WISCONSIN DEPARTMENT OF NATURAL RESOURCES
NOTICE OF FINAL GUIDANCE & CERTIFICATION

Pursuant to ch. 227, Wis. Stats., the Wisconsin Department of Natural Resources has finalized and hereby certifies the following guidance document.

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Emissions Determination for the Printing Industry

PROGRAM/BUREAU

Air Management

STATUTORY AUTHORITY OR LEGAL CITATION

Chapter NR 438, Wisconsin Administrative Code

DATE SENT TO LEGISLATIVE REFERENCE BUREAU (FOR PUBLIC COMMENTS)

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DNR CERTIFICATION

I have reviewed this guidance document or proposed guidance document and I certify that it complies with sections 227.10 and 227.11 of the Wisconsin Statutes. I further certify that the guidance document or proposed guidance document contains no standard, requirement, or threshold that is not explicitly required or explicitly permitted by a statute or a rule that has been lawfully promulgated. I further certify that the guidance document or proposed guidance document contains no standard, requirement, or threshold that is more restrictive than a standard, requirement, or threshold contained in the Wisconsin Statutes.

Gail E. Good

November 6, 2019

Signature

Date

Wisconsin Department of Natural Resources

Emission Determination for the Printing Industry Supplement to EPA Guidance Documents

AM-525 2019

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Executive summary

This document will assist the printing industry with determining air emissions from printing processes for purposes of annual reporting to the Air Emissions Inventory. Using the methods described below will provide for consistent reporting of emissions from printing facilities across the state and support U.S. Environmental Protection Agency's (EPA) data quality requirements.

Air pollution sources are required to report point source air emissions to the Wisconsin Department of Natural Resources (DNR) by March 1 of each year. DNR supplies this information to EPA by December of the following calendar year. EPA uses the information in many ways including determining how a particular regulation will affect a business sector. Consequently, submitting accurate information to DNR benefits both the state and businesses in that state.

Due to the diversity in print processes, determining air emissions from printing operations can be complicated. Different inks, coatings, fountain solution and clean-up formulations are used in individual printing processes. Printing facilities are required to track the amount of ink used and the percentage of volatile organic compounds (VOCs) and hazardous pollutants (HAPs) in the inks, as well as in the clean-up solvent used. The percentage of the VOCs and HAPs are usually determined from safety data sheets (SDS) or other information supplied by the vendor of the product. This information is then used to determine air emissions.

If SDS information does not exist, the operator must rely on outside information. EPA has compiled several documents that define the emission sources from printing. These references are identified at the end of this document in the References Section.

Although the EPA references describe printing, they do not supply default emission factors for printing processes due to the diversity of printing processes and input materials.

Other sources of air pollution are also emitted by printers. Combustion of fossil fuels like natural gas and fuel oil produce criteria pollutants, such as nitrogen oxides, sulfur oxides, carbon monoxide and particulate matter. Common fuel combustion units used in printing operations include boilers, heaters, furnaces, large hot water heaters, press dryers and oxidizers.

Particulate matter is solid matter or condensable organic matter that can form an aerosol. At a printing facility, particulate matter emissions are released from press dryers from the combination of ink and the combustion of fuel by the dryer. If a waste paper handling system is used for trimming or similar operations, dust or particulate matter emissions may result. Some sheet-fed operations may also use a spray powder in the operations which emits particulate matter.

EPA developed eight-digit Source Classification Codes (SCC) to categorize emissions factors for many industries, and recently updated SCCs for the printing industry. The SCCs match the emissions to a printing process and are included in DNR's electronic emission reporting system known as the Annual Reporting System (ARS).

This document was developed by DNR in partnership with the printing industry in Wisconsin represented by the Great Lakes Graphic Association, Printing Industries of America, Specialty Graphic and Imaging Association, Flexographic Technical Association and Petra Environmental Consultants.

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Introduction

The Wisconsin printing industry generates many types of print media using different printing processes. Due to the diversity of printing processes, it can be difficult to report emissions. This document describes methods for calculating annual emissions for reporting through ARS for general types of lithographic, flexographic, gravure, letterpress, screen printing and digital printing.

Volatile organic compound (VOC) emissions from printing operations emitted into the atmosphere are a precursor in the formation of ground level ozone. Ground level ozone is recognized as a health and environmental hazard by the U.S. Environmental Protection Agency (EPA). The constituents of these VOCs include hazardous air pollutants (HAPs) that also affect public health. HAPs are present in some inks, coatings, primers and adhesives applied on printing presses, and are also present in some materials used for cleaning presses. Other criteria pollutants—particulate matter (PM), carbon monoxide (CO), nitrogen oxides (NO_X) and sulfur dioxide (SO_2)—are emitted from fuel combustion units such as dryers, heaters and oxidizers. Additional PM may be emitted, if a printer has a paper trim system, or a sheet-fed printer that uses spray powders.

EPA's documents describing printing processes, expected emissions from the processes, and a general scheme to calculate emissions are not specific to Wisconsin and are decades old. This document was created to provide current guidance on how to determine emissions from each type of printing operation in Wisconsin.

DNR requires companies to report annual air emissions by March 1 each year. In lieu of reporting to the Air Emissions Inventory, businesses that have or need an air permit but emit below the reporting thresholds listed in Table 1 of Chapter NR 438, Wis. Adm. Code, must submit an Under Threshold Notification to notify DNR that their air emissions are below reporting levels. Both the emission reports and the Under Threshold Notification can be filed using the online Air Reporting System (ARS). The reporting thresholds vary by pollutant. DNR reviews the reported emissions and requires certification of the emissions from the facility by June 30 of the year the emissions were reported. DNR provides this emission data to EPA electronically by December 31 of the following year. DNR and EPA use this information in determining emission trends as well as the effects of new regulations on the industry.

DNR allows a printing operation to report air emissions in ARS in two ways:

1. Report emissions using throughput material totals and emission factors.
    - This approach requires knowing the appropriate Source Classification Code (SCC) or providing a site-specific emission factor based on testing and using those factors in ARS.
2. Calculate actual emissions using a material or mass balance approach.
    - This approach requires the facility to directly determine emissions by keeping records of inks, coatings, fountain solutions, cleaning solvents and other materials that contain VOCs or HAPs used during a calendar

year. Emissions are calculated by the VOC or HAP content of the individual material based on the information provided by the corresponding Safety Data Sheet (SDS) and applying the appropriate retention factor and capture/control efficiencies. These calculated numbers are directly reported in ARS.

Overview of emission calculations

Standardization of emission reporting across Wisconsin

Each year in early January, DNR notifies facilities to begin reporting air emissions for the preceding calendar year using an internet reporting program called the Air Reporting System (ARS). The system takes the information entered and calculates air emissions for a specific pollutant. The calculation is:

E = Throughput * EMF * (1- CE)

Where:

E	= emissions of pollutant
Throughput	= amount of materials used, product made, or fuel burned
EMF	= emission factor, in weight of pollutant emitted per unit of throughput
CE	= control efficiency, as a fraction or (percent control/100)

ARS allows a facility to override the emission calculation by entering the actual emissions for a pollutant which assumes 100 percent of what is reported is emitted.

There are two critical components of the emission calculation:

1. Emission factor
    - The emission factor information is primarily developed by EPA. This information can be tailored to a specific facility provided the facility has accurate data to support the number whether based on stack testing or analysis techniques such as mass balances, review of safety data sheets, etc.
2. Control efficiency.
    - The control efficiency can be assigned to a control such as catalytic or thermal oxidizers, or retention of VOCs on the printing surfaces and in shop towels.

Source Classification Codes

EPA creates Source Classification Codes (SCCs) to classify activities that generate emissions. Each SCC represents a unique source, category-specific process or function that emits air pollutants. The SCCs are used as a primary identifying data element in EPA's WebFIRE (a database linking SCCs representing specific processes to emission factors), the National Emissions Inventory (NEI) and other EPA databases.

Emissions are reported based on a SCC. EPA has established a SCC for each printing process. Not all of the established EPA SCCs will be used when reporting emissions. The SCCs are broken out by dryer (i.e., stack) and non-dryer (i.e., non-stack or fugitive) emissions. Speciation between dryer and non-dryer emissions was developed by EPA to account for emissions from presses with dryers and control devices. The available SCCs will be identified in ARS and the user will select the appropriate SCC code for their printing process category.

Emission determination method

Material balance, the most common method for estimating VOC and HAP emissions, uses the raw material usage rates, the fraction of the pollutant in the raw material and the portion (if any) of the pollutant in the raw material that is retained in the substrate. This method is used to estimate emissions most often where a relatively consistent amount of material is emitted during use.

The material balance emission rate is calculated by multiplying the raw material usage by the amount of pollutant in the raw material and subtracting the amount of the pollutant retained in the substrate. For VOC and HAP-containing materials, the amount of pollutant emitted is assumed to be 100 percent of the amount of pollutant contained in the material unless a control device is used to remove or destroy VOC and HAP in the exhaust stream or a known fraction of ink or solvent is retained in the substrate. To estimate VOC and HAP emissions where a control device is used, it is necessary to establish the efficiency of the capture system and the control device. Regardless of whether a control device is used, it is necessary to use all accepted retention factors and emission factors to accurately perform the mass balance equations. The appropriate retention factors have been incorporated into mass balance equations identified later in this document.

Source testing may provide accurate emission estimates, but the quality of the data will depend on a variety of factors including the number of data points generated, the representativeness of those data points and the proper operation and maintenance of the equipment being used to record the measurements.

Air pollution emissions from printing operations

Emissions from printing operations come from several areas of the process with the majority generated by the evaporation of VOCs from the application and drying of inks and overprint coatings. The other primary source is solvents used to clean the presses after the printing process is complete. Emissions can occur from other materials and activities, based on the printing process employed and the end product produced by the printing operation. Regardless of the printing process used, each of the printing processes follows the same basic sequence of imaging, pre-press, printing and post-press.

Pre-press

Pre-press operations include those operations used to create a positive or negative image which is then used to create a plate, cylinder or screen. In the past, significant emissions could be the result of the use of developers, fixers, photographic processing solutions or cleaning solutions. Due to digital technology and direct image transfer to plate, cylinder or screen; emissions from the imaging step are minimal. The plate, cylinder, or screen produced will be used in the printing stage to transfer ink in the form of the image to the substrate. Emissions from the lithographic platemaking operation are minimal. In flexographic platemaking, emissions may result from using VOC-containing materials. Those materials are being replaced by water washable plates that contain minimal VOCs.

Printing

Most emissions in the printing and graphic arts industry occur during the printing step, which includes the process of transferring the ink and overprint coating to a substrate. When estimating emissions, the printing step includes cleanup operations which may occur during or after a print run. Emissions result from the evaporation of VOCs in the inks and cleaning solutions. Offset lithographic printing presses will also produce emissions from the evaporation of VOCs contained in fountain solutions, which is a critical component of the lithographic printing process.

Depending on the printing process, dryers may be used to evaporate the solvents from the inks and coatings. In other printing processes, the inks dry at room temperature or are cured with ultraviolet light or electron beam. The solvents used in the inks and coatings will vary based on the specific printing process with some being more volatile than others. In some instances, a fraction of the VOCs are retained in the substrate which is the case for offset lithographic inks. The use of retention factors to account for this substrate retention is discussed later in this document.

Combustion of fuel, such as natural gas or fuel oil, to provide heat for building comfort or press dryers produce emissions. The emissions consist of nitrogen oxides, sulfur oxides, carbon monoxide, VOCs, HAPs and particulate matter (PM). In addition, some printing operations have boilers to generate steam for chemical recovery and other larger fuel combustion units and these emissions need to be included in the overall emissions inventory. A basic description of how to calculate emissions associated with fuel combustion is provided in the fact sheet *Combustion Sources and Air Pollution Construction Permits* (AM-427). In some cases, recovered solvent is used as a supplemental fuel that will have different emission factors than traditional fuels.

From a printing process perspective, the source of PM emissions is sheet-fed offset lithographic printing presses using anti-set-off spray powder. Spray powder is used to make an air gap between printed sheets of paper. By design, a significant portion of the spray powder applied remains on the surface of the printed sheet. Based on emission testing, 88.5 percent of the spray powder is not released. This equates into an emission factor of 11.5 percent.

Spray powder is generally made from natural, food-grade starches from plants and vegetables such as corn, wheat, semolina, potato, tapioca and rice. The diameter of the powder used is relative to the density of the stock (paper or board) being printed. The diameters range from 15 microns (μm) for paper up to 70 microns (μm) for heavy board.

Most manufacturers of spray powder offer both coated and uncoated powders. Uncoated powders can cause problems with the application equipment. Coated powders use the same range of raw materials but are encapsulated with a minuscule amount of natural coatings which enable the powders to flow freely though the spray guns. Enhanced versions of these coatings are used to give specific electrostatic (i.e. anti-static) and hydrophobic properties.

Spray powder is applied at the delivery end of a press and can either be released into the general pressroom air or vented to the atmosphere. Traditionally, venting involves the use of a hood over the delivery end of the press that is ducted through the roof to atmosphere. In some instances, a filter is placed in line to reduce the amount of spray powder released. Some new sheet-fed offset presses can be equipped with a spray powder collection system that reduces the amount released. These collection systems can be equipped with filters and either be directly vented to the atmosphere or internally into the general pressroom area.

Most sheet-fed presses do not exhaust emissions from spray powder application, therefore the PM emissions remain indoors and are not regulated by EPA or DNR. However, if the PM emissions are collected and the exhaust is directed outside, emissions should be calculated and reported.

Post-press

The post-press step includes such processes as cutting, folding, collating, binding, perforating and drilling. From an emissions perspective, binding is the most significant of the various post-press operations. Emissions may result from the volatilization of

VOCs contained in the adhesives used in the binding operation and solvents found in some types of ink jets inks, coatings and laminates used in the finishing process.

Some larger printing operations install a paper trim collection system. There are several systems used for the collection of paper trim in a printing facility. The most common are either a vacuum pump (typically located inside the building) or a cyclone (located either inside or outside the building). I If the air is going to be returned into the building, cyclones can be ducted to a baghouse. Additional filters can also be added to the return duct.

PM emissions are emitted from paper trim systems and should be reported if they are collected and the exhaust from the collection device is directed outside. If emitted only in the building, the PM from paper trim systems does not need to be reported.

Mass (or material) balance approach

Emissions from the materials used in the four fundamental process operations (i.e. imaging, pre-press, printing and post-press) are calculated using the mass balance, or material balance approach described below. The equations presented below apply to more than one process operation (i.e. emission point). For example, cleaning solutions may be used in both the pre-press step and the printing step.

Calculating emissions from each emission source

The emissions from each VOC and HAP-containing material (i.e. inks, fountain solutions, cleaning solvents and coatings) are calculated as follows:

Materials that are purchased by weight (pounds)

If no dryer or control device is in place, the equation is:

$$\mathbf{E_{material} = (U*W/100) * (1 - R/100)}$$

If a dryer and control device is in place, the equations are:

$$\mathbf{E_{material}\,(dryer) = (U*W/100) * [1 - (R/100)] * (J/100) * [1-(K/100)]}$$
$$\mathbf{E_{material}\,(non\text{-}dryer) = (U*W/100) * [1 - (R/100)] * [1 - (J/100)]}$$

Where:

$E_{material}$	= Emissions of VOC or HAP material, lb
U	= Material Usage, lb
W	= VOC or HAP Content, % by weight
R	= % VOC or HAP Retained in Substrate or Shop Towel
J	= Capture Efficiency, %
K	= Control Efficiency, %

Material usage is calculated as the amount of material purchased minus the amount that is in inventory and discarded as waste. The waste amount must be documented with hazardous waste manifest or other appropriate shipping paper. VOCs or HAPs that are captured and re-introduced to the process do not count as being controlled.

Materials that are purchased by volume (gallons)

If no dryer or control device is in place, the equation is:

$$\mathbf{E_{material} = (G*C) * (1 - R/100)}$$

If a dryer and control device is in place, the equations are:

$$E_{material}\,(dryer) = (G*C) * [1 - (R/100)] * (J/100) * [1-(K/100)]$$
$$E_{material}\,(non\text{-}dryer) = (G*C) * [1 - (R/100)] * [1 - (J/100)]$$

Where:

$E_{material}$ = Emissions of VOC or HAP material, lb
G = Material Usage, gal
C = VOC or HAP Content, lb/gal
R = % VOC or HAP Retained in Substrate or Shop Towel
J = Capture Efficiency, %
K = Control Efficiency, %

Total emissions

Total emissions for an input material (e.g., ink) from a press with a dryer and control device are determined by the following equation:

$$E_{material}\,(total) = E_{material}\,(dryer) + E_{material}\,(non\text{-}dryer)$$

The two equations can be combined, resulting in the following equation:

$$E_{material}\,(total) = [(G*C)\ \underline{or}\ (U*W/100)] * (1 - R/100) * (1 - [J/100 * K/100])$$

Retention factors

A detailed discussion of the factors assumed for the amount of each material retained on the substrate can be found in:

- Control Techniques Guideline for Offset Lithographic Printing and Letterpress Printing (EPA-453/R-06-002), September 2006
- Alternative Control Techniques for Offset Lithography, (EPA 453/R-94-054), June 1994
- Technical Support Document for Title V Permitting of Printing Operations, June 2007.

These documents address retention factors for lithographic printing ink. Similar inks are often used in letterpress operations; therefore, it is reasonable to assume the same retention factors in letterpress emission estimates depending on the specific material and process configuration. In addition, since varnish is printing ink without pigment and dries in the same manner as lithographic ink, the same retention and capture efficiency factors apply. The specific ink retention factors in these documents are not applicable for flexography, gravure, screen printing or certain digital printing presses, though the retention of cleaning solutions in shop towels do apply to these process categories.

The retention factors below are presented as a percentage of the VOC or HAP content in the material identified.

Material	Heatset web lithography	Sheet-fed lithography	Non-heatset web lithography	Heatset web letterpress	Sheet-fed letterpress
Ink	20	95	95	20	95
Fountain solution concentrate	0	0	0	0	0
Fountain solution additive	0	0	0	0	0
Automatic blanket wash	0	0	0	0	0
Cleaning solution (manual)	50*	50*	50*	50*	50*
Coatings:					
UV	0	0	0	0	0
Water-based	0	0	0	0	0
Conventional varnish	20	95	95	20	95

* The VOC composite vapor pressure of the cleaning solution cannot exceed 10 mm Hg at 20°C (68°F).

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Material	Rotogravure	Flexography	Screen	Digital
Ink	0	0	0	0
Dilution solvent	0	0	0	N/A
Cleaning solution (automatic)	0	0	0	0
Cleaning solution (manual)	50*	50*	50*	50*
Coating:				
UV	0	0	0	0
Water-based	0	0	0	0
Solvent-based	0	0	0	0

* The VOC composite vapor pressure of the cleaning solution cannot exceed 10 mm Hg at 20°C (68°F).

Capture efficiencies

A detailed discussion of capture efficiency determination is in the Guidelines for Determining Capture Efficiency (EPA, 1995d). The Control Techniques Guideline for Offset Lithographic Printing and Letterpress Printing (EPA-453/R-06-002), September 2006, and the Alternative Control Techniques for Offset Lithography, (EPA 453/R-94-054), June 1994, also provide a detailed discussion on capture efficiencies particularly in distinguishing between indirect and direct capture efficiencies for lithographic printing presses.

Indirect capture efficiency refers to VOC that is first dispersed in the press room air and is subsequently drawn into the dryer and into a control device. Direct capture efficiency refers to the fraction of VOC such as that contained in automatic blanket wash that is carried into the dryer on the substrate.

The capture efficiencies below are only for printing processes that use a dryer to evaporate the ink solvent to dry the ink. They are presented as a percentage of the VOC or HAP content in the material identified.

Material	**Heatset web lithography**	**Rotogravure**	**Flexography**
Ink	100	Must be measured	Must be measured
Dilution solvent	N/A	Must be measured	Must be measured
Fountain solution concentrate	70	N/A	N/A
Fountain solution additive	70	N/A	N/A
Automatic blanket wash	40	N/A	N/A
Coatings:			
UV	N/A	N/A	N/A
Water-based	N/A	N/A	N/A
Conventional varnish	100	N/A	N/A

VOC and HAP content determination

VOC content is determined using EPA approved test methods or formulation data if the formulation data is based on EPA approved test methods. The primary test method for VOC content is EPA Test Method 24. EPA Test Method 24A is used to determine VOC content of publication gravure inks and coatings. It is not applicable to use 24A for any other ink or coating used by the other print processes.

HAP content is determined using EPA Method 311. In situations where all the HAPs are VOCs, Method 24 or 24A is appropriate. SDSs may also be useful in determining VOC and HAP content of formulations. EPA allows for the use of formulation calculation of VOC and HAP if the basis for the calculation is derived from Method 24, Method 24A or Method 311 testing of concentrated materials or individual components.

The DNR's Small Business Environmental Assistance Program (SBEAP) provides an explanation of how to calculate VOC and HAP emissions using information on a material's SDS: https://dnr.wi.gov/files/PDF/pubs/sb/sb112.pdf. Alternatively, go to dnr.wi.gov and search: "SB112".

HAP emissions

HAP emissions are based on determining the amount of total HAPs and individual HAPs. Since most HAPs used in printing are also VOCs, the retention, release and control factors used for VOCs are applicable to HAP emissions.

Usually, the total HAP content is not provided on the SDS. Therefore, the individual HAP contents should be determined and summed to get the total HAPs. Individual HAP contents are found by examining the chemicals identified in Section 3 or 15 of the SDS and comparing them to the list of HAPs found at www.epa.gov/haps/initial-list-hazardous-air-pollutants-modifications.

SDSs will indicate the concentration of the chemical on a percent by weight (i.e. % wt or % bw) basis. If the material is purchased by weight, the individual HAP content by weight is used for the emission calculations. If the material is purchased by volume, the individual HAP content is determined by multiplying the concentration of the material by the density of the material. This will result in weight per volume of HAP content expressed as pounds per gallon or grams per liter. If the density of the material is not provided on the SDS, it is determined by multiplying 8.34 pounds/gallon by the specific gravity. Specific gravity is the density of the material compared to the density of water and is identified on the SDS. Total HAP content is determined by summing the individual HAP concentrations.

HAPs listed on an SDS and in EPA's list of HAP (i.e. 40 CFR 63.827(b) need to be included in the calculations. To make HAP emission determinations consistent with the OSHA hazard communication standard, EPA adopted the same thresholds for hazardous chemicals. The thresholds are:

- 0.1 weight percent for OSHA-defined carcinogens as specified in 29 CFR 1910.1200(d)(4)
- Greater than or equal to 1.0 weight percent for other organic HAP compounds.

This means that any HAP with a concentration less than the threshold identified above, does not need to be included in the emission calculations.

Control device efficiency determination

EPA Test Methods 18, 25 and 25A are used to determine control efficiency. The following documents provide guidance regarding when to use Method 25 and when to use Method 25A:

- Technical Support Document for Title V Permitting of Printing Operations
- CTG: Control Techniques Guideline for Offset Lithographic Printing and Letterpress Printing (EPA-453/R-06-002), September 2006
- ACT: Alternative Control Techniques for Offset Lithography, (EPA 4-94-054)

Control devices

Air pollution control equipment is installed to control the emissions from evaporative style ink dryer exhausts. Ink dryer exhaust occurs only from heatset web offset lithographic, and solvent-based flexographic and rotogravure printing presses.

Three methods of hydrocarbon emission control are employed to reduce the emissions from ink dryer exhaust:

- Condensation-droplet-removal
- Carbon adsorption
- Thermal oxidation

Condenser–droplet-removal control devices are used exclusively on heatset web offset printing presses. This technology consists of heat exchangers followed by either filters or electrostatic precipitators to remove oil droplets. The exchangers are often followed by an oil/water separator. In some instances, additional mist eliminators are used to reduce droplet loading or after treatment by a carbon filter to further reduce hydrocarbon vapor.

Since cooling is usually accomplished using ambient air, hydrocarbon removal efficiencies may vary widely depending on the condensing temperature reached and the input hydrocarbon concentration. The units cannot consistently achieve removal efficiency of 95 percent or greater which caused a decline in popularity.

Carbon adsorption is used almost exclusively with publication rotogravure printing presses. This is due to the nature of the toluene solvent used in the ink. Carbon adsorption is not well suited to control the emissions from packaging rotogravure or flexographic printing presses using solvent based inks due to the nature of the solvents used in these ink systems. The solvents can be blends of various alcohols and acetates that are not easily stripped from the carbon beds. Ink oils from heatset web offset printing presses are not compatible with carbon adsorption due to the large ink oil molecules that cannot be stripped from the carbon.

Oxidizers are divided into catalytic and thermal types. Both types often incorporate a heat exchanger to reduce fuel consumption provided operating hours are sufficient and air-flow volume is large enough to achieve an economic advantage.

The thermal oxidizer category is divided into direct thermal, thermal recuperative and thermal regenerative devices. The thermal oxidation process relies on high temperature (1400 – 1500°F), turbulence and adequate retention time (>0.5 second) in the combustion zone to ensure oxidation of organic vapors to carbon dioxide and water.

Each of the three types of thermal oxidizers or incinerators use a different approach to organic vapor destruction. All require a separate fuel, often natural gas, to maintain continuous combustion since the solvent concentration in the waste stream varies depending on press utilization, press speeds and ink coverage on the substrate.

In a thermal oxidizer, heat recovery is almost mandatory economically, and construction materials must handle higher temperatures.

Heat recovery is standard owing to the high temperatures involved and has resulted in two types of systems— recuperative and regenerative heat recovery.

- Recuperative units continually transfer heat from a hot stream to a colder stream in a countercurrent flow arrangement.
- Regenerative units cyclically store and transfer heat between streams, and temperatures are always changing.

The temperature storage unit consists of ceramic pieces. Operating temperatures of recuperative units range between 1,250°F and 1,450°F. Regenerative units operate in the range of 1,400°F to 1,800°F.

Hydrocarbon destruction efficiencies range from 97 percent to 99.8 percent for recuperative units and from 95 percent to 99 percent for regenerative units. Thermal recovery effectiveness typically ranges from 45 percent to 76 percent for recuperative units and from 80 percent to 95 percent for regenerative units. The use of heat exchangers reduces fuel consumption which results in fewer NOx compound emissions.

A catalytic oxidizer consists of a preheating section, a temperature indicator-controller, a chamber containing the catalyst and usually heat-recovery equipment. In catalytic oxidizers, the catalyst functions to promote the oxidation reactions at a lower temperature than occurs in a thermal oxidizer. The catalyst often is platinum combined with other metals and deposited in porous form on an inert substrate. Metallic oxide catalysts are usually homogeneous granules. Catalyst oxidizers typically control air temperature into the catalyst at 650–800°F. Typical hydrocarbon destruction efficiencies range from 90 percent to 98 percent depending on the ratio of the volume of catalyst used to the airflow volume.

Fuel combustion sources

Some printing presses are equipped with natural gas fired dryers that are used to heat the substrate and ink film to evaporate the ink solvents to dry the ink. In addition, many of these types of presses are also ducted to an add-on control device that will subsequently remove or destroy the VOC and HAP emissions. Newer technology in dryers have resulted in a combination dryer and oxidizer where the two units are integrated into a single device using the ink oils as fuel to heat the dryers and destroy the VOC before leaving the integrated system.

In addition, some printing operations have boilers and other large fuel combustion sources such as furnaces, roof top heaters, etc. To determine the emissions from dryers, oxidizers, combination dryers and oxidizers or other fuel combustion sources, a basic description of the how to calculate emissions associated with fuel combustion is provided in the fact sheet *Combustion Sources and Air Pollution Construction Permits* (AM-427), or go to dnr.wi.gov and search: “AM427.”

For reporting emissions in ARS, the source only needs to input the amount of fuel used by the operations. DNR has incorporated the appropriate emission factors so the emissions will be calculated and reported based on these factors.

Other emissions sources

Particulate matter emissions from spray powder used on sheet-fed offset lithographic printing presses are calculated following a simple equation:

$$E_{PM} = U * (EF/100) * [1 – (CE/100)]$$

Where:

E_{PM}	= Emissions, total, lb
U	= Usage of material, lb/year
EF	= Emissions factor
CE	= Collection efficiency of the filter

Particulate matter emissions from scrap paper collection systems are calculated following a simple equation:

$$E_{PM} = AF * EF * HR * [1 – (CE/100)]$$

Where:

E_{PM}	= Emissions, total, lb
AF	= Air flow (standard cubic feet per minute, SCFM)
EF	= Emission factor
HR	= Hours of operation per year
CE	= Collection efficiency of filter

Appendix A: Types of printing operations – Offset lithography

Description

The offset lithographic process uses a photo-sensitive printing plate where the image area is distinguished from the non-image area by the chemical treatment of the plate. On the press, the plate image is transferred to a blanket (which reverses or offsets it) which then transfers the image to the paper (reversing it again). Certain areas on the plate, made from aluminum, paper, or plastic, are chemically treated to accept ink while others are left untreated, so they will repel ink.

A mixture of water and other volatile and non-volatile chemicals and additives (i.e. fountain solution) that maintain the quality of the printing plate is applied to the plate. Alcohol and alcohol substitutes, including isopropyl alcohol, glycol ethers, and ethylene glycol, are the most common VOC additives used to reduce the surface tension of the fountain solution.

When the surface is inked, the ink remains in the ink-receptive area, but not in the untreated areas. When a material, such as paper, contacts the surface, ink is transferred to the paper. Lithography's major application is printing newspapers, books, magazines and all other forms of paper publications.

Lithography is divided into two broad subdivisions based upon ink drying and substrate feed mechanisms:

- Sheet-fed press - The substrate is fed into the press one sheet at a time. Sheet-fed printing is typically used for printing books, posters, brochures and artwork. Sheet-fed inks dry by a combination of penetration and oxidation.

- Web-press - Prints on a continuous roll of substrate, known as a web. Web-fed lithography is divided into heatset and non-heatset. Heatsetweb lithography dries the ink by evaporating the ink oils with indirect hot air dryers, and non-heatset web inks dry principally by absorption. Web-fed printing is commonly used for high speed production of magazines, catalogs, newspapers and other periodicals.

Lithography – emission determination

Total emissions for a facility can then be calculated by summing the emissions from usage of the various materials as follows:

$$\mathbf{E_{Total} = E_{ink} + E_{fountain\ solutions} + E_{cleaning\ solutions} + E_{automatic\ blanket\ wash} + E_{coatings/adhesives} + E_{other}}$$

Where:

E_{Total}	= Emissions, total, lb
E_{ink}	= Emissions, ink, lb
$E_{fountain\ solutions}$	= Emissions, fountain solutions, lb
$E_{cleaning\ solutions}$	= Emissions, cleaning solutions, lb
$E_{automatic\ blanket\ wash}$	= Emissions, automatic blanket wash, lb
$E_{coating/adhesives}$	= Emissions, coatings/adhesives, lb
E_{other}	= Emissions, other VOC or HAP containing materials, lb

Note: Calculation of emissions involving numerous inks, fountain solutions, coatings, solvents and other materials will require separate calculations such as presented here for each of the materials used with the different formulas at a given facility.

The approach used to determine emissions from a sheet-fed offset lithographic press would be identical for a non-heatset web offset lithographic press. This includes the same emission and retention factors.

Sample calculations

1. A print shop using a **sheet-fed lithographic** press reports the following material usage:

Material	Annual use	Unit	VOC content*	HAP	HAP content*
Ink	19,000	lb	35%		0%
Fountain solution concentrate	300	gal	1.85 lb/gal	ethylene glycol	1.85 lb/gal
Fountain solution additive	100	gal	4.5 lb/gal	ethylene glycol	4.5 lb/gal
Automatic blanket wash	3,000	gal	6.8 lb/gal	naphthalene xylene	0.296 lb/gal 0.144 lb/gal
Hand cleaning solution	2,200	gal	7.0 lb/gal	naphthalene	0.16 lb/gal
Coating: UV	1,500	lb	1%		0%
Coating: conventional	6,000	lb	35%		0%
Spray powder	1,000	lb	0%	0%	0%

*Percent by weight or lb/gal

No control devices are in place for this particular facility.

According to the CTG and ACT for Offset Lithographic and Letterpress Printing, it is assumed that 95 percent of the ink and conventional coating (i.e. varnish) VOC is retained in the substrate. A 50 percent retention factor is assumed for cleaning solutions because the shop's soiled towels are kept in a closed container and have a vapor pressure of less than 10 mmHg at 20°C.

The press does apply anti-offset spray powder at the delivery end of the press. The press is equipped with a hood and an inline filter. The hood vents to the atmosphere so the emissions need to be determined.

Since there is not a dryer used on a sheet-fed or a non-heatset web offset press, the emissions do not need to be speciated into dryer and non-dryer emissions. Speciation was developed by EPA to account for both dryer (i.e. stack) and non-dryer (i.e. non-stack or fugitive) emissions. All emissions from sheet-fed and non-heatset web offset lithographic printing presses are to be reported as non-dryer emissions. So, the facility should be sure to select the appropriate SCC in ARS.

The emissions are calculated as described below.

Variable	**Ink**	**Fountain solution conc.**	**Fountain solution additive**	**Auto blanket wash**	**Hand cleaning solution**	**Coating: UV**	**Coating: conventional**
U (amount used, lb)	19,000					1,500	6,000
G (amount used, gal)		300	100	3,000	2,200		
W (VOC content, wt%)	35%					1%	35%
C (VOC content, lb/gal)		1.85	4.5	6.8	7.0		
W (HAP content, wt%)	0%					0%	0%
C (HAP content, lb/gal)		1.85	4.5	0.44	0.16		
R (retention)	95%	0%	0%	0%	50%	0%	0%
J (capture efficiency)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
K (destruction efficiency)	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Variable	**Spray powder**
U (amount used, lb)	1,000
EF (emission factor)	11.5%
CE (collection efficiency)	40%

Ink emissions

With no control device in place, VOC and HAP emissions are calculated using the following equation:

E_{VOC} (ink)	**= U * (W/100) * [1 – (R/100)]** **= (19,000 lb/year) * (35/100) * [1-(95/100)]** **= 333 lb VOC/year from ink**

Note: In this example, the inks are 0 percent HAP by weight, therefore no HAPs are emitted.

Fountain solution emissions

With no control device in place, VOC and HAP emissions are calculated using the following equations:

E_{VOC} (concentrate)	= G * C * [1 – (R/100)] = (300 gal/year) * (1.85 lb/gal) * [1-(0/100)] = 555 lb VOC/year
E_{VOC} (additive)	= G * C * [1 – (R/100)] = (100 gal/year) * (4.5 lb/gal) * [1-(0/100)] = 450 lb VOC/year
E_{VOC} (total, fountain solution)	**= E_{VOC} (concentrate) + E_{VOC} (additive)** **= 555 lb VOC/year + 450 lb VOC/year** **= 1,005 lb VOC/year**
E_{HAP} (concentrate)	= G * C * [1 – (R/100)] = (300 gal/year) * (1.85 lb/gal) * [1 – (0/100)] = 555 lb HAP
E_{HAP} (additive)	= G * C * [1 – (R/100)] = (100 gal/year) * (4.50 lb/gal) * ((82+18)/100) * [1-(0/100)] = 450 lb HAP
E_{HAP} (total, fountain solution)	**= E_{HAP} (concentrate) + E_{HAP} (additive)** **= 555 lb + 450 lb HAP/year** **= 1,005 lb HAP/year**

Cleaning solution emissions

With no control device in place, VOC and HAP emissions are calculated using the following equations:

E_{VOC} (automatic blanket wash)	= G * C * [1 – (R/100)] = (3,000 gal/year) * (6.8 lb/gal) * [1 – (0/100)] = 20,400 lb VOC/year
E_{VOC} (hand cleaning solution)	= G * C * [1 – (R/100)] = (2,200 gal/yr) * (7.0 lb/gal) * [1-(50/100)] = 7,700 lb VOC/year
E_{VOC} (total, cleaning solution)	**= E_{VOC} (automatic blanket wash) + E_{VOC} (hand cleaning solution)** **= 20,400 lb VOC/year + 7,700 lb VOC/year** **= 28,100 lb VOC/year**
E_{HAP} (automatic blanket wash)	= G * C * [1 – (R/100)] = (3,000 gal/year) * (0.44 lb/gal) * [1 – (0/100)] = 1,320 lb HAP/year
E_{HAP} (hand cleaning solution)	= G * C * [1 – (R/100)] = (2,200 gal/year) * (0.16 lb/gal) * [1-(50/100)] = 176 lb HAP/year
E_{HAP} (total, cleaning solution)	**= E_{HAP} (automatic blanket wash) + E_{HAP} (hand cleaning solutions)** **= 1,320 lb HAP/year + 176 lb HAP/year** **= 1,496 lb HAP/year**

Coating emissions

With no control device in place, VOC and HAP emissions are calculated using the following equations:

E_{VOC} (UV coating)	= U * (W/100) * [1 – (R/100)] = (1,500 lb/year) * (1/100) * [1-(0/100)] = 15 lb VOC/year
E_{VOC} (conventional coating)	= U * (W/100) * [1 – (R/100)] = (6,000 lb/year) * (35/100) * [1-(95/100)] = 105 lb VOC/year
E_{VOC} (total, coating)	**= E_{VOC} (UV coating) + E_{VOC} (conventional coating)** **= 15 lb VOC/year + 105 lb VOC/year** **= 120 lb VOC/year**

Note: In this example, the coatings are 0 percent HAP by weight, therefore, no HAPs are emitted.

Particulate matter emissions

With a hood and inline filter, the emissions are calculated using the following equation:

$$
\begin{aligned}
E_{PM}\text{ (spray powder)} &= U * (EF/100) * [1 - (CE/100)] \\
&= (1{,}000 \text{ lb/year}) * (11.5/100) * [1-(40/100)] \\
&= 69 \text{ lb PM/year}
\end{aligned}
$$

Facility totals

Total emissions for this facility are calculated using the following equations:

E_{total}	**= E_{ink} + $E_{fountain\ solutions}$ + $E_{cleaning\ solutions}$ + $E_{coating}$**
E_{VOC}	**= 333 lb VOC/year + 1,005 lb VOC/year + 28,100 lb VOC/year + 120 lb VOC/year = 29,558 lb VOC/year = 14.8 tons/year**
E_{HAP}	**= 0 lb HAP/year + 1,005 lb HAP/year + 1,496 lb HAP/year + 0 lb HAP/year = 2,501 lb HAP/year = 1.25 tons/year**
E_{PM}	**= 69 lb PM/year = 0.0003 tons/year**

Note: Calculation of emissions involving numerous inks, coatings, solvents, adhesives and other materials will require separate calculations such as presented here for each of the materials used at a given facility.

2. A print shop using **heatset web offset lithographic** presses reports the following material usage:

Material	Annual use	Unit	VOC content*	HAP	HAP content*
Ink	90,000	lb	45%	0%	
Fountain solution concentrate	300	gal	1.85 lb/gal	ethylene glycol	1.85 lb/gal
Fountain solution additive	100	gal	4.5 lb/gal	ethylene glycol	4.5 lb/gal
Automatic blanket wash	500	gal	6.48 lb/gal	xylene cumene	0.10 lb/gal 0.08 lb/gal
Hand cleaning solution	1,000	gal	6.73 lb/gal	naphthalene	0.16 lb/gal
Coating: UV	1,500	lb	1%	0%	
Coating: conventional	10,000	lb	40%	0%	

*Percent by weight or lb/gal

An oxidizer with a destruction efficiency of 95 percent is used to control emissions at this facility.

The facility has a paper scrap trim collection system. The system consists of a cyclone that is vented to a baghouse. The baghouse vents to the atmosphere so the emissions need to be determined.

According to the CTG and ACT for Offset Lithographic and Letterpress Printing, it is assumed that 20 percent of the ink and conventional coating (i.e., varnish) VOC is retained in the substrate and the remaining 80 percent is completely captured (i.e. 100 percent) in the dryer. A 70 percent capture efficiency is used for fountain solutions using alcohol substitutes. In this example, a 40 percent capture efficiency is for automatic blanket washes with composite VOC vapor pressures of no greater than 10 mmHg at 20°C. Since soiled towels are kept in a closed container and have a composite VOC vapor pressure of less than 10 mmHg at 20°C, a 50 percent retention factor is assumed for hand cleaning solutions.

Emissions from heatset presses need to be speciated into dryer and non-dryer or all other emissions. Speciation was developed by EPA to account for both dryer (i.e. stack) and non-dryer (i.e. non-stack or fugitive) emissions.

The emissions are calculated as described below.

Variable	Ink	Fountain solution conc.	Fountain solution additive	Auto blanket wash	Hand cleaning solution	Coating: UV	Coating: conventional
U (amount used, lb)	90,000					1,500	10,000
G (amount used, gal)		300	100	500	1,000		
W (VOC content, wt%)	45%					1%	40%
C (VOC content, lb/gal)		1.85	4.5	6.48	6.73		
W (HAP content, wt%)	0%					0%	0%
C (HAP content, lb/gal)		1.85	4.5	0.18	0.16		
R (retention)	20%	0%	0%	0%	50%	0%	20%
J (capture efficiency)	100%	70%	70%	40%	N/A	N/A	100%
K (destruction efficiency)	95%	95%	95%	95%	N/A	N/A	95%

Variable	Paper dust
AF (SCFM)	35,000
EF (grains*/dscf)	0.005
CE (collection efficiency of filter)	0%
HR (hours of operation/yr)	6,000

* Grains are converted to pounds by dividing by 7000 grains/pound

Ink emissions

With a 95 percent efficient oxidizer in place, VOC emissions are calculated using the following equation:

E_{VOC} (ink), dryer = U * (W/100) * [1 – (R/100)] * J/100 * [1 - (K/100)]
= (90,000 lb/year) * (45/100) * [1 – (20/100)] * (100/100) * [1 – (95/100)]
= 1,620 lb VOC/year

E_{VOC} (ink), non-dryer = U * (W/100) * [1 – (R/100)] * [1 – (J/100)]
= (90,000 lb/year) * (45/100) * [1 – (20/100)] * [1 – (100/100)]
= 0 lb VOC/year

E_{VOC} (total, ink) = E_{ink} (dryer) + E_{ink} (non-dryer)
= 1,620 lb VOC/year + 0 lb VOC/year
= 1,620 lb VOC/year

Note: In this example, the inks are 0 percent HAP by weight, therefore, no HAPs are emitted.

Fountain solution emissions

With a 95 percent efficient oxidizer in place, VOC and HAP emissions are calculated using the following equations:

E_{VOC} (concentrate), dryer = G * C * [1 – (R/100)] * (J/100) * [1 – (K/100)]
= (300 gal/yr) * (1.85 lb/gal) * [1 – (0/100)] * (70/100) * [1 – (95/100)]
= 19 lb VOC/year

E_{VOC} (concentrate), non-dryer = G * C * [1 – (R/100)] * [1- (J/100)]
= (300 gal/yr) * (1.85 lb/gal) * [1 – (0/100)] * [1- (70/100)]
= 167 lb VOC/year

E_{VOC} (additive), dryer = G * C * [1 – (R/100)] * (J/100) * [1 – (K/100)]
= (100 gal/yr) * (4.5 lb/gal)* [1 – (0/100)] * (70/100) * [1 – (95/100)]
= 16 lb VOC/year

E_{VOC} (additive), non-dryer = G * C * [1 – (R/100)] * [1- (J/100)]
= (100 gal/yr) * (4.5 lb/gal) * [1 – (0/100)] * [1 – (70/100)]
= 135 lb VOC/year

E_{VOC} (total), dryer = E_{VOC} (concentrate) + E_{VOC} (additive)
= 19 lb/year VOC + 16 lb/year VOC
= 35 lb VOC/year

E_{VOC} (total), non-dryer = E_{VOC} (concentrate) + E_{VOC} (additive)
= 167 lb/year VOC + 135 lb/year VOC
= 302 lb VOC/year

E_{VOC} (total, fountain solution), = $E_{fountain\ solution}$ (dryer) + $E_{fountain\ solution}$ (non-dryer)
= 35 lb VOC/year + 302 lb VOC/year
= 337 lb VOC/year

E_{HAP} (concentrate), dryer = G * C * [1 – (R/100)] * (J/100) * [1 – (K/100)]
= (300 gal/yr) * (1.85 lb/gal) * [1 – (0/100)] * (70/100) * [1 – (95/100)]
= 19 lb HAP/year

E_{HAP} (concentrate), non-dryer = G * C * [1 – (R/100)] * [1- (J/100)]
= (300 gal/yr) * (1.85 lb/gal) * [1 – (0/100)] * [1- (70/100)]
= 167 lb HAP/year

E_{HAP} (additive), dryer = G * C * [1 – (R/100)] * (J/100) * [1 – (K/100)]
= (100 gal/yr) * (4.5 lb/gal)* [1 – (0/100)] * (70/100) * [1 – (95/100)]
= 16 lb HAP/year

E_{HAP} (additive), non-dryer = G * C * [1 – (R/100)] * [1- (J/100)]
= (100 gal/yr) * (4.5 lb/gal) * [1 – (0/100)] * [1 – (70/100)]
= 135 lb HAP/year

E_{HAP} (total), dryer = E_{HAP} (concentrate) + E_{HAP} (additive)
= 19 lb/year HAP + 16 lb/year HAP
= 35 lb HAP/year

E_{HAP} (total), non-dryer = E_{HAP} (concentrate) + E_{HAP} (additive)
= 167 lb/year HAP + 135 lb/year HAP
= 302 lb HAP/year

E_{HAP} (total, fountain solution) = E_{HAP} (concentrate) + E_{HAP} (additive)
= 35 lb/year HAP + 302 lb/year HAP
= 337 lb HAP/year

Cleaning solution emissions – Automatic blanket wash

With a 95 percent efficient oxidizer in place, VOC and HAP emissions from the automatic blanket wash are calculated using the following equations:

E_{VOC} (automatic blanket wash), dryer = G * C * [1 – (R/100)] * (J/100) * [1 – (K/100)]
= (500 gal/yr) * (6.48 lb/gal) * [1 – (0/100)] * (40/100) * [1 – (95/100)]
= 65 lb VOC/year

E_{VOC} (automatic blanket wash), non-dryer = G * C * [1 – (R/100)] * [1- (J/100)]
= (500 gal/yr) * (6.48 lb/gal) * [1 – (0/100)] * [1 – (40/100)]
= 1,944 VOC/year

E_{VOC} (total, automatic blanket wash)	**= $E_{automatic\ blanket\ wash}$ (dryer) + $E_{automatic\ blanket\ wash}$ (non-dryer)** **= 65 lb VOC/year + 1,944 VOC/year** **= 2,009 lb VOC/year**

E_{HAP} (automatic blanket wash), dryer
= G * C * [1 – (R/100)] * (J/100) * [1 – (K/100)]
= (500 gal/yr) * (0.18 lb/gal) * [1 – (0/100)] * (40/100) * [1 – (95/100)]
= 2 lb HAP/year

E_{HAP} (automatic blanket wash), non-dryer
= G * C * [1 – (R/100)] * [1- (J/100)]
= (500 gal/yr) * (0.18 lb/gal) * [1 – (0/100)] * [1 – (40/100)]
= 54 lb HAP/year

E_{HAP} (total, automatic blanket wash)	**= $E_{automatic\ blanket\ wash}$ (dryer) + $E_{automatic\ blanket\ wash}$ (non-dryer)** **= 2 lb HAP/year + 54 HAP/year** **= 56 lb HAP/year**

<u>Cleaning solution emissions – Hand wash</u>

Since hand washing does not occur while the dryer is running, VOC and HAP emissions from the hand wash cleaning solution are calculated using the following equations:

E_{VOC} (hand cleaning solution), non-dryer
= G * C * [1 – (R/100)]
= (1,000 gal/yr) * (6.73 lb/gal) * [1-(50/100)]
= 3,365 lb VOC/year

E_{HAP} (hand cleaning solution), non-dryer
= G * C * [1 – (R/100)]
= (1,000 gal/yr) * (0.16 lb/gal) * [1-(50/100)]
= 80 lb HAP/year

<u>Cleaning solution emissions – Combined</u>

E_{VOC} (all cleaning solution), non-dryer
= E_{VOC} (automatic blanket wash) + E_{VOC} (hand cleaning solution)
= 1,944 lb VOC/year + 3,365 lb VOC/year
= 5,309 lb VOC/year

E_{VOC} (total, all cleaning solution)	**= E_{VOC} (automatic blanket wash) + E_{VOC} (hand cleaning solution)** **= 2,009 lb VOC/year + 3,365 lb VOC/year** **= 5,374 lb VOC/year**

E_{HAP} (all cleaning solution), non-dryer = E_{HAP} (automatic blanket wash) + E_{HAP} (hand cleaning solutions)
= 54 (lb HAP/year) + 80 (lb HAP/year)
= 134 lb HAP/year

E_{HAP} (total, all cleaning solution)	**= E_{HAP} (automatic blanket wash) + E_{HAP} (hand cleaning solutions)** **= 56 lb HAP/year + 80 lb HAP/year** **= 136 lb HAP/year**

Coating emissions

Since the conventional coating (i.e., varnish) in this example is applied before the dryer ducted to a 95 percent efficient oxidizer, VOC emissions from the coating are calculated using the following equation:

E_{VOC} (conventional coating), dryer = U * (W/100) * [1 – (R/100)] * J/100 * [1 - (K/100)]

= (10,000 lb/year) * (40/100) * [1 – (20/100)] * (100/100) * [1 – (95/100)]
= 160 lb VOC/year

E_{VOC} (conventional coating), non-dryer = U * (W/100) * [1 – (R/100)] * [1 – (J/100)]
= (10,000 lb/year) * (40/100) * [1 – (20/100)] * [1 – (100/100)]
= 0 lb VOC/year

E_{VOC} (total, conventional coating)	**= $E_{conventional\ coating}$ (dryer) + $E_{conventional\ coating}$ (non-dryer)** **= 160 lb VOC/year + 0 lb VOC/year** **= 160 lb VOC/year**

Since the UV coating in this example is applied after the dryer, VOC emissions from the coating is calculated using the following equations:

E_{VOC} (UV coating), non-dryer = U * (W/100) * [1 – (R/100)]
= (1,500 lb/year) * (1/100) * [1 - (0/100)]

$= 15$ lb VOC/year

E_{VOC} (total, all coating)	**$= E_{VOC}$ (UV coating) $+ E_{VOC}$ (conventional coating)** **= 15 lb VOC/year + 160 lb VOC/year** **= 175 lb VOC/year**

Note: In this example, the coatings are 0 percent HAP by weight, therefore, no HAPs are emitted.

Particulate Matter emissions

With a cyclone ducted to a baghouse and 6,000 hours of operation, the emissions are calculated using the following equation:

E_{PM} (paper dust)	**= AF * (EF) * (HR) * [1 – (CE/100)]** **= (35,000 scfm * 60 min/hr) * (0.005 gr/dscf ÷ 7,000 gr/lb) * 6,000 hours/year * [1-(0/100)]** **= 9,000 lb VOC/year**

Facility totals

Total HAP and VOC emissions for this facility are calculated using the following equations:

$E_{totalVOC}$ dryer $= E_{ink} + E_{fountain\ solutions} + E_{cleaning\ solutions} + E_{coating}$
= 1,620 lb VOC/year + 35 lb VOC/year + 65 lb VOC/year + 160 lb VOC/year
= 1,880 lb VOC/year
= 0.94 tons VOC/year

$E_{totalVOC}$ non-dryer $= E_{ink} + E_{fountain\ solutions} + E_{cleaning\ solutions} + E_{coating}$
= 0 + 302 lb VOC/year + 5,309 lb VOC/year + 15 lb VOC/year
= 5,626 lb VOC/year
= 2.81 tons VOC/year

$E_{totalVOC}$	**$= E_{total}$ (dryer) $+ E_{total}$ (non-dryer)** **= 1,880 lb VOC/year + 5,626 lb VOC/year** **= 7,506 lb VOC/year** **= 3.75 tons/year**

$E_{totalHAP}$ dryer $= E_{ink} + E_{fountain\ solutions} + E_{cleaning\ solutions} + E_{coating}$
= 0 lb HAP/year + 35 lb HAP/year + 2 lb HAP/year + 0 lb HAP/year
= 37 lb HAP/year
= 0.02 tons HAP/year

$E_{totalHAP}$ non-dryer = $E_{ink} + E_{fountain\ solutions} + E_{cleaning\ solutions} + E_{coating}$
= 0 lb HAP/year + 302 lb HAP/year + 134 lb HAP/year + 0 lb HAP/year
= 436 lb HAP/year
= 0.22 tons HAP/year

$E_{totalHAP}$ = E_{total} (dryer) + E_{total} (non-dryer)
= 37 lb HAP/year + 436 lb HAP/year
= 473 lb HAP/year
= 0.24 tons/year

E_{PM} = 9,000 lb PM/year
= 4.5 tons/year

Note: Calculation of emissions involving numerous inks, coatings, solvents, adhesives and other materials will require separate calculations such as presented here for each of the materials used at a given facility.

Heatset web letterpress presses are extremely uncommon and not used for high volume commercial printing applications. If one is being used and emissions need to be determined, use the example for heatset web offset lithography as a model. The emissions will have to be speciated into dryer and non-dryer emissions as the ink will dry by evaporation.

Offset lithographic Source Classification Codes (SCC)

EPA has established two SCCs for VOC emissions from offset lithographic printing operations. The SCCs are for dryer (i.e. stack) and non-dryer (i.e. non-stack or fugitive) emissions. Speciation between dryer and non-dryer emissions was developed by EPA to account for the emissions from presses with dryers and control devices.

All emissions from sheet-fed and non-heatset web offset lithographic presses are to be reported as non-dryer emissions. Emissions from heatset web offset lithographic presses need to be speciated into dryer and non-dryer emissions. The facility should be sure to select the appropriate SCC in ARS.

SCC	EPA SCC description
40500402	Dryer emissions from heatset web offset lithographic presses
40500403	Non-dryer or all other emissions from offset lithographic presses
36000104	Scrap and paper trim collection

Appendix B: Types of printing operations - Flexography

Description

Flexography is a method of direct rotary printing that uses resilient relief image plates made of rubber or photopolymer material. Anilox rollers, also used in flexography, deliver a precise amount of ink, and set flexography apart from other printing processes. Flexography utilizes fast-drying fluid inks that print onto virtually any substrate, absorbent or nonabsorbent.

Flexography uses low-viscosity inks like that of a free-flowing liquid such as light oil or syrup which dry very quickly between the printing units of a press. Alcohol/solvent-based, water-based and energy-curable inks (i.e. ultraviolet and electron beam) are used in flexography to meet a wide variety of requirements. Flexographic printing inks are made up of a colorant, liquid vehicle, and additives.

Flexography was developed primarily for printing packaging materials. Board, paper, foil and film packaging substrates are commonly supplied in roll form for feeding into form-and-fill, overwrapping, bag making and other continuous web-processing machinery. For these applications, roll-to-roll or roll-to-cut printing is required. Since there are so many kinds of paper, board, plastics, foil and film, the term “substrate” applies to any surface to be printed. If the material is reasonably smooth and comes in roll form, chances are it can be printed flexographically.

Flexographic image carriers, whether molded from natural or synthetic rubber compounds or imaged using light-reactive photopolymer resins, are generally made from flexible, elastomeric materials. The ink is carried by the raised portion of the plate and transferred to the substrate. Removing and lowering the nonprinting areas through cutting, molding, etching, dissolving or laser engraving obtain the raised image.

Flexography uses image carriers in both plate and cylindrical forms. Flexographic printing plates have evolved from hand-engraved rubber plates to molded rubber plates, and on to photopolymer materials. Cylindrical image carriers are used for the printing of designs with continuous patterns for floor coverings, wallpaper and flexible packaging. A single-color printing unit is comprised of one of three different ink metering systems: two-roller, reverse angle doctor blade or doctor blade chamber system. This metering system supplies ink to the anilox roller which delivers a precise amount of ink to the image carrier. The image carrier is supported and adhered to a cylinder or sleeve which then transfers the image to the substrate supported by the impression roller. Most presses are multicolor generally consisting of two to twelve printing units in the printing section.

The flexographic printing industry uses four main press designs: central impression (CI), stack, inline and corrugated sheet-fed. Each press type has certain advantages for the different product segments and markets served by the industry. While all four types are unique in their configuration of the printing units, the anilox roller remains as the standard. The CI press has a common impression cylinder around which two to twelve printing units can be positioned. Today, most CI presses use an eight or ten printing unit configuration. On average, these presses run at speeds of 2000 to 2600 feet per minute (fpm). The stack press is built with the printing units literally “stacked” one above the other. The individual printing units mount on both sides of a vertical frame.

Stack presses commonly have six printing units. However as few as one, or as many as ten units are possible configurations. These presses run on average at speeds of 200 to 1,500 fpm. A primary benefit of stack presses is easy accessibility due to the ‘stacked’ design. They also have a relatively small footprint and take up less room than other types of presses. The inline press has its printing units positioned in tandem (a straight row). Six to twelve printing units are the most often used combinations with this type of press. However, due to its modular design, the number of units can be fewer than six or greater than twelve. On average, Inline presses run at speeds of 600-1000 fpm. However, some presses are capable of production speeds up to 1200 fpm.

Sheet-fed presses are used to print combined corrugated board which is supplied in sheet form. It requires a sheet-fed press which is usually attached to an in-line die cutting or slotting and gluing converting section. These attachments are used to create a variety of packaging including but not limited to corrugated boxes and point of purchase or point of sale displays to house other packaging ranging from large too small. Sheet-fed presses have as few as one to as many as eight printing units. A wide range of factors affects the press speeds in a production situation. Although some sheet-fed flexographic presses can exceed 18,000 sheets per hour (sph), the typical range is 4,000 to 10,000 sph depending on the design of the press, the type of corrugated board used and in-line die cutting “speed” limitations.

Flexography – Emission determination

Total emissions for a facility are calculated by summing the emissions from usage of the various materials as follows:

$$E_{Total} = E_{ink} + E_{dilution\ solvent} + E_{cleaning\ solutions} + E_{coatings/adhesives} + E_{other}$$

Where:

E_{total}	= Emissions, total, lb
E_{ink}	= Emissions, ink, lb
$E_{dilution\ solvent}$	= Emissions, dilution solvent, lb
$E_{cleaning\ solutions}$	= Emissions, hand cleaning solutions, lb
$E_{coating/adhesives}$	= Emissions, coatings/adhesives, lb
E_{other}	= Emissions, other VOC or HAP containing materials, lb

Note: Calculation of emissions involving numerous inks, coatings, dilution solvents, cleaning solvents, adhesives and other materials will require separate calculations such as presented here for each of the numerous materials being used at a given facility. Capture efficiencies will have to be determined for inks, coatings, dilution solvents, adhesives and other materials using U.S. EPA's Method 204, Permanent (PTE) or Temporary Total Enclosure (TTE) for Determining Capture Efficiency.

Sample calculations

1. A **solvent-based flexographic printing** operation that is printing on a variety of **plastic films** reported using the following materials on a press.

Material	Annual use	Unit	VOC content*	HAP	HAP content*
Ink	90,000	lb	58%	ethylene glycol	1%
Dilution solvent	75,000	lb	100%	N/A	0%
Hand cleaning solution	2,000	lb	100%	N/A	0%
Automatic cleaning solution	24,000	lb	100%	N/A	
Coating: primer	4,500	lb	97%	N/A	0%
Coating: overprint matte	4,500	lb	73%	N/A	0%

*Percent by weight or lb/gal

Since the inks and coatings are solvent-based, an oxidizer with a destruction efficiency of 99 percent is used at this facility. The press is in an enclosure that has 97.4 percent capture efficiency based on EPA Method 204, Permanent (PTE) or Temporary Total Enclosure (TTE) for Determining Capture Efficiency, test results. The automatic cleaning system is self-contained, and the loss is 0.5 percent.

According to the Technical Support Document for Title V Permitting of Printing Facilities, since soiled towels are kept in a closed container and have a composite VOC vapor pressure of less than 10 mmHg at 20°C, a 50 percent retention factor is assumed for hand cleaning solutions. However, the vapor pressure of the hand cleaning solution used on this press is greater than 10 mmHg at 20°C. Consequently, no retention of the cleaning solution occurs. Hand cleaning is performed when the press is not running which means the emissions do not get speciated between dryer and non-dryer.

In addition, there is no retention of the solvent used in the inks and coatings in the substrate. The substrate is not considered absorbent.

Emissions from flexographic presses with dryers and control devices need to be speciated into dryer and non-dryer or all other emissions. Speciation was developed by EPA to account for both dryer (i.e. stack) and non-dryer (i.e. non-stack or fugitive) emissions.

The emissions are calculated as described below.

Variable	Ink	Dilution solvent	Hand cleaning solution	Automatic cleaning solution	Coating: primer	Coating: overprint matte
U (amount used, lb)	90,000	75,000	2,000	24,000	4,500	4,500
W (VOC content, wt%)	58%	100%	100%	100%	97%	73%
W (HAP content, wt%)	1%	0%	0%	0%	0%	0%
R (retention)	0%	0%	0%	N/A	0%	0%
J (capture efficiency)	97.4%	97.4%	N/A	99.5%	97.4%	97.4%
K (destruction efficiency)	99%	99%	N/A	N/A	99%	99%

Ink emissions

With a 99 percent efficient oxidizer in place with a 97.4 percent capture efficiency, VOC and HAP emissions are calculated using the following equation:

E_{VOC} (ink), dryer = U * (W/100) * [1 – (R/100)] * J/100 * [1 - (K/100)]
= (90,000 lb/year) * (58/100) * [1 – (0/100)] * (97.4/100) * [1 – (99/100)]
= 508 lb VOC/year

E_{VOC} (ink), non-dryer = U * (W/100) * [1 – (R/100)] * [1 – (J/100)]
= (90,000 lb/year * (58/100) * [1 – (0/100)] *0 [1 – (97.4/100)]
= 1,357 lb VOC/year

E_{VOC} (total, ink) = E_{ink} (dryer) + E_{ink} (non-dryer)
= 508 lb VOC/year + 1,357 lb VOC/year
= 1,865 lb VOC/year

E_{HAP} (ink), dryer = U * (W/100) * [1 – (R/100)] * J/100 * [1 – (K/100)]
= (90,000 lb/year) * (1/100) * [1 – (0/100)] * (97.4/100) * [1 – (99/100)]
= 9 lb HAP/year

E_{HAP} (ink), non-dryer = U * (W/100) * [1 – (R/100)] * [1 – (J/100)]
= (90,000 lb/year * (1/100) * [1 – (0/100)] * [1 – (97.4/100)]
= 23 lb HAP/year

E_{HAP} (total, ink) = E_{ink} (dryer) + E_{ink} (non-dryer)
= 9 lb HAP/year + 23 lb HAP/year
= 32 lb HAP/year

Dilution solvent emissions

With a 99 percent efficient oxidizer in place with a 97.4 percent capture efficiency, VOC and HAP emissions are calculated using the following equation:

E_{VOC} (dilution solvent), dryer = U * (W/100) * [1 – (R/100)] * J/100 * [1 - (K/100)]
= (75,000 lb/year) * (100/100) * [1 – (0/100)] * (97.4/100) * [1 – (99/100)]
= 731 lb VOC/year

E_{VOC} (dilution solvent), non-dryer = U * (W/100) * [1 – (R/100)] * [1 – (J/100)]
= (75,000 lb/year * (100/100) * [1 – (0/100)] * [1 – (97.4/100)]
= 1,950 lb VOC/year

E_{VOC} (total, dilution solvent) = E_{ink} (dryer) + E_{ink} (non-dryer)
= 731 lb VOC/year + 1,950 lb VOC/year
= 2,681 lb VOC/year

Note: In this example, the dilution solvents are 0 percent HAP by weight, therefore, no HAPs are emitted.

Cleaning solution emissions

Cleaning occurs when the press is not running. The automatic cleaning solution is used in a self-contained unit and there is very little loss as a result of cleaning. VOC and HAP emissions are calculated using the following equation:

E_{VOC} (hand cleaning solution), non-dryer = U * (W/100) * [1 – (R/100)]
= (2,000 lb/year * (100/100) * [1 – (0/100)]
= 2,000 lb VOC/year

E_{VOC} (auto cleaning solution), non-dryer	= U * (W/100) * [1 – (R/100)] = (24,000 lb/year * (100/100) * [1 – (99.5/100)] = 120 lb VOC/year
E_{VOC} (total, all cleaning solution)	**= E_{VOC} (hand cleaning solutions) + E_{VOC} (auto cleaning solutions)** **= 2,000 lb/yr + 120 lb/yr** **= 2,120 lb/yr**

Note: In this example, the cleaning solvents are 0 percent HAP by weight therefore, no HAPs are emitted.

Coating emissions

With a 99 percent efficient oxidizer in place with a 97.4 percent capture efficiency, VOC and HAP emissions are calculated using the following equation:

E_{VOC} (coating:primer), dryer	= U * (W/100) * [1 – (R/100)] * J/100 * [1 - (K/100)] = (4,500 lb/year) * (97/100) * [1 – (0/100)] * (97.4/100) * [1 – (99/100)] = 43 lb VOC/year
E_{VOC} (coating:primer), non-dryer	= U * (W/100) * [1 – (R/100)] * [1 – (J/100)] = (4,500 lb/year * (97/100) * [1 – (0/100)] * [1 – (97.4/100)] = 114 lb VOC/year
E_{VOC} (total, coating:primer)	**= E_{ink} (dryer) + E_{ink} (non-dryer)** **= 43 lb VOC/year + 114 lb VOC/year** **= 157 lb VOC/year**
E_{VOC} (coating:overprint), dryer	= U * (W/100) * [1 – (R/100)] * J/100 * [1 - (K/100)] = (4,500 lb/year) * (73/100) * [1 – (0/100)] * (97.4/100) * [1 – (99/100)] = 32 lb VOC/year
E_{VOC} (coating:overprint), non-dryer	= U * (W/100) * [1 – (R/100)] * [1 – (J/100)] = (4,500 lb/year * (73/100) * [1 – (0/100)] * [1 – (97.4/100)] = 85 lb VOC/year

E_{VOC} **(total, coating:overprint)** **= E_{ink} (dryer) + E_{ink} (non-dryer)**
= 32 lb VOC/year + 85 lb VOC/year
= 117 lb VOC/year

Facility totals

Total VOC and HAP emissions for this facility are calculated using the following equations:

$E_{totalVOC}$ dryer = E_{ink} + $E_{dilution\ solvent}$ + $E_{cleaning\ solutions}$ + $E_{coatings/adhesives}$ + E_{other}
= 508 lb VOC/year + 731 lb VOC/year + 43 lb VOC/year + 32 lb VOC/year + 0 lb VOC/year
= 1,314 lb VOC/year
= 0.66 tons VOC/year

$E_{totalVOC}$ non-dryer = E_{ink} + $E_{dilution\ solvent}$ + $E_{cleaning\ solutions}$ + $E_{coatings/adhesives}$ + E_{other}
= 1,357 lb VOC/year + 1,950 lb VOC/year + 114 lb VOC/year + 85 lb VOC/year + 2,120 lb VOC/year
= 5,626 lb VOC/year
= 2.81 tons VOC/year

$E_{totalVOC}$ **= E_{total} (dryer) + E_{total} (non-dryer)**
= 1,314 lb VOC/year + 5,626 lb VOC/year
= 6,940 lb VOC/year
= 3.47 tons VOC/year

$E_{totalHAP}$ dryer = E_{ink} + $E_{dilution\ solvent}$ + $E_{cleaning\ solutions}$ + $E_{coatings/adhesives}$ + E_{other}
= 9 lb HAP/year + 0 lb HAP/year + 0 lb HAP/year + 0 lb HAP/year
= 9 lb HAP/year
= 0.0045 tons HAP/year

$E_{totalHAP}$ non-dryer = E_{ink} + $E_{dilution\ solvent}$ + $E_{cleaning\ solutions}$ + $E_{coatings/adhesives}$ + E_{other}
= 23 lb HAP/year + 0 lb HAP/year + 0 lb HAP/year + 0 lb HAP/year
= 23 lb HAP/year
= 0.012 tons HAP/year

$E_{totalHAP}$ **= E_{total} (dryer) + E_{total} (non-dryer)**
= 9 lb HAP/year + 23 lb HAP/year
= 32 lb HAP/year
= 0.02 tons/year

Note: Calculation of emissions involving numerous inks, coatings, solvents, adhesives and other materials will require separate calculations such as presented here for each of the materials being used.

2. A **water-based flexographic printing** operation reported using the following materials on a press.

Material	Annual use	Unit	VOC content*	HAP	HAP content*
Ink	30,000	lb	3%	0%	
Dilution solvent	300	gal	0%	Water	0%
Hand cleaning solution	1,000	gal	0%	Water	0%
Coating: UV	1,500	lb	1%	0%	
Coating: aqueous	10,000	lb	3%	0%	

*Percent by weight or lb/gal

Since the operation is using water-based inks, an oxidizer is not required. Therefore, there is no need to determine capture efficiency.

According to the Technical Support Document for Title V Permitting of Printing Facilities, since soiled towels are kept in a closed container and have a composite VOC vapor pressure of less than 10 mmHg at 20°C, a 50 percent retention factor is assumed for hand cleaning solutions. However, the material used on this press for cleaning is water. So, no retention of the cleaning solution occurs.

In addition, there is no retention of the solvent used in the inks and coatings in the substrate. The substrate is not considered absorbent.

Emissions from flexographic presses with dryers and control devices need to be speciated into dryer and non-dryer or all other emissions. Speciation was developed by EPA to account for both dryer (i.e. stack) and non-dryer (i.e. non-stack or fugitive) emissions. The emissions from a press using water-based inks would be considered non-dryer emissions.

The emissions are calculated as described below.

Variable	Ink	Dilution solvent	Hand cleaning solution	Coating: overprint water-based	Coating: UV
U (amount used, lb)	30,000			10,000	1,500
G (amount used, gal)		300	1,000		
W (VOC content, wt%)	3%	0%	0%	3%	1%

Variable	Ink	Dilution solvent	Hand cleaning solution	Coating: overprint water-based	Coating: UV
C (VOC content, lb/gal)					
W (HAP content, wt%)	0%	0%	0%	0%	0%
C (HAP content, lb/gal)					
R (retention)	0%	0%	0%	0%	0%
J (capture efficiency)	N/A	N/A	N/A	N/A	N/A
K (destruction efficiency)	N/A	N/A	N/A	N/A	N/A

Ink emissions

With no control device in place, VOC and HAP emissions are calculated using the following equation:

E_{VOC} (ink) = U * (W/100) * [1 – (R/100)]
= (30,000 lb/year) * (3/100) * [1-(0/100)]
= 900 lb VOC/year

E_{VOC} (dilution solvent) = U * (W/100) * [1 – (R/100)]
= (300 gal/year) * (0/100) * [1-(0/100)]
= 0 lb VOC/year

E_{VOC} (total, ink/solvent) = E_{VOC} (ink) + E_{VOC} (dilution solvent)
= 900 lb VOC/yr + 0 lb VOC/yr
= 900 lb VOC/yr

Note: In this example, the inks are 0 percent HAP by weight, therefore no HAPs are emitted.

Cleaning solution emissions

With no control device in place, VOC and HAP emissions are calculated using the following equation:

E_{VOC} (hand cleaning solution) = U * (W/100) * [1 – (R/100)] * [1 – (J/100)]
= (1,000 gal/year * (0/100) * [1 – (0/100)]
= 0 lb VOC/year

Note: In this example, the inks are 0 percent HAP by weight, therefore no HAPs are emitted.

Coating solution emissions

With no control device in place, VOC and HAP emissions are calculated using the following equation:

E_{VOC} (water-based coating) = U * (W/100) * [1 – (R/100)]
= (10,000 lb/year) * (3/100) * [1-(0/100)]
= 300 lb VOC/year

E_{VOC} (UV coating) = U * (W/100) * [1 – (R/100)]
= (1,500 lb/year) * (1/100) * [1-(0/100)]
= 15 lb VOC/year

E_{VOC} (total, coating) = E_{VOC} (water-based coating) + E_{VOC} (UV coating)
= 300 lb VOC/year + 15 lb VOC/year
= 315 lb VOC/year

Note: In this example, the inks are 0 percent HAP by weight, therefore no HAPs are emitted.

Facility totals

Total VOC and HAP emissions for this facility are calculated using the following equations:

$E_{totalVOC}$ = E_{ink} + $E_{dilution\ solvent}$ + $E_{cleaning\ solutions}$ + $E_{coatings/adhesives}$ + E_{other}
= 900 lb VOC/year + 0 lb VOC/year + 0 lb VOC/year + 315 lb VOC/year
= 1,215 lb VOC/year
= 0.61 tons VOC/year

Note: Calculation of emissions involving numerous inks, coatings, solvents, adhesives and other materials will require separate calculations such as presented here for each of the materials being used.

Flexography Source Classification Codes (SCC)

EPA has established two SCCs for VOC emissions from flexographic printing operations. The SCCs are for dryer (i.e. stack) and non-dryer (i.e. non-stack or fugitive) emissions. Speciation between dryer and non-dryer emissions was developed by EPA to account for the emissions from presses with dryers and control devices.

All emissions from water-based flexographic printing presses are to be reported as non-dryer emissions. Emissions from solvent-based flexographic printing presses need to be speciated into dryer and non-dryer emissions, therefore the facility should be sure to select the appropriate SCC in ARS.

SCC	EPA SCC description
40500308	Dryer emissions from flexographic printing presses
40500309	Non-dryer or all other emissions from flexographic printing Presses
36000102	Scrap and paper trim collection

Appendix C: Types of printing operations - Rotogravure

Description

The image area of a gravure cylinder consists of small, recessed cells which are typically electro-mechanically engraved. The engraved surface of a gravure cylinder consists of millions of minute cells engraved into a copper cylinder and is protected with a very thin, electroplated layer of chromium typically six to nine microns. Laser engraving gravure cylinders is a growing technology and makes up approximately 8 - 10 percent of the industry. Formerly the most common method of gravure cylinder engraving, chemical etching and now accounts for only a small fraction of etching. There is a specific type of mechanically engraved gravure cylinder where the cells are actually knurled (or pressed) into the copper. This technology is limited to those gravure printers that require much greater ink-film thickness such as automotive upholstery and thermo-formed products. Similar to chemical etching, this makes up for a very small percentage of total gravure cylinders.

During gravure printing, a low viscosity ink floods the lower portion of the gravure cylinder. The ink is then wiped from the surface of the cylinder with a doctor blade leaving ink only in the image area. The ink left in the recessed cells is pressed onto the substrate as the substrate is pressed against the gravure cylinder with a rubber-covered impression roll. Finally, the substrate is passed through a high volume, recirculated air dryer before application of the next ink or coating.

Low-boiling point organic solvents are commonly used to achieve the low viscosity, fast drying properties required of inks used in a rotogravure process. Inks in the press fountain contain as much as 75 percent solvent by weight. After printing, the roll is either rewound for shipment or subsequent converting, cut into sheets for subsequent converting or, in many modern paper-board presses converted in-line at the end of the press.

Rotogravure – emission determination

Total emissions for a facility are calculated by summing the emissions from usage of the various materials as follows:

$$\mathbf{E_{Total} = E_{ink} + E_{dilution\ solvent} + E_{cleaning\ solutions} + E_{coatings/adhesives} + E_{other}}$$

Where:

E_{total} = Emissions, total, lb
E_{ink} = Emissions, ink, lb
$E_{dilution\ solvent}$ = Emissions, dilution solvent, lb
$E_{cleaning\ solutions}$ = Emissions, hand cleaning solutions, lb

$E_{coating/adhesives}$ = Emissions, coatings/adhesives, lb
E_{other} = Emissions, other VOC or HAP containing materials, lb

Note: Calculation of emissions involving numerous inks, fountain solutions, coatings, solvents and other materials will require separate calculations such as presented here for each of the materials used with the different formulas at a given facility.

Sample calculations

1. A **solvent-based rotogravure** printing operation manufacturing **flexible packaging** reported using the following materials on a press.

Material	Annual use	Unit	VOC content*	HAP	HAP content*
Ink	112,500	lb	58%	ethylene glycol	1%
Dilution solvent	93,750	lb	100%	N/A	0%
Hand cleaning solution	2,000	lb	100%	N/A	0%
Automatic cleaning solution	24,000	lb	100%	N/A	
Coating: primer	5,650	lb	97%	N/A	0%
Coating: overprint matte	5,650	lb	73%	N/A	0%

*Percent by weight or lb/gal

Since the inks and coatings are solvent-based, an oxidizer with a destruction efficiency of 98 percent is used at this facility. The press is in an enclosure that has 98 percent capture efficiency based on EPA Method 204, Permanent (PTE) or Temporary Total Enclosure (TTE) for Determining Capture Efficiency, test results. The automatic cleaning system is self-contained with a loss of 0.5 percent.

According to the Technical Support Document for Title V Permitting of Printing Facilities, since soiled towels are kept in a closed container and have a composite VOC vapor pressure of less than 10 mmHg at 20°C, a 50 percent retention factor for hand cleaning can be assumed for hand cleaning solutions. However, the vapor pressure of the hand cleaning solution used on this press is greater than 10 mmHg at 20°C, therefore, no retention of the cleaning solution occurs. Hand cleaning is performed when the press is not running which means the emissions do not get speciated between dryer and non-dryer.

In addition, there is no retention of the solvent used in the inks and coatings in the substrate. The substrate is not considered absorbent.

Emissions from flexographic presses with dryers and control devices need to be speciated into dryer and non-dryer or all other emissions. Speciation was developed by EPA to account for both dryer (i.e. stack) and non-dryer (i.e. non-stack or fugitive) emissions.

The emissions are calculated as described below.

Variable	Ink	Dilution solvent	Hand cleaning solution	Automatic cleaning solution	Coating: primer	Coating: overprint matte
U (amount used, lb)	112,500	93,750	2,000	24,000	5,650	5,650
W (VOC content, wt%)	58%	100%	100%	100%	97%	73%
W (HAP content, wt%)	1%	0%	0%	0%	0%	0%
R (retention)	0%	0%	0%	N/A	0%	0%
J (capture efficiency)	98%	97.4%	N/A	98%	98%	98%
K (destruction efficiency)	98%	98%	N/A	N/A	98%	98%

Ink emissions

With a 98 percent efficient oxidizer in place with a 98 percent capture efficiency, VOC and HAP emissions are calculated using the following equation:

E_{VOC} (ink), dryer = U * (W/100) * [1 – (R/100)] * J/100 * [1 - (K/100)]
= (112,500 lb/year) * (58/100) * [1 – (0/100)] * (98/100) * [1 – (98/100)]
= 1,279 lb VOC/year

E_{VOC} (ink), non-dryer = U * (W/100) * [1 – (R/100)] * [1 – (J/100)]
= (112,500 lb/year * (58/100) * [1 – (0/100)] * [1 – (98/100)]
= 1,305 lb VOC/year

E_{VOC} (total, ink) = E_{ink} (dryer) + E_{ink} (non-dryer)
= 1,279 lb VOC/year + 1,305 lb VOC/year
= 2,584 lb VOC/year

E_{HAP} (ink), dryer = U * (W/100) * [1 – (R/100)] * J/100 * [1 - (K/100)]
= (112,500 lb/year) * (1/100) * [1 – (0/100)] * (98/100) * [1 – (98/100)]
= 22 lb HAP/year

E_{HAP} (ink), non-dryer = U * (W/100) * [1 – (R/100)] * [1 – (J/100)]
= (112,500 lb/year * (1/100) * [1 – (0/100)] * [1 – (98/100)]
= 23 lb HAP/year

E_{HAP} (total, ink) = E_{ink} (dryer) + E_{ink} (non-dryer)
= 22 lb HAP/year + 23 lb HAP/year
= 45 lb HAP/year

Dilution solvent emissions

With a 98 percent efficient oxidizer in place with a 98 percent capture efficiency, VOC and HAP emissions are calculated using the following equation:

E_{VOC} (dilution solvent), dryer = U * (W/100) * [1 – (R/100)] * J/100 * [1 - (K/100)]
= (93,750 lb/year) * (100/100) * [1 – (0/100)] * (98/100) * [1 – (98/100)]
= 1,838 lb VOC/year

E_{VOC} (dilution solvent), non-dryer = U * (W/100) * [1 – (R/100)] * [1 – (J/100)]
= (93,750 lb/year * (100/100) * [1 – (0/100)] * [1 – (98/100)]
= 1,875 lb VOC/year

E_{VOC} (total, dilution solvent) = $E_{dilution\ solvent}$ (dryer) + $E_{dilution\ solvent}$ (non-dryer)
= 1,838 lb VOC/year + 1,875 lb VOC/year
= 3,713 lb VOC/year

Coating emissions

With a 98 percent efficient oxidizer in place with a 98 percent capture efficiency, VOC and HAP emissions are calculated using the following equation:

E_{VOC} (coating:primer), dryer = U * (W/100) * [1 – (R/100)] * J/100 * [1 - (K/100)]
= (5,650 lb/year) * (97/100) * [1 – (0/100)] * (98/100) * [1 – (98/100)]
= 107 lb VOC/year

E_{VOC} (coating:primer), non-dryer
= U * (W/100) * [1 – (R/100)] * [1 – (J/100)]
= (5,650 lb/year * (97/100) * [1 – (0/100)] * [1 – (98/100)]
= 110 lb VOC/year

E_{VOC} (total, coating:primer) = $E_{coating}$ (dryer) + $E_{coating}$ (non-dryer)
= 107 lb VOC/year + 110 lb VOC/year
= 217 lb VOC/year

E_{VOC} (coating:overprint), dryer
= U * (W/100) * [1 – (R/100)] * J/100 * [1 - (K/100)]
= (5,650 lb/year) * (73/100) * [1 – (0/100)] * (98/100) * [1 – (98/100)]
= 81 lb VOC/year

E_{VOC} (coating:overprint), non-dryer
= U * (W/100) * [1 – (R/100)] * [1 – (J/100)]
= (5,650 lb/year * (73/100) * [1 – (0/100)] * [1 – (98/100)]
= 83 lb VOC/year

E_{VOC} (total, coating:overprint) = $E_{coating}$ (dryer) + $E_{coating}$ (non-dryer)
= 81 lb VOC/year + 83 lb VOC/year
= 164 lb VOC/year

Cleaning solution emissions

Cleaning occurs when the press is not running. The automatic cleaning solution is used in a self-contained unit and there is very little loss as a result of cleaning. VOC and HAP emissions are calculated using the following equation:

E_{VOC} (hand cleaning solution), non-dryer
= U * (W/100) * [1 – (R/100)]
= 2,000 lb/year * (100/100) * [1 – (0/100)]
= 2,000 lb VOC/year

E_{VOC} (auto cleaning solution), non-dryer
= U * (W/100) * [1 – (R/100)]
= (24,000 lb/year * (100/100) * [1 – (99.5/100)]
= 120 lb VOC/year

Facility totals

Total VOC and HAP emissions for this facility are calculated using the following equations:

$E_{totalVOC}$ dryer = $E_{ink} + E_{dilution\ solvent} + E_{coatings/adhesives} + E_{cleaning\ solutions} + E_{other}$
= 1,279 lb VOC/year + 1,838 lb VOC/year + 107 lb VOC/year + 81 lb VOC/year + 0 lb VOC/year
= 3,305 lb VOC/year
= 1.65 tons VOC/year

$E_{totalVOC}$ non-dryer = $E_{ink} + E_{dilution\ solvent} + E_{coatings/adhesives} + E_{cleaning\ solutions} + E_{other}$
= 1,305 lb VOC/year + 1,875 lb VOC/year + 110 lb VOC/year + 83 lb VOC/year + 2,000 lb VOC/year+ 120 lb VOC/year
= 5,493 lb VOC/year
= 2.75 tons VOC/year

$E_{totalVOC}$ = $E_{total\ (dryer)} + E_{total\ (non\text{-}dryer)}$
= 3,305 lb VOC/year + 5,493 lb VOC/year
= 8,798 lb VOC/year
= 4.40 tons/year

$E_{totalHAP}$ dryer = $E_{ink} + E_{dilution\ solvent} + E_{cleaning\ solutions} + E_{coatings/adhesives} + E_{other}$
= 22 lb HAP/year + 0 lb HAP/year + 0 lb HAP/year + 0 lb HAP/year
= 22 lb HAP/year
= 0.011 tons HAP/year

$E_{totalHAP}$ non-dryer = $E_{ink} + E_{dilution\ solvent} + E_{cleaning\ solutions} + E_{coatings/adhesives} + E_{other}$
= 23 lb HAP/year + 0 lb HAP/year + 0 lb HAP/year + 0 lb HAP/year
= 23 lb HAP/year
= 0.012 tons HAP/year

$E_{totalHAP}$ = $E_{total\ (dryer)} + E_{total\ (non\text{-}dryer)}$
= 22 lb HAP/year + 23 lb HAP/year
= 45 lb HAP/year
= 0.02 tons/year

Note: Calculation of emissions involving numerous inks, coatings, solvents, adhesives and other materials will require separate calculations such as presented here for each of the materials used at a given facility. Capture efficiencies will have to be determined for inks, coatings, dilution solvents, and adhesives and other materials using U.S. EPA’s Method 204, Permanent (PTE) or Temporary Total Enclosure (TTE) for Determining Capture Efficiency.

2. A **publication rotogravure** printing operation using a **carbon adsorber** reported using the following materials on a press.

Material	Annual use	Unit	VOC content*	HAP	HAP content*
Ink	126,000	lb	70%	Toluene	100%
Dilution solvent and cleaning solution	50,000	lb	100%	Toluene	100%

*Percent by weight or lb/gal

A publication rotogravure printing operation using a carbon adsorbed on its press with a reported 98 percent overall control efficiency based on test results from a liquid-liquid mass balance (i.e. K/100 * J/100 = 0.98). The solvent used in the ink, dilution and cleaning is toluene. Cleaning is performed during a print run and after the printing has ceased. The cylinder is removed from the press and cleaned in a separate dedicated cleaning unit similar to a parts washer. The air around the cleaning unit is ducted to the carbon adsorption unit for recovery.

According to the Technical Support Document for Title V Permitting of Printing Facilities, since soiled towels are kept in a closed container and have a composite VOC vapor pressure of less than 10 mmHg at 20°C, a 50 percent retention factor is assumed for hand cleaning solutions. However, the vapor pressure of the hand cleaning solution used on this press is greater than 10 mmHg at 20°C, therefore there is no retention of the cleaning solution. In addition, there is no retention of the solvent used in the inks in the substrate.

Emissions from rotogravure presses with dryers and control devices need to be speciated into dryer and non-dryer or all other emissions. Speciation was developed by EPA to account for both dryer (i.e. stack) and non-dryer (i.e. non-stack or fugitive) emissions. However, with publication rotogravure, the emissions do not get speciated due to the compliance requirements in EPA's gravure New Source Performance Standards (NSPS) and National Emission Standards for Hazardous Air Pollutants (NESHAP). These standards require an overall emission rate be determined.

To speciate the emissions for EPA's SCC, it is assumed that two percent of the overall emissions are from the dryer. This is because carbon adsorption systems are 98 percent efficient. The remaining 98 percent of emissions are to be reported as non-dryer.

The emissions are calculated as described below.

Variable	Ink	Dilution solvent and cleaning solution
U (amount used, lb)	126,000	50,000

Variable	Ink	Dilution solvent and cleaning solution
W (VOC content, wt%)	70%	100%
W (HAP content, wt%)	70%	100%
R (retention)	0%	0%
Overall efficiency (capture and removal efficiency)	98%	98%

Ink emissions

With an overall 98 percent efficient removal efficiency, VOC and HAP emissions are calculated using the following equation:

E_{VOC} (ink), overall = U * (W/100) * [1 – (R/100)] * [1 – (J/100) * (K/100)]
= (126,000 lb/year) * (70/100) * [1 – (0/100)] * [1 – (98/100)]
= 1,764 lb VOC/year

E_{VOC} (ink), dryer = 1,764 lb VOC/year * (2/100)
= 35 VOC/year

E_{VOC} (ink), non-dryer = 1,764 lb VOC/year * (98/100)
= 1,729 VOC/year

E_{HAP} (ink), overall = U * (W/100) * [1 – (R/100)] * [1 – (J/100) * (K/100)]
= (126,000 lb/year) * (70/100) * [1 – (0/100)] * [1 – (98/100)]
= 1,764 lb HAP/year

E_{HAP} (ink), dryer = 1,764 lb HAP/year * (2/100)
= 35 HAP/year

E_{HAP} (ink), non-dryer = 1,764 lb HAP/year * (98/100)
= 1,729 HAP/year

Dilution and cleaning solvent emissions

With an overall 98 percent efficient removal efficiency, VOC and HAP emissions are calculated using the following equation:

E_{VOC} (dilution solvent), overall = U * (W/100) * [1 – (R/100)] * [1 – (J/100) * (K/100)]
= (50,000 lb/year) * (100/100) * [1 – (0/100)] * [1 – (98/100)]
= 1,000 lb VOC/year

E_{VOC} (dilution solvent), dryer = 1,000 lb VOC/year * (2/100)
= 20 lb VOC/year

E_{VOC} (dilution solvent), non-dryer = 1,000 lb VOC/year * (98/100)
= 980 lb VOC/year

E_{HAP} (dilution solvent), overall = U * (W/100) * [1 – (R/100)] * [1 – (J/100) * (K/100)]
= (50,000 lb/year) * (100/100) * [1 – (0/100)] * [1 – (98/100)]
= 1,000 lb HAP/year

E_{HAP} (dilution solvent), dryer = 1,000 lb HAP/year * (2/100)
= 20 lb HAP/year

E_{HAP} (dilution solvent), non-dryer = 1,000 lb HAP/year * (98/100)
= 980 lb HAP/year

Facility totals

Total VOC and HAP emissions for this facility are calculated using the following equations:

$E_{totalVOC}$ non-dryer = E_{ink} + $E_{dilution\ solvent}$ + $E_{cleaning\ solutions}$ + E_{other}
= 35 lb VOC/year + 20 lb VOC/year
= 55 lb VOC/year
= 0.03 ton VOC/year

$E_{totalVOC}$ dryer = E_{ink} + $E_{dilution\ solvent}$ + $E_{cleaning\ solutions}$ + E_{other}
= 1,729 VOC/year + 980 lb VOC/year
= 2,709 lb VOC/year
= 1.35 ton VOC/year

$E_{totalVOC}$ overall = E_{ink} + $E_{dilution\ solvent}$ + $E_{cleaning\ solutions}$ + E_{other}
= 1,764 lb VOC/year + 1,000 lb VOC/year
= 2,764 lb VOC/year
= 1.38 tons VOC/year

$E_{totalHAP}$ non-dryer = E_{ink} + $E_{dilution\ solvent}$ + $E_{cleaning\ solutions}$ + E_{other}
= 35 lb HAP/year + 20 lb HAP/year
= 55 lb HAP/year
= 0.03 ton VOC/year

$E_{totalHAP}$ dryer = E_{ink} + $E_{dilution\ solvent}$ + $E_{cleaning\ solutions}$ + E_{other}
= 1,729 HAP/year + 980 lb HAP/year
= 2,709 lb HAP/year
= 1.35 ton HAP/year

$E_{totalHAP}$ overall = E_{ink} + $E_{dilution\ solvent}$ + $E_{cleaning\ solutions}$ + E_{other}
= 1,764 lb HAP/year + 1,000 lb HAP/year
= 2,764 lb HAP/year
= 1.38 tons HAP/year

Note: Calculation of emissions involving numerous inks, coatings, solvents, adhesives and other materials will require separate calculations such as presented here for each of the materials used at a given facility.

3. A **water-based decorative rotogravure** printing operation manufacturing **flooring** reported using the following materials on a press.

Material	Annual use	Unit	VOC content*	HAP	HAP content*
Ink	37,500	lb	3%	0%	
Dilution solvent	375	gal	0%	water	0%
Hand cleaning solution	1,250	gal	0%	water	0%
Coating: UV	1,875	lb	1%	0%	
Coating: aqueous	12,500	lb	3%	0%	

*Percent by weight or lb/gal

Since the operation is using water-based inks, an oxidizer is not required. Therefore, there is no need to determine capture efficiency.

According to the Technical Support Document for Title V Permitting of Printing Facilities, since soiled towels are kept in a closed container and have a composite VOC vapor pressure of less than 10 mmHg at 20°C, a 50 percent retention factor is assumed for hand cleaning solutions. However, the material used on this press for cleaning is water. So, no retention of the cleaning solution occurs.

In addition, there is no retention of the solvent used in the inks and coatings in the substrate.

Emissions from rotogravure presses with dryers and control devices need to be speciated into dryer and non-dryer or all other emissions. Speciation was developed by EPA to account for both dryer (i.e. stack) and non-dryer (i.e. non-stack or fugitive) emissions. The emissions from a press using water-based inks would be considered non-dryer emissions.

The emissions are calculated as described below.

Variable	Ink	Dilution solvent	Hand cleaning solution	Coating: overprint water-based	Coating: UV
U (amount used, lb)	37,500			12,500	1,875
U (amount used, gal)		375	1,250		
W (VOC content, wt%)	3%	0%	0%	3%	1%
W (HAP content, wt%)	0%	0%	0%	0%	0%
R (retention)	0%	0%	0%	0%	0%

Variable	Ink	Dilution solvent	Hand cleaning solution	Coating: overprint water-based	Coating: UV
J (capture efficiency)	N/A	N/A	N/A	N/A	N/A
K (destruction efficiency)	N/A	N/A	N/A	N/A	N/A

Ink emissions

With no control device in place, VOC emissions are calculated using the following equation:

E_{VOC} (ink) = U * (W/100) * [1 – (R/100)]
= (37,500 lb/year) * (3/100) * [1-(0/100)]
= 1,125 lb VOC/year

E_{VOC} (Dilution Solvent) = U * (W/100) * [1 – (R/100)]
= (375 gal/year) * (0/100) * [1-(0/100)]
= 0 lb VOC/year

E_{VOC} (total, ink/solvent) **= E_{VOC} (ink) + E_{VOC} (dilution solvent)**
= 1,125 lb VOC/yr + 0 lb VOC/yr
= 1,125 lb VOC/yr

Coating emissions

With no control device in place, VOC emissions are calculated using the following equation:

E_{VOC} (water-based coating) = U * (W/100) * [1 – (R/100)]
= (12,500 lb/year) * (3/100) * [1-(0/100)]
= 375 lb VOC/year

E_{VOC} (UV coating) = U * (W/100) * [1 – (R/100)]
= (1,875 lb/year) * (1/100) * [1-(0/100)]
= 19 lb VOC/year

E_{VOC} (total, coating) **= E_{VOC} (water-based coating) + E_{VOC} (UV coating)**
= 375 lb VOC/year + 19 lb VOC/year
= 394 lb VOC/year

Cleaning solution emissions

With no control device in place, VOC and HAP emissions are calculated using the following equation:

$$\mathbf{E_{VOC}\ (hand\ cleaning\ solution)} = U * (W/100) * [1 - (R/100)] * [1 - (J/100)]$$
$$= (1{,}250\ gal/year * (0/100) * [1 - (0/100)]$$
$$= 0\ lb\ VOC/year$$

Facility totals

Total VOC emissions for this facility are calculated using the following equations:

$$\mathbf{E_{totalVOC}\ non\text{-}dryer} = E_{ink} + E_{dilution\ solvent} + E_{coatings/adhesives} + E_{cleaning\ solutions} + E_{other}$$
$$= 1{,}125\ lb\ VOC/year + 394\ lb\ VOC/year + 0\ lb\ VOC/year$$
$$= 1{,}519\ lb\ VOC/year$$
$$= 0.76\ tons\ VOC/year$$

Note: Calculation of emissions involving numerous inks, coatings, solvents, adhesives and other materials will require separate calculations such as presented here for each of the materials used at a given facility.

Rotogravure Source Classification Codes (SCC)

EPA has established two SCCs for VOC emissions from rotogravure printing operations. The SCCs are for dryer (i.e. stack) and non-dryer (i.e. non-stack or fugitive) emissions. Speciation between dryer and non-dryer emissions was developed by EPA to account for the emissions from presses with dryers and control devices.

All emissions from water-based rotogravure printing presses should be reported as non-dryer emissions. Emissions from solvent-based and publication rotogravure printing presses need to be speciated into dryer and non-dryer emissions, therefore the facility should be sure to select the appropriate SCC in ARS.

SCC	EPA SCC description
40500515	Dryer emissions from rotogravure printing presses
40500516	Non-dryer or all other emissions from rotogravure printing presses
36000103	Scrap and paper trim collection

Appendix D: Types of printing operations - Letterpress

Description

Similar to flexography, letterpress printing uses metal or plastic plates with a raised printing image to transfer ink directly to a substrate. Letterpress presses are either be sheet-fed or web fed. Letterpress inks are virtually identical to lithographic inks, therefore the same drying mechanisms would occur. This means the inks used on sheet-fed letterpress presses dry by absorption and oxidation and heatset web letterpress inks dry by evaporation.

Letterpress machines are divided into three groups:

- Platen presses
- Flatbed cylinder presses
- Rotary presses

In a platen press, the raised plate is locked on a flat surface while the substrate is pressed between the raised plate and another flat surface. In both flatbed presses and rotary presses, the substrate passes between the plate cylinder and an impression cylinder during printing. With a flatbed press, only one side of the substrate is printed at a time, whereas rotary presses are designed to print both sides simultaneously.

All letterpress operations require the usage of ink and clean up solution. Clean up is necessary to prevent the ink building up on the press. The inks are virtually identical to lithographic inks. Consequently, the same emission and retention factors apply for determining VOC and HAP emissions.

Letterpress – emission determination

Total emissions for a facility are calculated by summing the emissions from usage of the various materials as follows:

$$\mathbf{E_{Total} = E_{ink} + E_{cleaning\ solutions} + E_{coatings/adhesives} + E_{other}}$$

Where:

E_{total}	= Emissions, total, lb
E_{ink}	= Emissions, ink, lb
$E_{cleaning\ solutions}$	= Emissions, hand cleaning solutions, lb
$E_{coating/adhesives}$	= Emissions, coatings/adhesives, lb
E_{other}	= Emissions, other VOC or HAP containing materials, lb

Note: Calculation of emissions involving numerous inks, coatings, solvents, and other materials will require separate calculations such as presented here for each of the numerous inks being used with the different formulas at a given facility.

Sample calculations

A print shop using a **sheet-fed cylinder letterpress** press reports the following material usage:

Material	Annual use	Unit	VOC content*	HAP	HAP content*
Ink	19,000	Lb	35%		0%
Hand Cleaning Solution	2,200	Gal	7.0 lb/gal	Naphthalene	0.16 lb/gal
Coating: Conventional	0	Lb	0%		0%

*Percent by weight or lb/gal.

No control devices are used at this facility. According to the CTG and ACT for Offset Lithographic and Letterpress Printing, it is assumed that 95 percent of the ink and conventional coating (i.e., varnish) VOC is retained in the substrate. Since soiled towels are kept in a closed container and have a vapor pressure of less than 10 mmHg at 20°C, a 50 percent retention factor is assumed for cleaning solutions.

Since there is no dryer or control device used on a sheet-fed letterpress, emissions do not need to be speciated into dryer and non-dryer emissions. Speciation was developed by EPA's SCC to account for both dryer (i.e. stack) and non-dryer (i.e. non-stack or fugitive) emissions. All emissions from sheet-fed and non-heatset web offset lithographic printing presses are to be reported as non-dryer emissions. So, the facility should be sure to select the appropriate SCC in ARS.

The emissions are calculated as described below.

Variable	Ink	Hand cleaning solution	Coating: conventional
U (amount used, lb)	19,000		0
G (amount used, gal)		2,200	
W (VOC content, wt%)	35%		0%
C (VOC content, lb/gal)		7.0	
W (HAP content, wt%)	0%		0%
C (HAP content, lb/gal)		0.16	
R (retention)	95%	50%	0%

Variable	Ink	Hand cleaning solution	Coating: conventional
J (capture efficiency)	N/A	N/A	N/A
K (destruction efficiency)	N/A	N/A	N/A

Ink emissions

With no control device in place, VOC and HAP emissions are calculated using the following equation:

E_{VOC} (ink)	**= U * (W/100) * [1 – (R/100)]** **= (19,000 lb/year) * (35/100) * [1-(95/100)]** **= 333 lb VOC/year from ink**

Note: In this example, the inks are 0 percent HAP by weight, therefore no HAPs are emitted.

Cleaning solution emissions

With no control device in place, VOC and HAP emissions are calculated using the following equations:

E_{VOC} (hand cleaning solution)	**= G * C * [1 – (R/100)]** **= (2,200 gal/yr) * (7.0 lb/gal) * [1-(50/100)]** **= 7,700 lb VOC/year**

E_{HAP} (hand cleaning solution)	**= G * C * [1 – (R/100)]** **= (2,200 gal/year) * (0.16 lb/gal) * [1-(50/100)]** **= 176 lb HAP/year**

Facility totals

Total HAP and VOC emissions for this facility are calculated using the following equations:

E_{total}	**= E_{ink} + $E_{cleaning\ solutions}$**

E_{VOC}	**= 333 lb VOC/year + 7,700 lb VOC/year** **= 8,033 lb VOC/year** **= 4.0 tons/year**

E_{HAP}	**= 0 lb HAP/year + 176 lb HAP/year** **= 176 lb HAP/year** **= 0.09 tons/year**

Note: Calculation of emissions involving numerous inks, coatings, solvents, and other materials will require separate calculations such as presented here for each of the materials used with the different formulas at a given facility.

Letterpress Source Classification Codes (SCC)

EPA has established two SCCs for VOC emissions from letterpress printing operations. The SCCs are for dryer (i.e. stack) and non-dryer (i.e. non-stack or fugitive) emissions. Speciation between dryer and non-dryer emissions was developed by EPA to account for the emissions from presses with dryers and control devices.

All emissions from sheet-fed letterpress presses are to be reported as non-dryer emissions. Emissions from heatset web letterpress presses are to be speciated into dryer and non-dryer emissions, therefore the facility should be sure to select the appropriate SCC in ARS.

SCC	EPA SCC description
40500204	Dryer emissions from letterpress presses
40500205	Non-dryer or all other emissions from letterpress presses

Appendix E: Types of printing operations - Screen printing

Description

The screen printing process involves the flow of ink through a porous mesh screen to which a stencil has been added to define the image. The ink flows through the imaged screen by hydraulic pressure that is initiated by the action of a flexible rubber or synthetic blade known as a squeegee. The squeegee blade sweeps across the surface of the pretensioned, pre-imaged screen pressing the ink through those areas of the screen not blocked by the stencil and onto the substrate in the pattern defined by the stencil image. The diameter of the mesh thread determines the overall mesh thickness. This, in combination with the number of threads woven per inch, determines the amount of ink deposited onto the substrate. Depending on the type of mesh used, ink is deposited onto a substrate in a thickness of 0.04 mil to 10 mils.

Due to the flexibility in the screen printing process, a wide variety of substrates are possible, including, but not limited to, textiles, plastics, metals, and paper. The type of ink system chosen by the screen facility is determined in large part by the substrate printed.

Facilities engaged in the production of decorated apparel (i.e. textiles, jackets, towels, fleece materials) primarily use plastisol or water-based textile ink systems. The VOC content of both ink systems are minimal, less than one percent.

Facilities engaged in the production of graphics use UV curable ink systems or solvent based systems. Those engaged in the industrial market may also use conductive ink technology. Both solvent and conductive ink technologies contain VOCs. UV curable ink systems are considered a high solid ink and similar to plastisol inks contain less than one percent VOC.

Coatings and adhesives are applied at screen facilities. Coatings are considered non-pigmented inks and contain the same properties as the inks used by the facility (i.e. solvent or UV curable). Adhesives are used for some applications, but more often the substrate is provided with an adhesive backing in place.

Depending on the ink system used by the facility, screen reclamation activities are undertaken with a combination of organic solvents and other non-VOC containing materials. During the reclamation process, the ink residue is removed from the screen through a hand cleaning process with a water-soluble ink degradant or cleaning solvents. To remove the emulsion, stencil remover is applied to begin the process of dissolving and is completed by using a high-pressure wash system. After this process, if there is an image remaining, a haze remover is applied. The haze remover does not contain any VOCs. Following this process, a degreaser is used to prepare the screen for reuse.

Screen printing – emission determination

Total emissions for a facility are calculated by summing the emissions from usage of the various materials as follows:

$$\mathbf{E_{Total} = E_{ink} + E_{dilution\ solvent} + E_{cleaning\ solutions} + E_{coatings/adhesives} + E_{other}}$$

Where:

E_{total}	= Emissions, total, lb
E_{ink}	= Emissions, ink, lb
$E_{dilution\ solvent}$	= Emissions, dilution solvent, lb
$E_{cleaning\ solutions}$	= Emissions, hand cleaning solutions, lb
$E_{coating/adhesives}$	= Emissions, coatings/adhesives, lb
E_{other}	= Emissions, other VOC or HAP containing materials, lb

Sample calculations

1. A **screen printing** operation using **solvent-based inks** reported the following annual material usage:

Material	Annual use	Unit	VOC content*	HAP	HAP content*
Ink	400	gal	5.5 lb/gal	0%	
Ink additive	100	gal	4.0 lb/gal		
Ink removers (cleaning solvents)	800	gal	8.0 lb/gal	ethylene glycol	0.8 lb/gal

*Percent by weight or lb/gal

No coatings or adhesives are used in the process. No control devices are used at this facility. Since no control devices are used on a screen printing press, emissions do not need to be speciated into dryer and non-dryer emissions. Speciation was developed by EPA to account for both dryer (i.e. stack) and non-dryer (i.e. non-stack or fugitive) emissions. All emissions from a screen printing press are reported as non-dryer emissions, therefore the facility should be sure to select the appropriate SCC in ARS.

According to the Technical Support Document for Title V Permitting of Printing Facilities, since soiled towels are kept in a closed container and have a composite VOC vapor pressure of less than 10 mmHg at 20°C, a 50 percent retention factor is assumed for hand cleaning solutions. Since soiled towels are kept in a closed container and have a vapor pressure of less than 10 mmHg at 20°C, a 50 percent retention factor is assumed for cleaning solutions.

The emissions are calculated as described below.

Variable	**Ink**	**Ink additive**	**Ink removers (cleaning solvents)**
G (amount used, gal)	400	100	800
C (VOC content, lb/gal)	5.5	4.00	8.0
C (HAP content, lb/gal)	0	1.85	0.8
R (retention)	0%	0%	50%
J (capture efficiency)	N/A	N/A	N/A
K (destruction efficiency)	N/A	N/A	N/A

Ink emissions

With no control device in place, VOC and HAP emissions are calculated using the following equation:

$$\begin{aligned} \mathbf{E_{VOC}\ (ink)} \quad &= G * C * [1 - (R/100)] \\ &= (400\ gal/year) * (5.5\ lb/gal) * [1-(0/100)] \\ &= 2{,}200\ lb\ VOC/year\ from\ ink \end{aligned}$$

Note: In this example, the inks are 0 percent HAP by weight, therefore no HAPs are emitted.

Ink additive emissions

With no control device in place, VOC and HAP emissions are calculated using the following equations:

$$\begin{aligned} \mathbf{E_{VOC}\ (ink\ additive)} \quad &= G * C * [1 - (R/100)] \\ &= (100\ gal/year) * (4.00\ lb/gal)*[1-(0/100)] \\ &= 400\ lb\ VOC/year \end{aligned}$$

Note: In this example, the inks are 0 percent HAP by weight, therefore no HAPs are emitted.

Cleaning solution emissions

With no control device in place, VOC and HAP emissions are calculated using the following equations:

$$\begin{aligned} \mathbf{E_{VOC}\ (ink\ removers)} \quad &= G * C * [1 - (R/100)] \\ &= (800\ gal/year) * (8.00\ lb/gal) * [1 - (50/100)] \\ &= 3{,}200\ lb\ VOC/year \end{aligned}$$

E_{HAP} (ink removers)	**= G * C * [1 – (R/100)]**
	= (800 gal/year) * (0.8 lb/gal) * [1 – (50/100)]
	= 320 lb HAP/year

Facility totals

Total HAP and VOC emissions for this facility are calculated using the following equations:

E_{total}	**= E_{ink} + $E_{inkadditive}$ + $E_{cleaning\ solutions}$**

E_{VOC}	**= 2,200 lb VOC/year + 400 lb VOC/year + 3,200 lb VOC/year** **= 5,800 lb VOC/year** **= 2.90 tons/year**

E_{HAP}	**= 0 lb VOC/year + 0 lb VOC/year + 320 lb VOC/year** **= 320 lb HAP/year** **= 0.16 tons/year**

2. A **screen printing** operation using **UV curable/plastisol inks** reported the following annual material usage:

Material	Annual use	Unit	VOC content*	HAP	HAP content*
Ink	400	gal	0.4 lb/gal	0%	
Ink removers (cleaning solvents)	800	gal	8.0 lb/gal	ethylene glycol	0.8 lb/gal

*Percent by weight or lb/gal

No coatings or adhesives are used in the process. No control devices are used at this facility. Since no control devices are used on a screen printing press, emissions do not need to be speciated into dryer and non-dryer emissions. Speciation was developed by EPA to account for both dryer (i.e. stack) and non-dryer (i.e. non-stack or fugitive) emissions. All emissions from a screen printing press are reported as non-dryer emissions, therefore the facility should be sure to select the appropriate SCC in ARS.

According to the Technical Support Document for Title V Permitting of Printing Facilities, since soiled towels are kept in a closed container and have a composite VOC vapor pressure of less than 10 mmHg at 20°C, a 50 percent retention factor is assumed for hand cleaning solutions. Since soiled towels are kept in a closed container and have a vapor pressure of less than 10 mmHg at 20°C, a 50 percent retention factor is assumed for cleaning solutions.

The emissions are calculated as described below.

Variable	Ink	Ink removers (cleaning solvents)
G (amount used, gal)	400	800
C (VOC content, lb/gal)	0.4	8.0
C (HAP content, lb/gal)	0	0.8
R (retention)	0%	50%
J (capture efficiency)	N/A	N/A
K (destruction efficiency)	N/A	N/A

<u>Ink emissions</u>

With no control device in place, VOC and HAP emissions are calculated using the following equation:

E_{VOC} (ink) **= G * C * [1 – (R/100)]**
= (400 gal/year) * (0.4 lb/gal) * [1-(0/100)]
= 160 lb VOC/year from ink

Note: In this example, the inks are 0 percent HAP by weight, therefore no HAPs are emitted.

Cleaning solution emissions

With no control device in place, VOC and HAP emissions are calculated using the following equations:

E_{VOC} (ink removers)	**= G * C * [1 – (R/100)]**
	= (800 gal/year) * (8.00 lb/gal) * [1 – (50/100)]
	= 3,200 lb VOC/year

E_{HAP} (ink removers)	**= G * C * [1 – (R/100)]**
	= (800 gal/year) * (0.8 lb/gal) * [1 – (50/100)]
	= 320 lb HAP/year

Facility totals

Total HAP and VOC emissions for this facility are calculated using the following equations:

E_{total}	**= E_{ink} + $E_{cleaning\ solutions}$**

E_{VOC}	**= 160 lb VOC/year + 3,200 lb VOC/year**
	= 3,360 lb VOC/year
	= 1.7 tons/year

E_{HAP}	**= 0 lb VOC/year + 0 lb VOC/year + 320 lb VOC/year**
	= 320 lb HAP/year
	= 0.16 tons/year

Note: Calculation of emissions involving numerous inks, coatings, solvents, adhesives and other materials will require separate calculations such as presented here for each of the materials used at a given facility.

Screen printing Source Classification Codes (SCC)

EPA has established two SCCs for VOC emissions from screen printing operations. The SCCs are for dryer (i.e. stack) and non-dryer (i.e., non-stack or fugitive) emissions. Speciation between dryer and non-dryer emissions was developed by EPA to account for the emissions from presses with dryers and control devices.

All emissions from a screen printing press are reported as non-dryer emissions, therefore the facility should be sure to select the appropriate SCC in ARS.

SCC	EPA SCC description
40500803	Dryer emissions from screen printing presses
40500804	Non-dryer or all other screen printing presses

Appendix F: Types of printing operations - Digital printing

Description

Digital printing is an umbrella term for non-impact or direct electronic printing processes. It usually refers to the printing of digital files through an output device where the image is rendered electronically and directly transferred to the substrate. Digital printing eliminates numerous mechanical steps in the conventional printing process including creating and assembling films; and making image carriers such as printing plates or screens. It provides on-demand printing, short turnaround times and even a modification of the image via variable data used for each impression.

In the case of commercial printing applications, digital printing devices eliminate the cutting and folding of printed “signatures” to order the pages of a product. Software sorts the pages in memory and prints them in the correct sequence.

The most popular methods of digital printing include electrophotography, inkjet and liquid electrophotography. In electrophotography, toner (i.e. a kind of powder ink) is transferred to the substrate by heat and pressure. Liquid electrophotography is a process that uses a combination of electrophotography and offset printing using a fluid ink. Repeatedly, the photoconductor transfers the fluid ink to a heated offset blanket which in turn transfers the ink to the substrate. With inkjet printing, ink is sprayed through nozzles onto the surface of the substrate. Ink jet inks are either solvent-based, UV cured, water-based dye or pigmented systems including dye sublimation types.

In addition to being used as a stand-alone output device, ink jet units are employed in binding and finishing operations. These units are designed to print addresses on finished products being sent via the postal service or an independent carrier. The units tend to be smaller in size due to the nature of their use. Since addresses are printed in-line and the inks must dry rapidly, they are typically solvent-based.

Once deposited on the substrate, inkjet inks dry by evaporation or in the case of UV curing inks, cure by UV light. Electrophotographic toners adhere to the surface of the substrate using a fuser fluid with heat process. In liquid electrophotography, the heated blanket drives off the solvent or imaging oil in the fluid ink. The newer presses have an on-board recovery system that captures the imaging oil and reuses it in the printing process as an ink dilatant prior to application.

Digital output devices need to be cleaned. Typically, small quantities of solvents are used to clean the components. For example, digital print heads in ink jet application units are cleaned on a period basis to ensure proper performance.

The wide variety of application methods facilitates the manufacture of various products. The substrates used in digital printing include paper, photo paper, canvas, glass, metal, marble and others.

With digital printing, the substrate on which the job is printed can be either flat sheets or rolls of material. With cut sheet digital printing devices, the substrate is fed sequentially into a digital output device one sheet at a time. Common substrate types include paperboard products, pressure-sensitive films and thin plastics.

Roll-fed digital printing devices feed a continuous roll of material and generally print at higher speeds than cut sheet. After the image is printed, it is rewound onto a rewinder and taken off-line for finishing. Roll-based devices allow for printing on flexible surfaces including paper, vinyl, fabrics and thin plastics.

Flatbed devices are typically hand-fed and allow direct printing on rigid substrates which range from the common such as poster board, foam board or rigid plastics to the uncommon such as metal, glass, wood and others.

A distinct difference between the use of digital printing and traditional printing is the relationship between the equipment and ink delivery system. Output devices are designed with a specific ink and ink delivery system in place. The type of equipment chosen is driven by the product produced with some applications being product specific

Digital printing – emission determination

Total emissions for a facility are calculated by summing the emissions from usage of the various materials as follows:

$$\mathbf{E_{Total} = E_{ink} + E_{cleaning\ solutions} + E_{coatings/adhesives} + E_{other}}$$

Where:

E_{Total} = Emissions, total, lb
E_{ink} = Emissions, ink, lb
$E_{cleaning\ solutions}$ = Emissions, cleaning solutions, lb
$E_{coating/adhesives}$ = Emissions, coatings/adhesives, lb
E_{other} = Emissions, other VOC or HAP containing materials, lb

Sample calculations

1. A print shop using a **solvent-based ink jet** process reports the following material usage:

Material	Annual use	Unit	VOC content*	HAP	HAP content*
Ink	48	liters	9.0 lb/gal	0%	0%
Cleaning solvent	1	liter	8.0 lb/gal	0%	0%

*Percent by weight or lb/gal

This facility uses a large format inkjet printer. No coating or adhesives are in use in the process. Since no control devices are used on a digital output device or press, they do not need to be speciated into dryer and non-dryer emissions. Speciation was developed by EPA to account for both dryer (i.e. stack) and non-dryer (i.e. non-stack or fugitive) emissions. All emissions from a digital output device or press are reported as non-dryer emissions, therefore the facility should select the appropriate SCC in ARS.

According to the Technical Support Document for Title V Permitting of Printing Facilities, since soiled towels are kept in a closed container and have a composite VOC vapor pressure of less than 10 mmHg at 20°C, a 50 percent retention factor is assumed for hand cleaning solutions. However, since the vapor pressure of the hand cleaning solution used on this press is greater than 10 mmHg at 20°C, no retention of the cleaning solution occurs.

The emissions are calculated as described below.

Variable	Ink	Cleaning solvent
G (amount used, gal)*	12.48	0.26
C (VOC content, lb/gal)	9.0	8.0
C (HAP content, lb/gal)	0%	0%
R (retention)	0%	0%
J (capture efficiency)	N/A	N/A
K (destruction efficiency)	N/A	N/A

* Liters were converted to gallons by multiplying by 0.26

Ink emissions

With no control device in place, VOC and HAP emissions are calculated using the following equation:

E_{VOC} (ink) **= G * C * [1 – (R/100)]**
= (12.48 gal/year) * (9.0 lb/gal) * [1-(0/100)]
= 112.32 lb VOC/year from ink

Note: In this example, the inks are 0 percent HAP by weight. Therefore, no HAPs are emitted.

Cleaning solution emissions

With no control device in place, VOC and HAP emissions are calculated using the following equations:

E_{VOC} (cleaning solution)	**$= G * C * [1 – (R/100)]$** **$= (12.48$ gal/year$) * (8.00$ lb/gal$) * [1 – (0/100)]$** **$= 99.84$ lb VOC/year**

Facility totals

Total HAP and VOC emissions for this facility are calculated using the following equations:

E_{total}	**$= E_{ink} + E_{cleaning\ solutions}$**

E_{VOC}	**= 112.32 lb VOC/year + 99.84 lb VOC/year** **= 212.16 lb VOC/year** **= 0.11 tons/year**

2. A print shop using an **Indigo press** reports the following material usage:

Material	Annual use	Unit	VOC content*	HAP	HAP content*
Electro ink	400	cartridges	82%	0%	0%
Imaging agent	7	liter	5.14 lb/gal	0%	0%
Recycling agent	19	liter	6.59 lb/gal	0%	0%
Imaging oil	275	liter	6.43 lb/gal	0%	0%
Cleaning solvent	3	gal	6.54 lb/gal	0%	0%

*Percent by weight or lb/gal

This facility uses an Indigo (liquid electrophotography) press. No coating or adhesives are used in the process. Since no control devices are used they do not need to be speciated into dryer and non-dryer emissions. Speciation was developed by EPA to account for both dryer (i.e. stack) and non-dryer (i.e. non-stack or fugitive) emissions. All emissions from a digital output device or press are to be reported as non-dryer emissions, therefore the facility should be sure to select the appropriate SCC in ARS.

According to the Technical Support Document for Title V Permitting of Printing Facilities, since soiled towels are kept in a closed container and have a composite VOC vapor pressure of less than 10 mmHg at 20°C, a 50 percent retention factor is assumed for hand cleaning solutions. However, since the vapor pressure of the hand cleaning solution used on this press is greater than 10 mmHg at 20°C, no retention of the cleaning solution occurs.

The emissions are calculated as described below.

Variable	Electro ink	Imaging agent	Recycling agent	Imaging oil	Hand cleaning solution
U (amount used, lb)*	1,376				
G (amount used, gal)**		1.82	4.94	71.5	2
W (VOC content, wt%)	82%				
C (VOC content, lb/gal)		5.14	6.59	6.43	6.54
W (HAP content, wt%)	0%				
C (HAP content, lb/gal)		0	0	0	0
R (retention)	0%	0%	0%	0%	0%
J (capture efficiency)	N/A	N/A	N/A	N/A	N/A
K (destruction efficiency)	N/A	N/A	N/A	N/A	N/A

* Cartridges were converted to weight by dividing the weight in grams (1560 grams) by453.59 grams per pound.
** Liters were converted to gallons by multiplying by 0.26

Ink emissions

With no control device in place, VOC and HAP emissions are calculated using the following equation:

E_{VOC} (electro ink)	= U * (W/100) * [1 – (R/100)] = (1,376 lb/year) * (82/100) * [1-(0/100)] = 1,128 lb VOC/year from ink
E_{VOC} (imaging agent)	= G * C * [1 – (R/100)] = (1.82 gal/year) * (5.14 lb/gal) * [1-(0/100)] = 9.35 lb VOC/year from imaging agent
E_{VOC} (recycling agent)	= G * C * [1 – (R/100)] = (4.94 gal/year) * (6.59 lb/gal) * [1-(0/100)] = 32.55 lb VOC/year from recycling agent
E_{VOC} (imaging oil)	= G * C * [1 – (R/100)] = (71.5 gal/year) * (6.43 lb/gal) * [1-(0/100)] = 459.7 lb VOC/year from imaging oil
E_{VOC} (total, inks)	**= $E_{electro\ ink}$ + $E_{imaging\ agent}$ + $E_{recycling\ solutions}$ + $E_{imaging\ oil}$** **= 1,128 lb VOC/year + 9.35 lb VOC/year + 32.55 lb VOC/year + 459.7 lb VOC/year** **= 1,629.62 lb VOC/year**

Note: In this example, the inks are 0 percent HAP by weight. Therefore, no HAPs are emitted.

Cleaning solution emissions

With no control device in place, VOC and HAP emissions are calculated using the following equations:

E_{VOC} (cleaning solution)	**= G * C * [1 – (R/100)]** **= (2 gal/year) * (6.54 lb/gal) * [1 – (0/100)]** **= 13.08 lb VOC/year**

Facility totals

Total HAP and VOC emissions for this facility are calculated using the following equations:

$$E_{total} = E_{electroink} + E_{imaging\ agent} + E_{recycling\ agent} + E_{imaging\ oil} + E_{cleaning\ solutions}$$

$$\begin{aligned} E_{VOCtotal} &= 1{,}128 \text{ lb VOC/year} + 9.35 \text{ lb VOC/year} + 32.55 \text{ lb VOC/year} \\ &\quad + 459.7 \text{ lb VOC/year} + 13.08 \text{ lb VOC/year} \\ &= 1{,}642.7 \text{ lb VOC/year} \\ &= 0.8 \text{ tons/year} \end{aligned}$$

Note: Calculation of emissions involving numerous inks, coatings, solvents, adhesives and other materials will require separate calculations such as presented here for each of the materials used at a given facility.

Digital printing Source Classification Codes (SCC)

EPA has established two SCCs for VOC emissions from digital printing operations. The SCCs are for dryer (i.e. stack) and non-dryer (i.e. non-stack or fugitive) emissions. Speciation between dryer and non-dryer emissions was developed by EPA to account for the emissions from presses with dryers and control devices.

All emissions from a digital output device or press are to be reported as non-dryer emissions, therefore the facility needs to select the appropriate SCC in ARS.

SCC	EPA SCC description
40500805	Dryer emissions from digital output devices
40500806	Non-dryer or all other emissions from digital output devices

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