Inkjet Printing and the Clean Air Act

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Abstract

Inkjet printing is widely used to output images. While many believe inkjet to be a *green* technology, there are environmental issues associated with its use — primarily emissions to air. The Clean Air Act regulates the emissions of volatile organic compounds (VOCs) and hazardous air pollutants (HAPs). Both categories of substances are found in inkjet ink systems. To determine whether air regulations impact their operations, all inkjet printing facilities should calculate their total emissions of VOCs and HAPs. These emissions include both *potential-to-emit* (based on maximum operating capabilities of the equipment and facility) and *actual emissions* (based on actual operation conditions). Only by making these calculations and comparing the findings to the local regulations, can a digital printer determine their regulatory compliance requirements. Regulations vary across the U.S., based on the quality of the air in the specific geographic location.

Introduction

Inkjet printing is becoming a widely-used method of outputting digital and photographic images. Unlike the continuous tones provided in the photographic process, inkjet images are made up of tiny discrete dots ejected from a print head onto a substrate. Thus, the inkjet printing process is more closely related to the conventional printing process where dots of ink are applied to a substrate to form the image.

While eliminating the need for photo chemicals, inkjet printing does not eliminate all health, safety and environmental considerations. In fact, companies that have been processing film for years and add or switch to inkjet printing will find themselves confronted with new chemical exposures and environmental issues to address. On the compliance side, inkjet printers are faced with regulations that are common to traditional printing operations. This paper will focus particularly on the environmental regulations.

Air Quality Regulations

Air quality regulations date back to 1970 when the original Clean Air Act (CAA) was enacted. The CAA addressed six areas of concern by establishing national air quality standards for ozone (ground-level), lead, nitrogen dioxide, sulfur dioxide, carbon monoxide and particulate matter. These pollutants are found across the U.S. and are called *criteria air contaminants* because the EPA has established them by using health-based criteria (science-based guidelines) as their basis. One set of limits (primary standards) protects health; another set of limits (secondary standards) is intended to prevent environmental and property damage. A geographic area that meets or does better than the primary standard is called an attainment area; areas that don't meet the primary standard are called nonattainment areas. Although EPA has been regulating criteria air pollutants since the 1970 CAA was passed, many urban areas are classified as nonattainment for at least one criteria air pollutant. It is estimated that about 130 million Americans live in nonattainment areas.

Ozone and Smog

What is typically called smog primarily comprises ground-level ozone. Ozone can be good or bad depending on where it is located. Ozone in the stratosphere high above the Earth protects human health and the environment, but ground-level ozone is the main harmful ingredient in smog. Therefore, EPA has established an air quality standard for ozone.

Ground-level ozone is produced by the combination of pollutants from many sources, including cars, paints and solvents. When a car burns gasoline, releasing exhaust fumes, or a printer produces a banner, smog-forming pollutants are released into the air and rise into the sky. Once released, the smog-forming pollutants literally cook in the sky. If it's hot and sunny, smog forms. This occurs more easily on hot days as compared to cooler days.

For ozone, EPA classifies attainment and nonattainment areas according to how many days each year the area exceeds the ozone air quality standard. The classifications range from basic (relatively easy to clean up quickly) to extreme (will take a lot of work and a long time to clean up). Deadlines are set for achieving attainment status that are specific to the geographic area. If deadlines are missed, the law allows more time to clean up, but usually a nonattainment area that has missed a clean-up deadline will have to meet the stricter clean-up requirements set for more polluted areas.

EPA's comprehensive approach covers a variety of pollutant sources and clean-up methods. Many of the smog clean-up requirements involve motor vehicles (cars, trucks, buses) but increasingly, as pollution worsens, pollution controls are required for smaller sources such as digital output printing operations. Given the large number of small sources, EPA is identifying which of them to tackle first, based on health and environmental hazards, production volume, etc. This action will result in certain areas of the U.S. regulating small sources prior to other areas, a situation we are currently experiencing.

Digital Printing and Ozone

Irrespective of the media, the primary issue for digital printers is their use of volatile organic compounds, or VOCs. VOCs are used in inkjet inks to provide the properties the ink needs to work efficiently. While there is no air quality standard for VOCs, these chemicals play a critical role in forming ozone. Consequently, VOCs are regulated via the CAA because they are an ozone precursor.

As digital output printing devices increasingly tend toward the use of solvent-based inks, a growing number of facilities, especially those printers that are using wide-format printers, will find that they must determine the applicability of the CAA regulations to their operations. The retail sector may not recognize this obligation because the technology has been strongly promoted as being *green* and terms such as *eco solvents* are widely used in association with inkjet inks. In fact, many companies have purchased digital output equipment because they believed the technology was greener.

Digital Printing and Hazardous Air Pollutants

Toxic air pollutants, also known as hazardous air pollutants or HAPs, are those pollutants that are known or suspected to cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental effects. EPA works with state, local, and tribal governments to reduce air toxics releases for the 188 chemicals found on the EPA list of HAPs. Many states have their own set of air toxics that they regulate, in addition to EPA's list of 188. Examples of HAPs include benzene, perchlorethlyene, methylene chloride, dioxin, asbestos, toluene, and metals such as cadmium, mercury, chromium, and lead compounds. Some of these HAPs can be found in certain types of inkjet inks and UV-curable inks.

Estimating Emissions from Digital Printing

The use of VOCs and HAPs in inkjet inks means that digital printing facilities must assume that air regulations will apply to them. In fact, air discharge regulations will increasingly apply as the government looks at smaller and smaller sources of air contaminants.

Language found in most air regulations provides the basis for requiring digital printers to undertake basic calculations to determine applicability: "The provisions of this rule apply to any stationary source capable of emitting or causing to emit, a volatile organic compound." This language allows regulatory agencies to request that nearly any size facility create the necessary documentation to show that the air emissions from their operation are not detrimental to the general air quality.

The basic calculations comprise both the potential and actual emissions from their equipment. The term *potential to emit* refers to the highest amount of VOCs and HAPs that the facility could emit, based on the maximum operating capacity of its equipment (operating 24 hours a day, 7 days a week at highest capacity). The term *actual emissions* refers to a facility's air emissions based on the actual hours of operation.

Volatile Organic Compounds (VOCs)

For the majority of the U.S., facilities using and emitting less than 10 tons per year of total VOCs will not be required to undergo permitting. There are exceptions to this general rule, such as parts of California, where permits are required to discharge amounts as low as 0.5 tons of total VOCs per year. This could mean that a facility with two grand-format printers would be required to undergo permitting for their operations.

Following is a method to determine **potential-to-emit** VOC emissions from a single inkjet printer. To estimate facility-wide VOC emissions, a printer would consider all printing processes. The VOC calculations are shown in chart 1, and are based on the following information:

- VOC content of ink (as per the material safety data sheet (MSDS) or the ink manufacturer)
- Equipment ink consumption specification
- Equipment operating speed
- Potential hours of operation
- Actual hours of operation

To calculate the **actual VOC emissions,** change the multiplier in Column D to the actual number of hours that the facility will operate this equipment. These calculations must be performed for each piece of equipment that emits VOCs in the facility and then an aggregate emissions volume must be determined. The aggregate number is then compared to the limits in the relevant air regulations, to determine permitting requirements.

Hazardous Air Pollutants (HAPs)

For the majority of the U.S., facilities emitting less than 10 tons per year for any single HAP and 25 tons per year for any combination of HAPs will not be required to undergo permitting. Again, there are exceptions to this general rule. Following is a method to determine **potential-to-emit** HAPs emissions from a single inkjet printer. To determine facility-wide HAP emissions, a printer would consider all printing processes. The calculations are shown in chart 2, and are based on the following information:

- Potential ink consumption (chart1, column E)
- Actual ink consumption (chart 1, column D multiplied by actual hours of operation)
- Precise weight of HAPs in inks
- Listing of ink constituents that are HAPs

Chart 1

Calculating VOC Emissions from an Inkjet Printer			
A	B	C	D
Ink consumption	**Printer speed**	**Ink consumption (per hour)**	**Potential annual ink consumption (1,000 ml = 1 L)**
7.98 ml/m²	3.6 m²/hr	28.7 ml/hr	251 liters

Calculating VOC Emissions		
E	F	G
Potential annual ink consumption (3.79 L = 1 gal)	**VOC content of ink (as per manufacturer)**	**Potential VOC/year (in lbs)**
66 gallons	5 lbs/gallon	330 lbs

Key to Chart 1

Column A	Ink consumption as provided by the manufacturer (reported as amount of ink per area of substrate)
Column B	Printer speed per manufacturer specifications (reported as surface area per hour)
Column C	Calculated figure determined by multiplying Col A by Col B
Column D	Calculated figure determined by multiplying Col C by 8760 (the number or hours in a year) and convert ml to liters (1000 ml in 1 liter)
Column E	Convert liters to gallons by multiplying by 3.785
Column F	The VOC content of the ink in lbs of VOC per gallon (as per MSDS)
Column G	Calculated figure determined by multiplying Col E by Col F

To convert the HAPs potential to emit to **actual emissions**, change the number in column 4 to the actual ink consumption rather than the potential consumption.

Once these figures have been created, the facility can then contact the local air office to determine the need for permitting.

Conclusion

As seen in these simple calculations, there are new regulatory issues associated with the use of digital printing technologies. For companies that have not before dealt with the regulatory regimes surrounding the use of solvents and hazardous air pollutants, The task of determining the need to permit air discharges can be daunting. The cooperative efforts of equipment designers, equipment manufacturers and trade associations will lead to easier transition from analog to digital.

Chart 2

Calculating HAPs Emissions from an Inkjet Printer			
1	5	6	7
Name of HAP	**Potential HAP Use (in gal)**	**Weight of HAP in lbs/gal**	**HAPS in lbs (weight of HAP x potential use, in gal)**
Diethylene glycol	19.8	9.31	184
Ethylene glycol	16.5	9.28	153
Total HAPs			337

Calculating HAPs Emissions from an Inkjet Printer			
1	2	3	4
Name of HAP	**CAS#**	**Weight by % (max.)**	**Potential material use (in gal)**
Diethylene glycol	111-46-6	30%	66
Ethylene glycol	107-21-1	25%	66
Total HAPs			

Key to Chart 2

Column 1	The name of each HAP (as per the MSDS)
Column 2	The CAS# of each HAP (as per the MSDS)
Column 3	The maximum % of each HAP (as per the MSDS)
Column 4	The potential ink consumption (chart 1, column E)
Column 5	Calculated figure determined by multiplying Col 3 X Col 4
Column 6	The weight of each HAP in lbs/gal (as per the MSDS)
Column 7	Calculated figure determined by multiplying Col 5 X Col 6. Total all the HAPs.

Biographies

Steven Noble is the Director of Environmental Activities for Photo Marketing Association International, where he is responsible for assisting image processors with maintaining knowledge of and compliance with environmental and OSHA regulations. He has been employed in various aspects of the regulatory compliance field for 17 years. Steve is involved in the National Pollution Prevention Roundtable, authors two monthly documents for PMA that address EHS compliance issues for its members and is a member of IS&T. E-mail: snoble@pmai.org.

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