECTOR

Companies using heatset web offset may also employ sheet fed offset printing (not in the scope of the SE Directive) for short runs and cover printing or, for long runs, publication rotogravure (in the scope of the SE Directive).

The market in Europe is dominated by three printing machine producers who use similar technology. Ancillary equipment and materials, such as dampening solution circuits, coated rollers, roller cleaning systems, dryers and integrated waste gas cleaning systems are provided by a limited number of suppliers.

4 Technical process description

The printing and non-printing areas of the image carrier plates used in offset printing have different material properties: hydrophobic (lipophilic) areas that attract ink and hydrophilic areas that attract water based ‘dampening solution’ and repel ink (this approach contrasts with other printing techniques where the printing and non-printing areas have either embossed or engraved surfaces).

Heatset web offset is characterised by

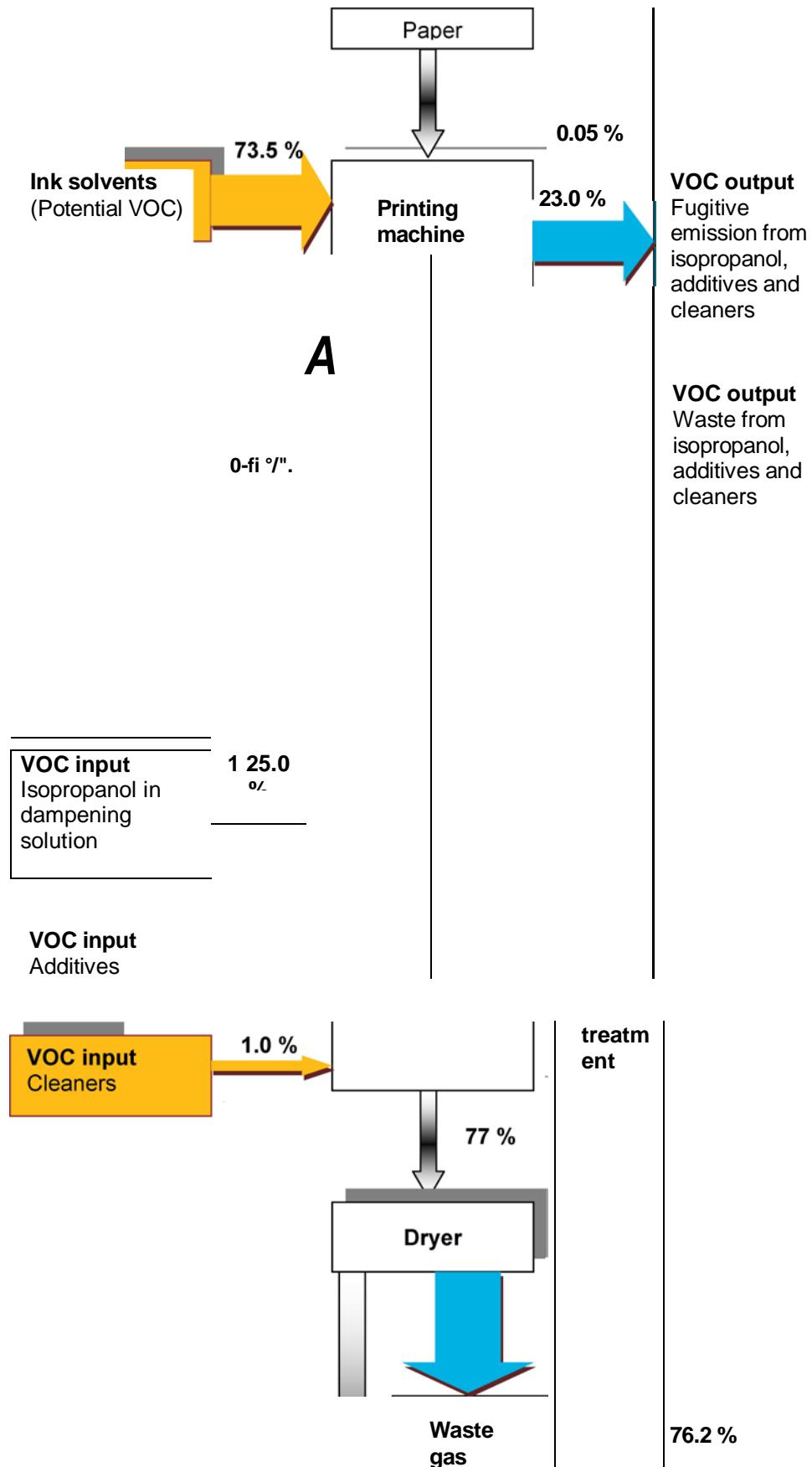
- Printing onto material from a roll or ‘web’ (not single sheets),
- Passage of the ink *indirectly* from the image carrier plate via a rubber coated cylinder to the printed material. This ‘off-set’ technique avoids abrading of the image carrier plate.
- Application of heated air (180°- 300°C) to hasten drying of inks. (Other offset printing techniques use ‘cold set’ inks where drying is via ink diffusion into the paper and ink oxidation with ambient air).

**HEATSET OFFSET
PRINTS ONTO
PAPER FROM A
ROLL. INKS ARE
DRIED WITH
HEATED AIR.**

Heatset web offset machines print on paper, at a speed of ~10-17 m/s. The speed determines the dryer length (up to 18 m) to allow the retention time of 1 second needed for the ink to dry.

4.1 Process flow and relevant associated VOC emissions

Figure 1 shows the main relevant solvent inputs and VOC outputs (arrows indicate the relevance of the VOC amount) [German EPA 2003]:



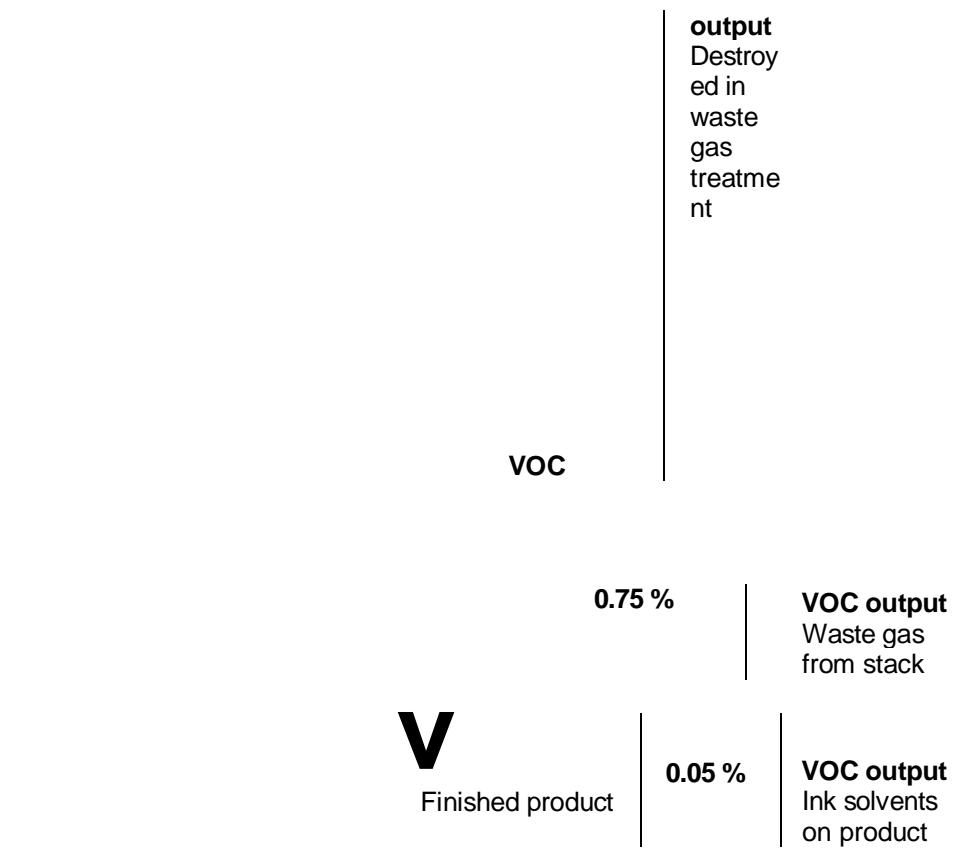


Figure 1: Main VOC input and output of heatset web offset printing

4.2 Process description

Heatset printing machines have 'double printing units' for each colour on both sides of the web. Ink and dampening solution are automatically pumped to each unit. Ink rollers and dampening solution rollers transport the materials from separate reservoirs to the image carrier roller. Several roller coatings are used that provide different hydrophilic properties.

As dampening solution during printing is constantly being contaminated with paper dust and ink spots, circulated dampening solution has to be passed via an effective filter before fresh water, isopropanol and other additives are added to obtain the desired characteristics for printing.

Dampening solution circuits use various decontamination systems - usually cloth filtration. They are equipped with systems for cooling as well as for measuring and dosing with isopropanol and additives. If fresh water contains high or variable concentrations of alkaline salts then de-salting is used to adjust the composition of the dampening solution.

When an operator becomes aware of printing errors, the image carrier plate and the rubber rollers are cleaned to remove paper dust or excess ink. Roller cleaning may be done manually or by automatic cleaning systems. Automatic systems apply cleaning solvents using spray, brush or tissue/wipe mechanisms. Besides such 'ad-hoc' roller cleaning, general machine cleaning is carried out regularly (e.g. once a week).

After printing, the paper passes through an oven to dry the ink. The waste gases are ducted to a waste gas treatment system.

Heatset printing machines are often enclosed, mainly for noise protection reasons.

[EGTEI 2003] [BREF STS 2007] [Ökopol 2008]

INK AND
DAMPENING
SOLUTION ARE
PASSED
(‘OFF-SET’) FROM
THE IMAGE
CARRIER TO A
RUBBER ROLLER
WHICH PRINTS ON
THE PAPER

VOC EMISSION IS
INFLUENCED BY
DAMPENING
CIRCUIT SYSTEM,
BY TYPE OF
ROLLERS AND
CLEANING
SYSTEMS AS WELL
AS BY EFFICIENCY
OF WASTE GAS
COLLECTION AND
TREATMENT.

4.3 Inks

Inks for heatset web offset need to be based on oils. That is because the technique uses printing plates that attract lipophilic substances (oils) for colour areas and hydrophilic substances (water based) for colourless areas.

Heatset offset printing inks are based on high boiling mineral oils that do not evaporate at ambient air temperature and thus do not dry quickly. Therefore they can rest without harm in the machine for several hours, e.g. during stops for maintenance.

The majority of images are created using the three standard colours and black. Therefore cleaning the colour systems is only necessary if additional colours are used (e.g. for brand marks) or during routine machine cleaning. Heatset inks usually contain about 35 % oil. About 85 % of the oil content of the inks evaporates in the dryer at 180°-300°C. Hence, about 30 % of total heatset ink input evaporates in the dryer. [German EPA 2003]

At the conditions of use (in the dryer), the volatility of the organic solvents in the heatset inks is comparable with the volatility of substances having a vapour pressure of > 0.01 kPa at 20°C. Therefore, according to the VOC definition of the SE Directive these ink solvents are VOC.

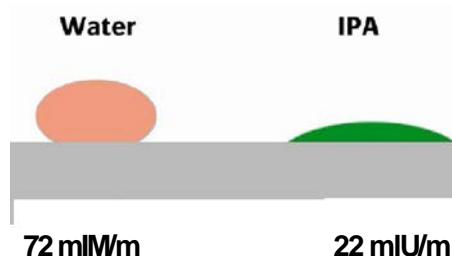
IN GENERAL
ABOUT 30 % OF
THE HEATSET
INK AMOUNT IS
EVAPORATED IN
THE DRYER

According to the SE Directive, solvent residue in finished product is not to be considered as part of fugitive emissions (see table 2 on page 4).

VOC are emitted in the dryer from inks, dampening solution and – in the case of cleaning during paper transport – from cleaners. They are ducted to a thermal oxidiser to be abated. If there is insufficient VOC in the waste gases to maintain the minimum flame temperature (about 2 g/m³), natural gas is used as an additional fuel.

4.4 Dampening solution system

For conventional plates the process water must adhere strongly to the surface to separate printing from non-printing area. This requires a constant pH-level. Therefore additives are used in the process water to stabilise the water-ink-balance on the plate and to lower the surface tension of the water.



Figúre 2: Different surface tensions of water and isopropanol

Two main additives are commonly used:

- isopropyl alcohol ('isopropanol' or 'IPA') to lower the surface tension
- salts to regulate the pH-level.

Less frequently ethanol is used instead of isopropanol. Other additives are phosphoric acid, gum arabic, corrosion inhibitors, wetting agent, drying stimulator, fungicide, antifoaming agent. [IMPEL 2000]

Isopropanol and ethanol not only lower the surface tension when dampening solution is transported onto the printing plate but also cool the printing system when they evaporate; they also prevent the growth of microorganisms in the dampening solution.

ISOPROPANOL AND ETHANOL ARE MOST COMMONLY USED SOLVENTS IN THE DAMPENING SOLUTION

4.5 Cleaning system

Volatile organic solvents are commonly used for cleaning the machine and all of its parts (mainly the plate, the ink reservoirs and numerous cylinders).

Most heatset web offset machines have automated roller cleaning systems. Additional weekly manual cleaning of the entire machine is considered good maintenance practice. [KBA-2 2008]

WEEKLY MANUAL CLEANING IS USED AS GOOD MAINTENANCE PRACTICE

5 Solvent use, emissions and environmental impact

5.1 Solvents used

The following VOC relevant substances are used [German EPA 2003], [Ökopol 2008]:

1. **Inks** are based on about 33-35 % aliphatic hydrocarbons (solvents). The solvents are made of mineral oil. They are not volatile at ambient temperatures but are volatile in the dryer. About 85 % of the oil fraction is evaporated in the dryer as VOC (equivalent to about 30 % of the total ink amount). Solvent residue in the finished product is not considered as part of fugitive emissions (see table 2) because it is not volatile at ambient temperatures.
2. **Dampening solution** consists mainly of water. It generally contains about 3 % dissolved salts and from 0 % up to 20 % isopropanol (= isopropyl alcohol or IPA). Less commonly, dampening solution can contain ethanol instead of isopropanol. At 20°C, isopropanol has a vapour pressure of about 4 kPa and ethanol of about 5.9 kPa. Both are therefore classified as VOC under the SE Directive.
3. **Other additives**, based on less volatile or non-volatile organic compounds (often glycols), have been used to reduce the isopropanol content of dampening solution. The VOC content of these additives can vary from 0 % up to 30 %. The dosage is about 3 %, resulting in a final concentration of 0 - 1 % VOC in the dampening solution.
4. **Cleaners** are mainly based on hydrocarbons. Aromatic hydrocarbons have good cleaning properties but their use has been restricted for health protection reasons. Common cleaners are mainly aliphatic hydrocarbons with vapour pressures of 0.1 - 11 kPa at 20°C (100 % VOC, flash points of 30° - 80 °C). To a lower extent aromatic hydrocarbons are contained. Oily cleaning products, introduced in the nineties, are based on natural oils, high boiling mineral oils or mixtures thereof (0 % VOC, vapour pressure < 0.01 kPa at 20°C, flash point > 100°C).

ABOUT 85 % OF SOLVENTS IN INKS EVAPORATE IN THE DRYER

ISOPROPANOL IS CLASSIFIED AS VOC

ADDITIVES FOR ISOPROPANOL SUBSTITUTION MAY CONTAIN SUBSTANCES CLASSIFIED AS VOC

CLEANING AGENTS ARE MAINLY BASED ON HYDROCARBONS

5.2 Solvent consumption and emission levels

One tonne of ink allows printing about 330,000 m² (both sides) or 100,000 catalogues (48 pages DIN A4). [Ökopol 2008]

The ink consumption of the smallest heatset web offset printing machines (printing 8 pages in one revolution) is about 30 kg/h. [Ökopol 2008]. If such a machine is operated with one shift for 5 days a week, the annual VOC consumption from inks alone is about 20 tonnes, exceeding the SE Directive threshold of 15 tonnes per year (if inks contain about 35 % of VOC and not taking into account VOC from dampening solution and cleaners).

Thus heatset web offset activities generally exceed the VOC threshold of 15 t/a. [Ökopol 2008]

EVEN SMALLEST HEATSET MACHINES REGULARLY EXCEED THE SOLVENT CONSUMPTION THRESHOLD OF 15 TONNES PER YEAR

Many companies have installed more than one machine. Most machines print 16 pages or more (up to 80). As machine costs are high, they are often operated for 3 shifts/day and 6 days/week. [Ökopol 2008]

The best performing heatset web offset installations add only 0 - 3 vol.-% isopropanol to dampening solution [Ökopol 2008]. Without efficiency optimisation the isopropanol content is typically around 10 vol.-% but can be as high as 20 %.

Most heatset web offset printing machines are equipped with automatic washing systems. The best performing installations use non-VOC cleaners (with a vapour pressure < 0.01 kPa, flash point > 100°C) for automatic cleaning and low volatile or non-VOC cleaners for manual cleaning (with a vapour pressure < 0.2 kPa, flash point > 60°C). [German EPA 2003]

The application of best available techniques is associated with a VOC emission of 2.5 – 10 % for new machines and 5 – 15 % for existing machines, related to total ink consumption. [BREF STS 2007, p. 570]

In order to comply with the waste gas emission limit values of 20 or 50 mgC/m³ (see table 2 on page 4), heatset web offset installations have to apply thermal waste gas treatment. The best performing thermal oxidisation systems achieve levels < 15 mgC/m³. [BREF STS 2007, p. 518] [Ökopol 2008]

**HEATSET WEB
OFFSET CAN BE
REALISED WITH
0—3 VOL-%
ISOPROPANOL**

**VOC-FREE
CLEANERS CAN
BE USED. LOW
VOLATILE
CLEANERS
HAVE VAPOUR
PRESSURES <
0.2 kPa.**

5.3 Key environmental and health issues

In heatset web offset printing a broad range of solvents are used, mainly isopropanol, ethanol, glycols as additives of the dampening solution and predominantly aliphatic hydrocarbons for cleaning.

Process emissions of solvents, together with NOx emissions, are precursors of ground level ozone formation in the presence of sunlight.

Emissions of VOC to air may occur from:

- the storage of the solvents
- the process (mainly from dampening solution)
- cleaning operations (automatic and manual)

**EMISSIONS TO AIR
OCCUR FROM
STORAGE,
PROCESS AND
CLEANING
OPERATIONS.**

Existing occupational workplace limits should be taken into consideration.

Emissions from thermal oxidisation systems will contain organic compounds that have not been destroyed or are only partly destroyed, as well as CO₂, CO, and NOx. When natural gas is used as additional fuel, emissions may also contain unburned methane (CH₄).

Emissions of VOC to water occur from the disposal of dampening solution (local regulations have to be considered). Spills and leaks from storage areas may result in emissions to soil and groundwater.

The process generates waste containing solvents which need to be disposed in a way that emissions to air, soil and groundwater are prevented or limited.

Cleaners may contain aromatic hydrocarbons such as xylene and toluene. These substances have higher impacts on human health than aromatic hydrocarbons. Toluene is classified with the risk phrase R40 ("may cause cancer").

6 VOC substitution

The following sections describe potential substitutes for VOC (using VOC-free and reduced-VOC systems). There are also descriptions of the application technologies or special conditions needed and the advantages and disadvantages compared to systems that use solvents with a high VOC content.

VOC emissions result from the forced drying of the oily hydrocarbon solvents in the inks. These emissions can only be avoided by adapting the printing process (see chapter 10 for information on the state of development of water based offset inks). UV inks (drying by using ultraviolet light, without VOC emissions) cannot be used in heatset machines because the printing speed is too high.

Substitution is possible for the other two major emission sources:

- isopropanol in dampening solution and
- VOC based cleaners (for parts and machinery)

This can be done by:

1. Avoiding the use of dampening solution altogether by using waterless offset. This has to be combined with tempering of rollers, use of adapted inks, plates and plate development equipment.
2. Reducing the isopropanol content in the dampening system by replacing it with special additives. This requires the use of exact measurement of all additives, special roller materials, keeping the process water cool, clean and with a constant salt content, and controlling temperature and humidity of the ambient air in the press room.
3. Using non-volatile products for parts and machine cleaning, for rollers and reservoir cleaning - substituting volatile cleaners with organic substances having a vapour pressure of < 0.01 kPa; for regular manual machine cleaning - using dry ice (CO_2).

**WATERLESS
WEB OFFSET
PRINTING IS
APPLICABLE FOR
VOC REDUCTION**

**VOC-FREE
DAMPENING
SOLUTION AND
VOC-FREE
CLEANERS CAN
BE USED**

**VOC CAN BE
SUBSTITUTED BY
USING
WATERLESS
OFFSET**

**BY REDUCING
ISOPROPANOL IN
DAMPENING
SOLUTION**

**BY VOC-FREE
CLEANERS**

6.1 VOC-free systems

This section describes the ways that VOC-free products or systems can be used to replace the organic solvents currently used.

6.1.1 Substitution of dampening solution by waterless heatset

Substitution of the entire dampening water system (and related VOC emissions from isopropanol and other additives) may be achieved with 'waterless offset'.

Waterless offset needs specialised image carrier plates and related developing equipment and adapted inks.

Waterless plate developing chemicals, besides avoiding VOC emissions, have a reduced wastewater impact. Shorter start-up times are needed to obtain the correct printed image which reduces personnel costs and minimizes paper waste. [Nienstedt 2007]

Whilst Japan has long used waterless heatset web offset printing [EWPA 2008], the technology has had little commercial uptake in Europe until 2004, with the exception of a few sheet fed applications. Printers have feared becoming dependent on one printing plate supplier and were concerned that investment in disparate systems would reduce their flexibility to produce the same job on different machines (because waterless plates differ from conventional plates). Additionally, it was feared that the market would not pay more for improved quality.

In 2004, however, waterless cold set web offset for newspaper printing has become commercially viable, due to the higher prices paid for high quality advertisements and lower operational costs due to shorter start-up times. Meanwhile these cold set newspaper machines have been equipped also with heatset dryers in two companies in Belgium and Denmark, printing semi-commercial magazines. Another company in France will install waterless offset with the option to be complemented with a heatset dryer (as long as the machine is used for coldset, it is not covered by the SE Directive). [KBA-2 2008]

When using waterless heatset offset, production costs are reduced by about 7 - 12 %. At present, the product range is reduced to about 70 % of the total range achievable using conventional heatset printing because 'high-end' products (like top quality catalogues) can not be produced, yet. [KBA-2 2008]

**WATERLESS WEB
OFFSET REDUCES
PRODUCTION COSTS
SIGNIFICANTLY**

6.1.2 Full substitution of isopropanol in dampening solution

Substituting isopropanol in the dampening solution may be more practical than changing to waterless offset printing systems. To do so, however, several pre-conditions have to be met. Isopropanol reduction to zero, without loss of printing quality, is only possible on new machines (installed after 2000) as older machines do not have appropriate cylinder acclimatising systems and older rollers cannot be adjusted with adequate precision.

Special additives have been developed to facilitate the substitution. These additives also lower the surface tension of the water and prevent the growth of micro-organisms. The additives contain up to 30 % organic hydrocarbons (mainly glycols) and some of these are classified as VOC; so to achieve a 100 % VOC-free dampening solution system, the composition of additives has also to be considered.

For more information about improving the pre-conditions for isopropanol reduction see chapter 7.1.

**ATTENTION HAS TO
BE PAID TO THE
COMPOSITION OF
ADDITIVES FOR
ISOPROPAOL
REDUCTION AS
THESE MAY CONTAIN
VOC**

6.1.3 Substitution of VOC cleaners by non-VOC cleaners

VOC-free, high boiling, cleaning agents ('HCA') or VOC-free vegetable oil based cleaning agents ('VCA') can be used in place of conventional volatile products (usually having vapour pressures of 0.1 – 11 kPa). Smaller quantities are needed for effective cleaning and they can be diluted with up to 50 % water. The resulting reduction in consumption fully compensates for their higher price [Ökopol 2008].

**VOC-FREE OILY
CLEANERS CAN BE
MIXED UP TO 50 %
WITH WATER**

These cleaning products require new working practices. Products with low volatility often do not work immediately when applied to the surface to be cleaned. They have to be rinsed off using water - as a second step. Therefore, switching to non-volatile substances for cleaning will require workers to adjust their working practices.

When non-volatile cleaners are manually applied they have to be used sparingly because if dripped into the machine they may cause printing errors.

Automatic cleaning systems often have to be adapted to allow the use of non-VOC cleaners because much lower quantities (about 50 %) are needed and ducts and openings have to be adapted so as to provide equal quantities over the entire length of the rollers. Some elastic tube materials are not resistant to the use of oily cleaning agents. Providers of washing machinery can deliver lists of appropriate cleaning agents.

**AUTOMATIC WASHING
SYSTEMS MAY HAVE TO
BE ADAPTED TO
VOC-FREE CLEANERS**

Blanket coated rollers for automatic cleaning are usually applied in combination with spray cleaning of printing rollers. Instead of spraying the cleaners for later absorption in the blanket, pre-impregnated blankets are available, impregnated with non-VOC cleaners.

Economic and cross-media effects

VOC-free cleaners not only avoid emissions but also significantly improve the health and safety of the work place because of their reduced flammability risks. Storage too is less costly.

Non-volatile cleaners, being oily substances, should be handled with care. Workers should use gloves when using these materials. Spillages can make floors slippery and lead to a higher risk of accidents. Spillage can also result in the contamination of the dampening solution and of the plate. This can cause printing errors and may necessitate re-printing and related increase of environmental impacts. Appropriate staff training can help to avoid spillage.

**VOC-FREE
CLEANERS ARE
OILY AND
THEREFORE
SPILLAGE TO
THE FLOOR
LEADS TO
ACCIDENT RISKS**

While VOC-free spray systems for automatic cleaning generate liquid waste (cleaning agents mixed with water and dirt), pre-coated VOC-free blanket cleaning systems generate solid waste (textiles with dirty cleaning agents). Handling and appropriate treatment of waste is often easier for solid than for liquid waste.

Membrane filtration is more energy efficient than distillation for recovery of non-VOC cleaners because of the high boiling point of non-VOC cleaners.

6.2 VOC-reduced systems

If the complete substitution of organic solvents is impractical then changing to systems with a reduced VOC content, such as those described in this section, can decrease emissions.

6.2.1 *Partial substitution of isopropanol in dampening solution*

The extent to which isopropanol reduction is possible depends on each individual machine. The proportion of organic compounds in dampening solutions should generally not exceed 10 wt.-%⁴ in the case of existing presses and 5 wt.-% in the case of new presses. [DEFRA 2008] Further reductions can be achieved if process conditions are optimised (see chapter 7.1) [Ökopol 2008].

Reductions are best established in small steps, guaranteeing that each reduction step is tested for at least a 2 - 3 month period, while observing the printing characteristics at each reduction level. Suppliers of additives and roller materials often support the testing of reduced isopropanol level operation.

For isopropanol reduction it is essential that the characteristics of the dampening solution are kept constant. The fresh water composition must be stable. Cooling equipment is needed to keep the temperature constant. For more information about improving the pre-conditions for isopropanol reduction see chapter 7.1.

The emission reduction resulting from isopropanol substitution depends on the initial levels used. Since the major part of VOC from inks is destroyed in the thermal treatment of the waste gases, fugitive emissions from isopropanol represent about 80 % of VOC emissions (the remaining 20 % is from cleaners). Thus, by isopropanol substitution, a major part of the VOC emissions can be avoided. If, for example, the isopropanol concentration level in the dampening solution is reduced from 10 vol.-% to 5 vol.-%, a 40 % emission reduction can be achieved.

REDUCTION OF IPA CONCENTRATION FROM 10 % TO 5 % CAN LEAD TO 40 % REDUCTION OF VOC EMISSIONS

Economic and cross-media effects

Isopropanol substitution not only has direct health benefits: storage of non-flammable substitutes carries less risk and thus requires less safety measures.

When using substitutes, more energy is consumed in the process for cooling of the working space and rollers as isopropanol evaporation has a cooling effect in the machine. Additionally, energy is needed for more accurate measurement and filtering of the dampening solution to ensure printing quality.

Substitutes are more corrosive to ferrous machine parts and may cause damage if not handled properly - this risk may be avoided by appropriate spillage management.

⁴ wt.-%: weight percent, vol.-%: volume percent

Isopropanol substitutes, like anti-fouling substances and some glycols, may have harmful human health effects. Therefore, special attention should be given to safety data sheets to ensure that least harmful products are used for substitution.

6.2.2 *Substitution of VOC cleaners by low-VOC cleaners*

Low volatility organic solvents can be used (with vapour pressures of around 0.1 kPa at 20°C and flash points of about 60°-80°C) instead of traditional cleaners having a high volatility (vapour pressure of 3 – 11 kPa at 20°C).

As with non-VOC cleaning agents the switch to low volatility organic substances requires flexible working practices but there are off-setting operational benefits. These products can be diluted with up to 50 % water leading to less consumption and reduced costs.

Automatic cleaning systems may have to be adapted to use low volatile cleaning agents as flexible tube materials and dose metering volumes may not be adequate. Providers of washing machinery have lists of suitable low volatility cleaners and are able to adapt their systems for their use.

7 Other VOC emission prevention measures and abatement techniques

Preventive measures, process improvements and abatement techniques can be used to reduce VOC emissions if VOC substitution as described in section 6 is not possible. The following measures are commonly applied for heatset web offset.

7.1 Process improvements

In order to obtain low isopropanol levels precise dosing is needed for additives as well as for isopropanol. This requires the use of accurate measurement and dosing devices, traditional density measurement methods and conventional dosing without measurement are insufficient. There are infrared and ultrasonic measurement systems on the market that are suitable.

Whereas traditional dosing was done by calibrated volumetric pumping systems, the best performing systems now use conductivity measurements of the incoming water before and after dosing with additives.

Accumulated dust and ink contamination in the dampening solution can be a problem because at low isopropanol levels there is a risk of more frequent printing errors. High efficiency filters reduce contamination but are prone to blockage, so parallel filters with automatic switching are commonly used. Alternatively membrane filters with automatic purging systems can be used.

It is essential to maintain a constant roller performance when working at reduced isopropanol levels. This requires regular maintenance, including calibration, as well as ensuring that the hydrophilic properties of the roller

**Low IPA LEVELS
REQUIRE MORE
PRECISE DOSING**

**CONTROL OF ROLLER
PERFORMANCE IS A
PRECONDITION FOR
IPA REDUCTION**

surfaces are high to guarantee a constant water supply to the plate cylinder.

To achieve reduced isopropanol concentration in the dampening solution, conventional rollers can be substituted by rollers coated with a special hydrophilic rubber surface or with hydrophilic ceramic.

In order to optimise results with automatic cleaning, various types of brushes can be used in the different sections of the cleaning device.

A general reduction of VOC emissions from isopropanol and cleaners can also be achieved by applying good practice measures [IBU 2008, DEFRA 2008]:

- Training of workers to first assess and improve the process conditions before increasing the isopropanol level in dampening solution.
- Training of workers to use as little cleaner as necessary during manual cleaning of image carrier plates, machine parts and machinery.
- Training of workers to avoid spillage of cleaners.
- Training of workers in how to avoid emissions from spillage during bottling or transport and from open containers (virgin material as well as used cleaners and rags).
- Keeping pre-impregnated rags in an enclosed container prior to use.

TRAINING OF PERSONNEL CAN LEAD TO VOC REDUCTION

7.2 Waste gas abatement

Installation of waste gas treatment systems is necessary to comply with the waste gas emission limit values of the SE Directive.

7.2.1 Efficient use of solvent emissions

Thermal treatment and energy recovery for ink drying is commonly used. Solvent recovery is no efficient option as the recovered fraction would need further treatment for re-use, containing isopropanol from the dampening solution and a mixture of hydrocarbons from inks and cleaners, besides water from the dampening solution.

The most efficient abatement technique for destroying VOC in heatset web offset waste gases has an efficiency of > 99 % - resulting in emission levels below 20 mgC/m³ [BREF STS 2007, p. 566].

For higher energy efficiency the best systems use the energy content of the incoming VOC and recover energy in the waste gases for heating the dryer (heat recuperation). This 'integrated' system can also be installed in existing installations equipped with non-recuperative thermal oxidation.

Authothermic combustion is difficult to achieve with machines printing 16 pages per revolution, but possible for larger machines (cylinder length of 1.80 m – 2.25 m). [MAN Roland 2008]

In dryers, following the heating zones, there are drying zones with a temperature of around 180°C. In the last zone before the cooling zone of the dryer, the concentration of evaporated ink solvents is at its highest. For effective oxidation this solvent vapour must be heated to a minimum of 770°C.

MOST EFFICIENT WASTE GAS ABATEMENT SYSTEMS DESTROY > 99 % OF VOC

EXCESS HEAT FROM THERMAL OXIDISATION CAN BE USED FOR ROOM/WATER HEATING

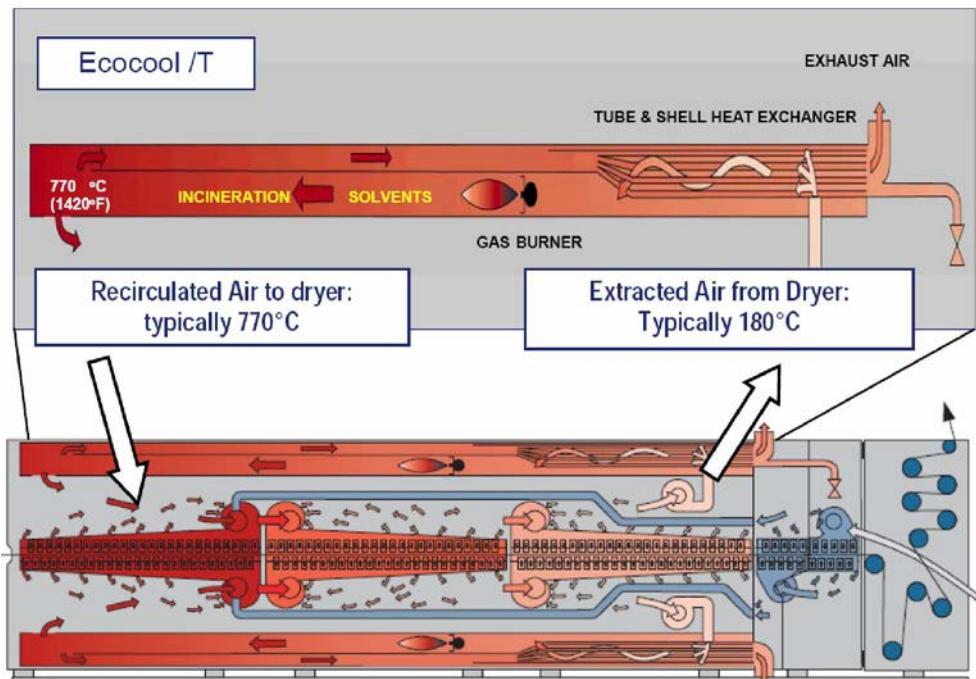
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Heatset web offset printing

To avoid explosion, dilution air must be introduced to prevent solvent concentrations exceeding 25 % of the lower explosion limit. Solvent concentration measurement can be used to optimise the dilution, and the dilution air can be preheated in a heat exchanger using the exhaust gases. The energy from the burnt solvents minimises the fuel gas needed to reach the necessary minimum temperature of 770°C. [GOSS 2008]

HEAT EXCHANGER
PRE-HEATS INCOMING
FRESH AIR WITH HOT
AIR EXTRACTED
FROM THE DRYER

MEASURING SOLVENT
CONCENTRATION IN
THE DRYER MINIMISES
THE ADDITIONAL FUEL
REQUIREMENTS



[GOSS 2008]

Figure 3: Dryer with integrated thermal waste gas treatment and heat exchanger

Energy produced from oxidation leads to excess heat, which is available for other purposes such as room/water heating via an effective heat exchange (also applicable in combination with integrated systems using VOC combustion for ink drying). [Company-1 2008]

Enclosed machinery reduces fugitive emissions, especially when combined with an air conditioning system that extracts all ambient air from the printing room through the waste gas cleaning system.

Cleaning agents are difficult to capture in the waste gas treatment systems for safety reasons and the dryer is usually turned off during cleaning periods (the temperature of the dryer is too high and an explosion might occur if it were running). Some 10 % of isopropanol emissions (dampening solution) are captured and routed to the dryer and then treated in the incinerator. [EGTEI 2005]

7.2.2 Minimisation of fugitive emissions

If machines are enclosed and dryers work with integrated waste gas treatment, all air extraction of the encapsulated machine can be via the dryer and the waste gas treatment system. In such a case, the extraction rate can be regulated to ensure that fugitive emissions are minimised. [Ökopol 2008]

INTEGRATED DRYER
AND NEGATIVE
PRESSURE IN
ENCLOSED MACHINE
ROOMS HELP TO
DESTROY MOST
VOC EMISSIONS

8 Summary of VOC emission reduction measures

The following table summarizes the various approaches to substitute or reduce VOC emission as described in chapters 6 and 7.

Table 4: Measures for VOC substitution and VOC reduction in heatset web offset

Objectives	Description	
VOC-free systems	VOC-free cleaners	Use of cleaners with a vapour pressure of < 0.01 kPa at 20°C.
	Waterless heatset web offset printing	Use of specific printing plates and adapted inks that enable printing without dampening solution.
	VOC-free dampening solution	Use of specific VOC-free additives, in combination with process improvement measures (see below).
VOC-reduced systems	Reduction of isopropanol in dampening solution	Stepwise reduction of the isopropanol content in the dampening solution to < 5 %, in combination with process improvement measures (see below).
		Use of specialised additives for the dampening solution that mimic the functionality of isopropanol.
	Less volatile cleaners	Use of cleaners with a vapour pressure of around 0.1 kPa at 20°C. Use of dry ice (CO ₂) for regular machine cleaning
Process improvement	Optimised dosing and measurement	Use of precise measuring and dosing systems for isopropanol and additives.
	Optimised dampening solution quality	Use of temperature control, effective particle filters, fresh water treatment.
	Optimisation of rollers of dampening system	Use of special roller surfaces (ceramic, special rubber).
	Optimised cleaning	Use of automatic cleaning systems for all rollers.
	Optimised use of isopropanol	Training of workers to improve process conditions instead of increasing the isopropanol level.
	Optimised handling of cleaners and cleaning waste	Training of workers to avoid excess use, spillage and emissions from storage handling.
Abatement technologies	Thermal oxidisation	Treatment systems with efficiency > 99 % and emission values < 20 mgC/m ³ . Recovery of waste heat (for integrated system and for water and/or room heating system).
	Air extraction via abatement system	Machine containment, extraction of cabin air via abatement system.

9 Good practice examples

9.1 Printing house 1

A heatset web offset printing company uses 4 heatset offset machines, mainly for publications. A new 16-pages machine has been purchased that is able to print without the use of isopropanol.

The new machine is equipped with ceramic coated rollers for better dampening solution transport to the plate. The dampening solution is connected with a high efficiency dust filtering system. The machine is equipped with water-based cooling system for the ink rollers. A VOC-free additive is used, in place of isopropanol, at no additional costs.

Compared with the former machine, the new machine avoids the use of ~17,500 litres isopropanol consumption per year (13.8 t/a) with an annual costs savings of about 17,500 Euro (at ~1 €/litre of isopropanol).

There are no cross-media effects, it has a similar energy requirement to that of conventional heatset web offset printing, cooling of the rollers and dampening solution leads to increased printing stability.

[Ökopol 2008]

**GOOD PRACTICE 1:
PRINTING WITHOUT
ISOPROPANOL IN
DAMPENING SOLUTION**

9.2 Printing house 2

Two web offset printing companies in Belgium and Denmark use waterless heatset web offset. Each machine saves yearly ~ 12,000 – 15,000 liters iso-propanol and ~130,000 – 150,000 liters water due to the waterless system.

The quality of the printing products is better than the quality of conventional coldset printing (used for newspaper production); mainly semi-commercial magazins are printed. The machine investment costs for the machine are similar as for a conventional machine.

[KBA-2 2008]

**GOOD PRACTICE 2:
WATERLESS HEATSET
OFFSET PRINTING**

10 Emerging techniques and substitutes under development

VOC-free cleaning agents

New water based cleaning agents (VOC-free), suitable for manual and automatic cleaning, are currently undergoing testing in pilot plant. The residues from these cleaners do not need to be rinsed off after cleaning because they do not lead to oily spots that would cause printing errors. Therefore, they have the advantage over high boiling organic cleaning agents that no second cleaning step with water is needed. [Ökopol 2008]

**VOC-FREE WATER
BASED CLEANERS ARE
UNDER DEVELOPMENT**

Inks without organic solvents

While there have been development projects for sheet fed offset printing using water based inks (results were presented at the international DRUPA trade fair in 2004), no comparable work is known for heatset web offset. [Ökopol 2008]

11 Information sources

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