

ILLINOIS POLLUTION CONTROL BOARD
October 1, 1987

IN THE MATTER OF:)
)
VOLATILE ORGANIC MATERIAL) R82-14
EMISSIONS FROM STATIONARY)
SOURCES: RACT III)

ADOPTED RULE FINAL ORDER

OPINION OF THE BOARD (by B. Forcade):

This matter comes before the Board as part of a regulatory proposal initially filed by the Illinois Environmental Protection Agency ("Agency") on June 30, 1982, for the control of organic material emissions from selected industrial categories and generic sources. The particular proposal that is the subject of today's Opinion and Order regulates organic material emissions from one of these industrial categories, heatset web offset lithographic printing. Thirty-three hearings have been held, to date, regarding the entire R82-14 regulatory proposal. A number of these hearings have specifically addressed the heatset web offset lithographic printing category. An economic impact study (EcIS) was prepared specifically addressing this category (Ex. 71).

On August 10 and 22, 1984, the Board proposed regulatory language and a supporting opinion, respectively, for First Notice (hereinafter, the first First Notice). The first First Notice contained elements of the original Agency proposal, as well as language and modifications submitted by the Printing Industry of Illinois (PII). Public comments received during the first First Notice period cited many problems with the proposed rule and PII specifically requested an additional hearing (P.C. 54, 57 & 62). On May 30, 1985, the Board, noting the confusion and controversy associated with this category, acknowledged that the first First Notice rule needed revision and that the existing record needed to be supplemented. The Board proposed a second First Notice (hereinafter the second First Notice) for the purpose of generating comments and criticisms and authorized additional hearings.

Hearings solely addressing the heatset web offset category were held on April 1 and 2, 1986, in Chicago. On September 22,

The Board acknowledges the contributions of David G. Mueller and Dr. Harish Rao in this proceeding.

1986, the Department of Energy and Natural Resources (DENR) filed a letter indicating that further economic impact assessment would not be undertaken by DENR for this particular category of rules, as a heatset web offset EcIS was already a part of the Board's record (P.C. 87). Final comments were received through September 29, 1986.

On April 30, 1987, the Board proposed regulatory language for a third First Notice (hereinafter, the third First Notice), which was published at 11 Ill. Reg. 10780, June 12, 1987. The statutory 45-day comment period ended on July 27, 1987. The U.S. Environmental Protection Agency (USEPA) filed comments on July 23, 1987 (P.C. 111). The Agency filed first notice comments, which were mailed July 27, 1987 (P.C. 112). The Administrative Code Unit of the Secretary of State's Office also filed comments regarding non-substantive format changes. The Board proposed the rules for second notice review by the Joint Committee on Administrative Rules (JCAR) on August 6, 1987. The Administrative Code Unit's comments were incorporated in the second notice Order. JCAR issued a Certification of No Objection on September 23, 1987. By Board order, dated September 24, 1987, the rules were directed to the Secretary of State for final notice publication in the Illinois Register. This Opinion supports the September 24, 1987, Order.

This is one of a series of Board actions directed at establishing emission controls to achieve attainment of the National Ambient Air Quality Standard (NAAQS) for the pollutant ozone (O₃). Ozone is not emitted from tailpipes or smokestacks like other pollutants, but is formed in the atmosphere by the action of sunlight on nitrogen oxides (NOx) and hydrocarbons (HC). This mechanism, which leads to ozone formation, involves a series of photochemical reactions. NOx and HC are, therefore, called ozone precursors. The amount of ozone formed in the atmosphere is a function not only of the concentration of NOx and HC, but also of the meteorology, in particular the amount and intensity of sunlight. Ozone is a seasonal pollutant, reaching its highest concentrations on warm, sunny summer afternoons. The ozone season in Illinois extends from April through October.

The strategy for controlling ozone has been to reduce hydrocarbon emissions, which are the primary ozone precursor, to the atmosphere. These hydrocarbons are termed "volatile organic materials" (VOM) or "organic materials" (OM) in Board regulations. This regulatory proceeding is one of a series that implements reasonably available control technology (RACT) for the control of hydrocarbons from existing major stationary sources emitting greater than 100 tons per year. The implementation of RACT in non-attainment areas for ozone is required as a part of a federally approvable state implementation plan (SIP) under the federal Clean Air Act (CAA) (42 U.S.C. 7401 et seq.). Section 172 of the CAA requires that RACT be implemented at existing

stationary sources in the non-attainment areas of those states needing an extension from the 1982 deadline until 1987 to achieve the air quality standard for ozone. Illinois is such a state, having requested the extension in its 1979 and 1982 SIP.

The definition of RACT is contained in 40 CFR 51, along with the requirements for a federally approvable SIP. However, the specific parameters of what constitutes reasonably available controls, and, therefore, the levels of control which the states must adopt to insure that RACT is implemented, are not contained in federal regulations. Instead, the United States Environmental Protection Agency (USEPA) publishes a series of documents entitled "Control Technique Guidelines" (CTGs). Each of the CTGs, which are summaries of industry specific case studies, contains the means and the degree of control which the USEPA requires the state to adopt categorically as part of its SIP in order to have an acceptable SIP. Failure to adopt rules identical to those presented in the CTGs, or other ones demonstrated by the individual state as comparable, can mean that the state will have an inadequate SIP, which in turn, can trigger the sanction provisions of the CAA found at Sections 110, 113 and 176 (42 U.S.C.A. 7410, 7413, 7506). While the mandate for sanctions is contained in the CAA, the mandate to adopt the CTGs or otherwise demonstrate a state rule to be comparable is not. It is not even contained in the federal regulations, but instead is articulated in the "General Preamble for Proposed Rulemaking and Approval of State Implementation Plan Revisions for Non-attainment Areas" (44 FR 20372).

This federal policy statement includes yet another requirement which is relevant to this rulemaking. The USEPA allows the states until the January after one year from the finalization of a CTG to adopt either the "rules" contained therein, or comparable rules, if sources covered by that particular CTG are within a state's non-attainment areas. Also of interest is the unstated policy of the USEPA to publish draft CTGs. Draft CTGs are informally distributed for the purpose of generating comments. These comments are often incorporated in final CTG publications. Presumably, state adoption of rules comparable to draft CTGs is not mandatory. A draft CTG has been issued for the heatset web offset industrial category, but was withdrawn or terminated by letter, dated March 22, 1982, from USEPA Deputy Administrator John Hernandez (Exs. 29(e), 24(o)). The significance of this will be discussed further in Section 1, below.

The proposed regulation of the heatset web offset industrial category has been one of the most complex and controversial regulatory proceedings in recent memory. This is due to the multiplicity of technical and legal issues that have arisen in the course of this, now, five-year proceeding. Consequently, it is necessary to separately address each issue in what is, hope-

fully, a logical progression. The general categories are as follows: 1) necessity and rationale for regulation of the heatset web offset category; 2) description of heatset web offset printing process and potential emission sources; 3) scope of regulation - fountain solutions and ink solvents; 4) geographical applicability of the proposed regulations; and 5) content of regulations - technical and economic issues associated with control options.

1. Necessity and Rationale for Regulation of the Heatset Web Offset Industrial Category

As a threshold matter, PII has argued that there is no legal necessity to regulate the heatset web offset industry, as no final CTG exists and the draft CTG was specifically withdrawn or terminated by USEPA (R. 3988). Alternatively, PII argues that the industry's emissions are de minimus and, consequently, do not merit regulation (R. 3989; P.C. 82, p. 6). Much debate between the PII and the Agency occurred during earlier stages of this proceeding as to the legal effect of a withdrawn draft CTG and the necessity for specific rules for heatset web offset printing. There now appears some degree of consensus among PII, the Agency and USEPA that category specific rules are not legally required as a consequence of the existence of a final CTG (R. 3984, 3988; Ex. 102). However, this does not necessarily obviate the need to impose RACT controls on this industrial category as the CAA requires the application of RACT on all major stationary sources of emissions in non-attainment areas for ozone currently on a SIP extension. Consequently, all major stationary sources must be controlled either by applicable CTG-based rules, generic RACT rules or category specific rules that are not CTG-based but are, nonetheless, RACT.

The criterion for determining whether the heatset web offset industry needs to be RACT regulated is whether or not sources emitting over 100 tons/year exist in areas designated non-attainment for ozone. Emissions less than 100 tons/year would be below the strict legal threshold established in the CAA. Whether or not such emissions are de minimus for the purposes of air quality planning for attainment is a separate issue.

There are two separate potential sources of emissions from the heatset web offset printing process: VOMs in the fountain solution and organic material emission from heated ink solvents. While there is disagreement between the Agency and PII as to whether ink solvent emissions should be regulated at all, there is no dispute that VOMs in the fountain solution are legitimate subjects of regulation if emitted in sufficient quantities. Information prepared and submitted by the PII in post-hearing comments shows both isopropyl alcohol (isopropanol) usage and emissions (the primary VOM in fountain solutions) and ink solvent usage and emissions for heatset web offset printing

facilities in non-attainment areas (P.C. 82, Table A-C). Table A of this survey shows two facilities in non-attainment areas with isopropanol emissions greater than 100 tons/year. Thus, even if the Board proposed regulatory scope only included fountain solution VOM emissions, major stationary sources exist in non-attainment areas. These figures do not take into account the use of isopropanol substitutes which are also VOM. Consequently, some form of RACT regulation is an absolute requirement under the CAA. The regulatory choices that remain are generic controls now proposed in R86-18 or rules specific to the heatset web offset industry. At this stage in the proceeding, the Board believes that it is best to propose category specific rules in this R82-14 docket for imposition of RACT, rather than subject this category to generic controls. As a general matter, category specific rules that account for unique aspects of an industrial process are preferable to generic regulations. Comments are specifically requested on this issue.

A second, correlative issue, is whether the levels of control prescribed in the terminated draft CTG constitutes RACT for the heatset web offset industry. This is a separate issue from whether category specific rules are legally required as a consequence of the CTG. The Board's second First Notice and the Agency's most current proposal are based on the terminated draft CTG. However, as the Board stated in the May 30, 1986, Opinion proposing the second First Notice:

"The Board is not advocating this proposed language but is using this second First Notice opinion and order as a vehicle for reopening the record in this category and outlining the unresolved issues...The new language will provide a starting point to develop an achievable and reasonable rule." (R82-14, RACT III, Opinion, May 30, 1985, at pp. 1-2)

The Board finds that the regulations based on the withdrawn draft CTG are not necessarily RACT for this category and that the Board is not bound to promulgate regulations equivalent to those contemplated in this document. The Board must promulgate rules that, based on the record, represent RACT and are technically feasible and economically reasonable pursuant to Section 27 of the Act. The issue of whether ink solvents will be included in these RACT controls will be addressed further in Section 3, below.

2. Heatset Web Offset Lithography - Process and Emission Sources

"Heatset" refers to a class of web-offset lithography which uses a heated dryer to solidify or set the printing inks by driving off excess solvents from a printed surface. "Offset", as used in the lithographic printing industry, refers to the blanket

cylinder which transfers ink from the plate to the surface to be printed. "Web" refers to the continuous roll-fed printed substrate or paper.

Each printing unit of a press has a series of vertically arranged rollers and cylinders above and below the web. These roller/cylinder systems draw either water-based fountain solution or solvent based ink from wells. Maintaining the distinction between image and non-image areas to be printed is done through chemical means. The non-image areas are receptive to water, or fountain solution. The image areas are water repellent and oil or solvent receptive, so that the ink stays on the image areas. The fountain solution and the inks are transferred by complexly arranged rollers to the plate cylinder. The image is then transferred from the image plate to a rubber covered blanket cylinder and then to the web. The infeed section of the press allows the rolls of paper to be mounted, aligned, unwound and fed through the press.

In a typical process-color heatset web offset lithographic printing press, each printing unit simultaneously applies a single color to both sides of the web. Together all printing units can overlay colors for a full color image without drying between printing units. After the printing web leaves the last printing unit, it enters the dryer. The most common type of dryer is a high velocity, hot air blower. Air temperatures can be as high as 500 F. Much of the heated air is recirculated, with only enough being discharged to prevent the buildup of explosive solvent vapors. The web leaves the dryer with surface temperatures between 266 F and 329 F and travels over an assembly of driven steel drums with chilled water circulating through them which cool the web to a maximum 86 F. This cooling, in combination with the evaporation of the ink in the dryers, prevents the ink from transferring to adjacent sheets when the printed web is cut, folded and stacked (R. 667-668, 2713; Ex. 29(e)).

There are two types of materials, fountain solutions and ink solvents, used in heatset web offset printing that result in organic emissions from the process. The fountain solutions used are typically composed of an etchant, such as phosphoric acid, gum arabic, a dampening solution, such as isopropanol, and water. The etchant is often purchased in a premixed concentrate that contains the etchant, gum arabic, mineral salts and a very small quantity of solvent. These solvents are VOM (R. 4044). Isopropanol, which is a VOM, is a commonly used dampening agent. High print quality is often attributable to the level of isopropanol used. Generally, a higher level of isopropanol in the fountain solution results in better print quality. Typical isopropanol usage ranges from 15-25 percent of the fountain solution. Automatic dampening systems usually maintain a 20 percent level, while manual make-up systems range from 15-25

percent. While alcohol substitutes are available, these substitutes are all VOM. However, the alcohol substitutes are generally less volatile than isopropanol (R. 4046; P.C. 62). The feasibility of replacing isopropanol with lower volatility substitutes is limited and a minimum five percent isopropanol is necessary for dampening systems using older, less flexible rollers (R. 666-671, 4001; P.C. 62).

Ink solvents, or ink oil, are hydrocarbons comprised of mixtures of narrow cut petroleum fractions having an average molecular weight of about 206. C₁₁ and C₂₂ hydrocarbons have been identified in ink solvents and a commonly used solvent has C₁₂ and C₁₆ hydrocarbons. The composition of the hydrocarbons could include saturated alkanes, unsaturated olefins and aromatics. The solvents boil within limited temperature ranges. Frequently, the boiling ranges identify the ink solvent. For example, Magie 470 oil has a boiling range of 462 F to 516 F. Most ink formulations contain 35 to 43 percent, by weight, hydrocarbons (R. 4030-4032, 4040). Two major types of ink solvents are used in heatset inks. One series of solvents is a severely hydrotreated variety of the other. Magie Sol 47 is the hydrotreated version of the Magie 470 oil. Hydrotreatment results in converting the unsaturated olefins and aromatics into saturated compounds.

The ink solvents used in the heatset web offset industry do not fall within the current regulatory definition of VOM, as the solvents have vapor pressures less than 0.0019 psia at 70 F. 35 Ill. Adm. Code 211.121 and 215.104. Neither do they fall within the regulatory definition of "photochemically reactive material" at 35 Ill. Adm. Code 211.122. The heatset web offset industry switched to these ink solvent formulations in order to be exempted from the applicability of the existing generic organic emission limitation of 8 lbs/hour at 35 Ill. Adm. Code 215.301 (R. 3990).

Emissions from the heatset web offset printing process emanate from the printing unit (i.e., the fountains and the roller/cylinder system) and the dryer. The terminated draft CTG estimates that 50 percent of the fountain solution emissions occur in the pressroom from the press unit and 50 percent occur in the dryer. However, the Agency believes that emissions from the press unit occur in the range of 0.8 to 25 percent, while 75 to 99.2 percent of the emissions evolve off of the web in the dryer (Ex. 28(g)). The emission factor for fountain solution VOMs is 100 percent, i.e., virtually all VOMs in the fountain solution volatilize and are emitted to the atmosphere from both the printing unit (i.e. pressroom emissions) or the dryer vent.

No ink solvents are emitted from the printing unit because of their low volatility at standard temperature and pressure. The vast majority of the ink solvent organic emissions that occur

evolve in the dryer, which volatilizes the ink solvents through high heat. These emissions are emitted to the atmosphere via a stack from the dryer. The Agency contends that all of the ink solvent emissions that occur, occur in the dryer (R. 3957). However, a very small amount of emissions may come off the web as it exits the dryer and travels on the cooling rollers. Some secondary outgassing may occur from an extremely hot web (R. 3959). Some portion of the ink solvents is retained on the printed web, or product, and is never released to the atmosphere.

Emission factors for the ink solvents are difficult to quantify. The terminated draft CTG estimates that 20 percent of the ink solvents remain in the web, or product, which would result in an emission factor of 80 percent. PII contends that emission factors vary depending on the type of product being printed. Product variables that affect emissions include: the relative absorbency of different types of paper, the ratio of printed to unprinted surface, the number of colors used and the thickness of the printed ink layer (R. 4042). These variables can result in emission factors ranging from 50 percent to 80 percent (R. 4041, 4043). Results of a long-term study conducted by World Color Press, Inc., involving 37 printing jobs using a wide variety of press configurations and web paper, found that the web typically retains 19.96 percent of the ink solvent applied which corresponds to an emission factor of approximately 80 percent (P.C. 84, p. 13). PII in its emission survey used an average emission factor figure of 70 percent (P.C. 82). Because of the variability of products produced, there is variability in the amount of emissions, which are dependent on the absorbency of the paper and the amount of ink applied. Because of the variability in emissions it is very difficult to quantify the emissions with precision. The nature of the printing business is such that printers cannot control the type of product produced, as it is done on a job-shop basis (R. 4043, 4047).

Many heatset web offset dryer vents are controlled in some manner, either by afterburners or condensers. These controls are necessary, in some circumstances, because of opacity and odor regulations. Plumes of condensed ink solvent vapors can cause opacity violations, absent controls. Odor controls are often necessary in urban areas. Consequently, most of the presses located in urbanized non-attainment areas have some form of control device (P.C. 82).

3. Scope of Regulation

The main focus of controversy and disagreement in this proceeding has been whether or not the organic emissions from ink solvents should be regulated. PII contends that: 1) these emissions are de minimus; 2) the ink solvents are not VOMs as defined in current Board regulations; 3) a large portion of the

dryer vent emissions quickly condense and are therefore not available for gas-phase photochemical reactions in the atmosphere; and 4) the ink solvent emissions are not photochemically reactive and should not be regulated. The Agency contends that: 1) emissions are not de minimus but are approximately 2000 tons/year in non-attainment areas and over 5500 tons/year in attainment areas; 2) ink solvents are emitted to the atmosphere by heat volatilization in the dryer; 3) the results of the various studies are inconclusive regarding reactivity; and 4) unless specifically excluded from regulation by USEPA, ink solvents should be regulated. In support of these arguments, PII and the Agency have presented testimony and exhibits regarding volatility, condensation and reactivity of ink solvents and ink solvent emissions.

PII presented the results of a study conducted by Battelle Columbus Laboratories ("Battelle Study") concerning the volatility and reactivity of commonly used ink solvents in environmental chamber irradiation experiments (Exs. 22, 39, 101(b); P.C. 54). This project was contracted for by the Graphic Arts Technical Foundation, a printing industry research organization. The first part evaluated the volatility of heatset printing ink solvents and the feasibility of conducting tests within smog chambers to determine their photochemical reactivity (Ex. 22). The second part evaluated ink solvents reactivity in comparison with the hydrocarbon ethane (Ex. 39). A third part compared recondensed ink solvents with "fresh" ink solvents in order to determine if the printing and drying process alters their composition in such a way as to increase or decrease reactivity (P.C. 54; Ex. 101(b)). Additionally, the third part extended the work performed in the previous two parts and included experiments on the reactivity of isopropanol, Magie 500 oil and toluene (P.C. 54; Ex. 101(b)).

Task 1 of the Battelle Report investigated the volatility of heatset printing solvents in order to determine the portion that would be available for participation in the gas-phase reactions important in the photochemical production of ozone. Two solvents, MagieSol 47 and Magie 470 oil, were used in the study. Various methods of volatilization were used, one method being found most appropriate. Task 1 demonstrated that it was technically feasible to proceed and evaluate the relative reactivity of different materials under ratios of hydrocarbons to nitrogen oxides known to lead to ozone formation (R. 755-758). Task 1 also found that the solvents were sufficiently volatile that "virtually all of the oil constituents are available to participate in gas-phase photochemical reactions" (Ex. 22). However, results from Task 1 do not rule out the possibility that condensation can occur under certain conditions. Condensation is experienced in the field and is evidenced by visual smoke (Ex. 111(a)). Condensation is primarily a function of concentration of oils in the stack and particulates in the atmosphere that

provide a locus for condensation. Stack gas temperature and atmospheric conditions also influence condensation. Unfortunately, the question of exactly how much of the solvent is available for gas-phase reactions remains unanswered. The Task 1 experiments do not cover this aspect adequately to support quantification of how much ink solvent is available in a gaseous state and how much condenses.

Task 1 also focused on possible photochemical aerosol formation during chamber irradiations. The formation of a photochemical aerosol would indicate that the test materials are reactive and contribute to the formation of ozone. The environmental chamber background air contained a high ratio of hydrocarbons to nitrogen oxides (NO_x). After approximately two hours of irradiation, a photochemical aerosol appeared during the experiments with Magie 470 oil, but did not with those conducted with MagieSol 47. The authors concluded that this was due to the aromatic content of the 470 oil, which was assumed to be 10 percent. Based on this assumption, they calculated that 20 percent of the oil is converted to aerosol during the two hour irradiation. However, in a subsequent analysis of MagieSol 47 and Magie 470 oil using gas chromatograph/mass spectrometer (GC/MS), ultra violet (UV) absorption and NMR techniques, it was found that the 47 oil had no detectable level of aromatic and that 470 oil contained, at most, one percent aromatic (Ex. 110). In light of this new understanding of the aromatic content in these oils, it must now be assumed that all of the aromatics and some additional component of the 470 oil is photochemically reactive. Using the one percent aromatic content assumption and carrying out a calculation similar to the one performed in the Battelle Study, 100 percent of the aromatic and a portion of the aliphatic component of the 470 oil would be converted to aerosol through photochemical reactions.

There are a variety of parameters that can be used to evaluate photochemical reactivity. The Battelle Study identified eight and chose one, maximum ozone concentration, to be used as the yardstick for the Task 2. One series of experiments was conducted to compare the reactivities of the two ink oils to that of ethane. In some experiments, concentrations were expressed on a mass basis, that is parts per million as carbon, while in others molar concentrations were employed, that is parts per million by volume. In both cases, the oils produced a higher ozone concentration than ethane within the first twelve hours of irradiation, although ethane eventually generated more ozone when compared by mass. It must be noted that the ratio of hydrocarbons to nitrogen oxide was 5:1, much higher than normally found in an urban mixture. HC/NO_x ratios of 1.5 to 2.0 are typical in urban atmospheres.

In another series of experiments, ink solvents or ethane was added to a typical atmospheric hydrocarbon mixture composed of

seventeen hydrocarbons. Recalling that part of the purpose of the second part was to compare the oils' reactivity to ethane's, in approximately half of this series of experiments, the oils were substituted in place of the ethane used in the other half. When ethane was replaced by MagieSol 47, the maximum ozone concentration dropped 5 percent. When it was replaced with Magie 470 oil, it dropped about 13 percent. So this series demonstrated that replacing ethane with either of the ink oils results in a reduction in the maximum concentration of ozone formed in the first twelve hours (Ex. 39).

In response to comments by Dr. Basil Dimitriades of USEPA, Research Triangle Park, additional studies were performed to gather data under conditions that were more realistic in terms of hydrocarbons to NO_x ratios that exist in the atmosphere. This report, which contains the results of Task A and B, also extended the work of Task 1 and 2. This further investigation of reactivity was also performed by Battelle. This report used the data from the Task 2 Battelle Study in the analysis. Task A also included experiments on the reactivity of isopropanol, Magie 500 oil and toluene. Task B involved performing three experiments to determine whether printing oils are modified by the printing process in a manner that would affect their photochemical reactivity.

Task A experiments assumed that synergistic and inhibitory effects in multicomponent mixtures can best be represented by utilizing a matrix of atmospheric organic compounds and that such a procedure is a realistic method for comparing the reactivity of a test compound such as the heatset oils with a reference compound (ethane). Smog chamber experiments were carried out at non-methane organic compounds/nitrogen oxides (NMOC/NO_x) ratios of 1.5, 2.8 and 5. The authors concluded that the three representative ink oils, namely MagieSol 47, 470 and 500 "...are generally no more reactive than an unreactive reference compound (ethane). One exception is the 470 oil at NMOC/NO_x of 1.5, where reactivity of the oil exceeds that of ethane" (Ex. 101(b)).

Task B experiments investigated whether the heatset web offset printing process alters the ink oil in such a way that the oil's reactivity would be affected. The experiments show that the reactivity of oil emitted from an actual press run was equal to the reactivity of the same oil which had not been exposed to the printing process (Ex. 101(b)).

The USEPA contracted with William P.L. Carter to conduct a computer modeling study of the photochemical reactivity of heatset printing oils (Carter Report). This study was carried out at the Statewide Air Pollution Research Center (SAPRC) of the University of California in Riverside (Ex. 101(d)). The purpose of the Carter Report was to use a mathematical modeling approach to study the mechanistic aspects of heatset ink oil reactivity in light of the data obtained from the Battelle experiments.

The study consisted of two major tasks. The first was to simulate the results of the Battelle chamber experiments based on current understanding of the chemical reaction mechanisms of the higher alkanes and thus determine the most appropriate way to represent the oils in model simulations. The second task is strongly dependent on the outcome of the first task. In the second task, box-type airshed model calculations were carried out to assess the relative contributions to O₃ formation from the addition of heatset oils.

In carrying out the first task, a number of major assumptions were involved. First, a choice of 0.6 ppb for the chamber dependent proportionality factor was made. The authors indicate that this was a best fit. However, a look at Table 2 shows that the model calculated values for O₃ maximum are very much lower (about 40%) than the O₃ maximum obtained experimentally (Runs 2-16 and 2-7). Several other chamber-dependent parameters are assumed by the authors to be appropriate for simulating the Battelle experiments. Second, a detailed mechanism for the NOx-air reactions of ethane, propane, n-butane, n-pentane, iso-octane, toluene, m-xylene and their oxygenated reaction products was assumed to represent the reactions of ethane and the components of the urban surrogate used in the Battelle experiments. The authors have included comments in Table 1 on why such a representation of the surrogate mix was used. A third and more controversial assumption is the representation of the ink oils. The authors used n-pentadecane, which has a molecular weight close to the average molecular weight of the ink oils. A probable set of reactions for this compound are included. In addition, m-xylene (2-10%) was added to the model to represent the reactivity of the oils and to better fit the data from the single oil component experiments (Table 2). The following discussion relates to this last assumption.

The aromatics in the oils are represented by varying the amounts of m-xylene added to the n-pentadecane. It was believed by the authors that both Magie 470 and Magie 500 oils contain approximately 10-12% aromatics. However, as stated earlier and presented in Exhibit 110, these oils may contain no more than 1% aromatics. If this is really the case, the use of m-xylene to represent the reactivity is probably not appropriate. Then the addition of m-xylene would simply be an artifact to raise the O₃ concentrations predicted by the model. The fact that maximum O₃ concentrations obtained in the chamber experiments using the 47 and 470 oils are not too far apart does suggest that the aromatic content of the 470 oil is not too large. From the results of the model simulations of the urban surrogate-NOx experiment and the urban surrogate with added ethane or printing oils (shown in Table 3, Exhibit 101(d)) the author's conclusion that the representation of the printing oils as n-pentadecane plus variable m-xylene (2-5% for the 47 oil and 5-10% for the 470 oil)

is not justified by the data. In particular the m-xylene percentage (5%) that demarcates the 47 oil from the 470 oil is not clearly seen in the data. Thus the use of this representation can at best be described as qualitative. Quantitatively, the model requires more refinement.

The second task in the Carter Study deals with the assessment of the relative reactivities of ethane and the mixtures of compounds thought to represent the printing oils. This has been done by measuring the change in O_3 concentration caused by the addition of known small amounts of the test compounds (ethane, mixtures representing the printing oils or the urban surrogate) to the assumed existing emissions. Two Empirical Kinetic Model Approach (EKMA) scenarios and two multi-day with stagnation or transport scenarios were used for modeling the relative reactivities. Based on results of the modeling, the author states that:

"under practically all conditions except the highest HC/NO_x ratios, then n-pentadecane, 5-10% m-xylene mixtures, which, based on the chamber simulations, is taken to represent the reactivity of the two printing oils most extensively studied by Battelle, are significantly more reactive than ethane."

Further, Carter notes that the

"mixture (sic) taken to represent the printing oils are less reactive than the mixture taken to represent emissions from other sources in urban areas, indicating that these oils are probably less reactive relative to O_3 formation than most pollutants emitted into urban areas."

The authors conclude with a discussion of some of the weaknesses of their assumption of a n-pentadecane and m-xylene mixture to represent the ink oils. Of note is the statement that such a representation is "our best estimate of a chemical model" and that it is "necessarily highly approximate, and it contains a number of uncertainties." The reaction mechanism for n-pentadecane is based on an extension of models for C₄-C₉ alkanes because limited data exist for reaction mechanisms for alkanes with more than four carbons. These points in their conclusion suggest a need to quantify the uncertainty wherever possible. The results do indicate that the reduction in the aromatic content of ink oils can reduce the reactivity to that of ethane.

Another important result from the modeling study was the effect of hydrocarbon to nitrogen oxide (HC/NO_x) ratios on predicted daily maximum O_3 concentrations. The maximum increase

in O₃ above that predicted in the base case is seen to occur at the low to moderate HC/NO_x ratios (4 to 8). However the absolute predicted O₃ concentrations are lower at the low HC/NO_x ratios.

HC/NO_x ratios of 1.5 to 2.0 are typical in urban atmospheres. The ratio of concentrations of ink oils to NMOC is also expected to be low in the atmosphere. Not having carried out computer runs at HC/NO_x ratios below 6, the authors extrapolate from the available data to state that the O₃ production is less sensitive to added organics at low HC/NO_x ratios (i.e., below 6). Thus, evidence of any increase in ozone production due to ink solvents is likely to be obscured.

PII contends that the quantity of ink solvent emissions are de minimus and should not be regulated as a significant source of ozone precursors. This contention is not supported by the record. As previously discussed, the CAA provides a legal threshold for regulation of 100 tons/year for stationary sources. PII's own survey on isopropanol and ink solvent usage in non-attainment areas shows that ink solvent emissions are in the area of 2000 tons/year from the industrial category with approximately nine facilities emitting over 100 tons/year of isopropanol and ink solvents (P.C. 82). Ink solvent emissions in attainment areas are approximately 5500 tons/year. The estimate of ink solvent emissions is based on a 70 percent emission factor, which is favored by PII. The record indicates that higher emission factors are appropriate in some circumstances (Ex. 29(e); P.C. 84). Even with this possibly low estimate, there are major stationary sources in non-attainment areas, thus necessitating regulation purely based on quantity of emissions. PII also argues that not all of these emissions are available in the gas-phase and that those that are available are non-reactive. However, assuming for the moment that ink solvent emissions are appropriately subject to regulation as ozone precursors, from a pure quantity of emissions standpoint, the ink solvents are not de minimus.

PII's second major argument is that a large portion of the ink solvent emissions from the dryer condense from the gas-phase back to the liquid phase and are, consequently, not available for photochemical reaction in the atmosphere. The record shows that condensation of ink solvent emissions does occur to some degree in the industry. Condensation can result in visible plumes of smoke (Ex. 23, 111(a)). As a consequence, many heatset web offset presses are controlled either by afterburners or condensers in order to avoid violations of the Board's opacity regulations (R. 3989-3990, 4151; P.C. 82). However, industry witnesses admit that this condensation plume formation is not an automatic occurrence and "in many instances, there are presses in different plants where the concentrations that we are able to account for are not adequate to form a condensate" (R. 773). Condensation is dependent on the concentration of oil emissions

in the stack, ambient temperature and ambient particulates in the atmosphere, which provide a locus for condensation. Additionally, even when condensation does occur, it is unclear what portion of the emissions remain in the gaseous state. Task 1 of the Battelle Study demonstrated that ink solvents volatilize when subjected to heat and "virtually all of the oil constituents are available to participate in gas-phase photochemical reactions" (Ex. 22). Task 1 left unanswered the question of how much of the solvent emissions are available for ozone formation. One industry witness indicated that there are no numbers in existence quantifying the condensation phenomenon, in part because the quantity constantly changes depending on production factors and atmospheric conditions (R. 4121-4122).

In summation, while the record shows that the phenomenon of condensation of ink solvent emissions does occur in some circumstances, there is little factual support for PII's position that a significant portion of ink solvent emissions are not available in a gaseous state for photochemical reaction. By PII's own evidence condensation does not occur automatically, the quantitative aspect of condensation is totally unknown and its occurrence is dependent on fluctuating meteorological and emission conditions. Based on this record, the Board cannot accept PII's argument that a significant portion of the emissions are not available for ozone formation. The evidence before the Board indicates that under certain conditions, all of the ink solvent emissions remain in a gaseous state and are available for photochemical reaction in the atmosphere (Ex. 22).

PII argues that ink solvents, as presently constituted, are not VOMs as defined in Board regulations at 35 Ill. Adm. Code 211.122 and 215.104. PII is absolutely correct that heatset ink solvents do not fall within the current regulatory definition of VOM, which is written in terms of volatility at a specified standard temperature and pressure. This argument might be persuasive if this was an adjudicatory proceeding construing existing regulatory language. See DuPage Publications v. IEPA, PCB 85-44, 85-70 and 85-130, ___ P.C.B. ___, May 9, 1986; P.C.B. ___, August 14, 1986. However, the purpose of the instant proceeding is to first determine whether this industrial category should be regulated, and then, if regulation is necessary, what level of control is RACT. The Board is at liberty in this proceeding to fashion regulatory language that will address the issue of whether or not ink solvents should be controlled. In response to this issue, the Agency proposed an amendment to the definition of VOM that would include ink oils. Because of potential impact beyond the scope of the heatset web offset industrial category, this proposed amendment was separately docketed as a new regulatory proceeding, R86-37.

Regardless of the current definition of VOM, the real issue is whether the ink solvents are emitted to the atmosphere in the

course of the heatset web offset printing process. Regarding this particular issue, there is little factual dispute that the high temperature dryers, which "set" the inks, volatilizes a large portion of the ink solvents. These volatilized solvents are emitted through dryer stacks to the atmosphere. While there is variability in the emission factors, a reliable range is 70 to 80 percent (P.C. 82, 84). As previously discussed, some portion of these emissions can condense under certain conditions but that portion cannot be reliably quantified. Thus, regardless of the current VOM definition most commonly used in RACT regulations, organic emissions are volatilized into the gaseous state and are emitted to the atmosphere in significant quantities. The Board is not limited to using the existing VOM definition in the context of these rules and can certainly use the term "organic materials" if appropriate. The undisputed facts show that volatilized organic material emissions do result from the heatset printing process.

PII's final argument is that the heatset ink solvents are not photochemically reactive and should not be regulated. The Agency contends that ink solvents are photochemically reactive and that there is an insufficient factual basis for excluding them from regulations as ozone precursors. The Agency and USEPA view the evidence generated on photochemical reactivity as inconclusive. At the outset of this discussion, it is apparent from the studies performed to date that the relative photochemical reactivity of heatset ink solvents is close to that of ethane. Ethane is exempted from regulations as an ozone precursor by both USEPA and the Board because it is negligibly photochemically reactive and, therefore, not of regulatory concern. Whether ink solvents are more or less reactive than ethane is uncertain. Under certain environmental conditions, ink solvents are less reactive and, under other conditions, they are more reactive (Exs. 39, 101(b)). Another point that is apparent from a review of the record is that both ethane and ink solvents are photochemically reactive, i.e., they generate ozone under atmospheric conditions (Ex. 22). Very nearly all organic compounds that are in the gas-phase react in the atmosphere to ultimately form ozone. PII's assertion that the ink solvents are not photochemically reactive is clearly an overstatement.

For regulatory purposes, organic compounds have been categorized both in terms of volatility and reactivity. The volatility classification is premised on the concept that only organic materials that are volatile at standard temperature and pressure enter the atmosphere as gases and are, therefore, available for photochemical reaction. Of course, organic materials can be volatilized through heat or pressure in the course of an industrial process. This aspect has already been discussed as it relates to the heatset ink solvents. Organic compounds have been classified in terms of the rate at which they photochemically react. Organic materials that react slowly over

time have been classified as low reactive; organic materials that react more quickly are classified as reactive. Very few materials are totally non-reactive or inert. The choice of ethane as a benchmark for regulation is not a purely scientific or technical decision but is, in fact, a regulatory decision which is based on the best data available along with other planning and policy considerations. Ethane and certain other selected materials are excluded from regulation because they react so slowly as to have a negligible impact on air quality. The decision whether or not to regulate ink solvents is likewise a regulatory decision which encompasses a review of the available scientific data, the reliability and certainty of that data, an analysis of the potential air quality impact of the emissions and the regulatory framework for regulation. The issue can be distilled to this: Are the data presented sufficiently conclusive to support a finding that heatset ink solvent emissions have a negligible impact on air quality due to their extremely low photochemical reactivity?

The PII relies primarily on the results of the Battelle Study in support of its position that ink solvents are non-reactive (Exs. 22, 39, 101(b)). PII argues that the Battelle Study is the only credible evidence in the record on ink solvent reactivity and that this evidence shows that they are equivalent to or less reactive than ethane. PII criticizes the findings of the Carter Report based on alleged errors in certain key assumptions and methods. The Agency maintains that ink oils participate in photochemical reactions in the atmosphere and that, unless specifically excluded from regulation by a final rulemaking action by USEPA, they should be controlled. The Agency and PII agree that the USEPA is undecided on the issue of whether ink solvents are significantly photochemically reactive and whether they should be excluded from regulation. USEPA views the current data as "inconclusive." USEPA continues to view ink solvents as ozone precursors subject to regulation in the absence of conclusive data. No formal decision has been made on the issue of whether or not to exclude them from regulation.

The results of the Battelle Studies do provide some of the best evidence presently available on ink solvent reactivity under certain conditions. However, the results and conclusions that can properly be drawn are limited. Task 1 of the Battelle Study shows that ink oils can be volatilized with heat and will remain in a gaseous state. Task 1 also demonstrates the ink solvents' ability to photochemically react, i.e., formation of a photochemical aerosol after irradiation. Battelle Tasks 2, A and B results show that under various simulated environmental conditions, ink solvent reactivity varies in relation to ethane. Under most of the simulated conditions, the solvents appeared less reactive than ethane. Magie 470 oil at NMOC/NOx of 1.5 was more reactive than ethane.

In reviewing the Battelle data, the Board must consider the reliability of the data and the conclusions drawn from that data. Statistically speaking, there were relatively few replicate samples from which a comparison of the reactivities of the solvents to ethane could be made. Except at the NMOC/NO_x ratio of 5.0 which had two runs each for isopropanol and the ink solvents and four runs for ethane, there is essentially just one run for each compound tested at the other NMOC/NO_x ratios. Conclusions drawn from such limited data should be viewed with caution. Additionally, certain of the test conditions were not standard throughout the tests comparing ethane with ink solvents. At the NMOC/NO_x ratio of 2.8, the ratio of test compound (ethane) to NMOC was 0.11 while all other experiments were run at equal molar concentrations of test compound and surrogate urban mixture. Because of this, a rather high value (509 ppb) occurs for the maximum ozone obtained for run A-2 with ethane and the urban mix. The tests using ink solvents (Run 2-8, 2-9, A-10) resulted in lower ozone values. This comparison to ethane tends to make the solvents look as if they are less reactive. In fact, the test conditions were not comparable. On the other hand, when equal molar concentrations of ethane and surrogate urban mixture are used, at the same NMOC/NO_x ratio of 2.8, the maximum O₃ produced is 378 ppb (Run A-13). If the ink solvents had also been tested under these conditions, it is possible that they might have produced a maximum O₃ concentration in excess of 378 ppb; in which case, the conclusion would have been that the ink solvents were more reactive than ethane. In fact, this latter conclusion is plausible based on the observation that ethane reactivity decreases faster than that of the ink oils for reductions in the NMOC/NO_x ratio from 5.0 to 1.5.

The results of the relative reactivity are presented in figure 4 of the Summary Report Task A and B (Ex. 101(b)). Conclusions from this data regarding the reactivity of ink solvents are possible only if the conditions of the experiment are also stated. The conditions are necessary for reasonable interpretation since the solvents are more reactive than ethane under some conditions and less reactive under other conditions. The only conclusion that can be drawn from the summary results is that the reactivities of the solvents are not very different from that of ethane under test conditions. It also appears from the data that a reduction in the ratio of test compound to NMOC increases the reactivity of the ink solvent test compounds with respect to ethane. Since the actual concentrations of the heatset ink solvents in the atmosphere is low compared to the urban mix, the data suggests that the oils might be more reactive than ethane and, therefore, produce more ozone than ethane would under likely environmental conditions.

In summary, there is ambiguity in some of the Battelle Study results and inherent limitations to drawing broad conclusions

from environmental chamber test results. It is not possible to exactly simulate actual ambient atmospheric conditions in environmental chamber experiments. The Battelle results show that ink solvent reactivity is dependent on the experimental conditions. Additionally, it is not practical to simulate, in environmental chamber studies, the full range of reaction conditions which occur in the atmosphere, and which affect the relative reactivity of the materials being compared.

The Carter Report was intended to help fill in these informational gaps through computer modeling based on Battelle Study data. The Carter Report, first, explored the chemical reaction mechanisms of the higher alkanes in order to accurately represent the ink solvents in model simulation. Second, Carter conducted box-type air-shed model calculations to assess the relative contributions to ozone formation. Carter made a number of conservative assumptions regarding chamber-dependent parameters, the mechanisms for NO_x to air reactions representing the Battelle ethane to urban surrogate reactions, and the representation of the ink solvents. This last assumption is the most controversial and, in light of subsequent data, perhaps erroneous (Ex. 110). The actual aromatic content of the test ink solvents is much lower than presumed by either Carter or Battelle. Thus, in the case of the Carter Report, the choice of m-xylene to represent the reactivity is probably not appropriate and could artificially raise the ozone concentrations predicted by the model.

Only limited conclusions can be drawn from the Battelle and Carter reports. The experimental data does not conclusively settle the reactivity issue. The assumptions about the reaction mechanisms are flawed because of the current lack of knowledge. GC/MS analysis of sample ink solvents indicate extremely low levels of aromatics, much less than previously believed (Ex. 110). The Battelle Study concluded that the photochemical reactions that did occur during chamber irradiations were attributable to the assumed 10 percent aromatics. The findings of Ex. 110 undercut this conclusion. Some component of the ink solvent, other than the aromatics, must be reacting at rates higher than previously attributed to the higher alkanes. The assumptions of the Carter Report ink solvent surrogate are also undercut by Ex. 110. Part of the problem is due to the fact that ink solvents are not pure compounds, but are comprised of various components. The exact composition of these complex solvent formulations can vary from lot to lot (P.C. 84). Additionally, not much is known about the photochemical mechanisms of the higher alkanes, above C₁₀, which comprise a large component of the ink solvents. Because of these informational uncertainties, it is difficult to draw conclusions with a high level of confidence.

It is necessary to review the regulatory strategy for control of ozone precursors in light of the uncertainty surrounding the composition and photochemical reactivity of the ink solvents. Early federal and state efforts at ozone control focused on controlling higher reactive organic materials and allowed exemptions for low (slow) reacting organic materials. This approach, initially adopted in California's "Rule 66", was adopted by the Board and is now found at 35 Ill. Adm. Code 211.122 (definition of "photochemically reactive material") and 215.301. USEPA regulations in this area also allowed for a control strategy of: 1) reducing organic material emissions generally; and 2) replacing highly reactive material with lesser reactive material. 40 CFR Part 51 Appendix B. Under this regulatory scheme, ink solvents are presently exempt from the 8 lbs/hour level of control under 215.301.

Subsequent to this first effort at ozone control, the regulatory strategy changed. USEPA's guidance to the states indicated that the reactivity concept was useful as an interim measure only and would not be considered a reduction in emissions for purposes of estimating attainment of the ambient air quality standard for ozone. USEPA severely reduced the category of materials deemed not of regulatory concern due to their extremely low reactivity from what was previously excluded under the "Rule 66" strategy. 42 FR 35314 (July 8, 1977). Only four materials were excluded from regulation, one of which is ethane. This listing has been expanded to include eleven compounds, to date. Illinois adopted this approach in its definition of VOM, which excludes the eleven federally excluded compounds.

USEPA analysis of available data and information showed that very few VOMs are of such low photochemical reactivity that they can be ignored in ozone control programs. USEPA found that many VOMs that were previously designated as low reactivity materials are now known to be moderately or highly reactive in urban atmospheres. Second, even compounds that are presently known to have low reactivity can form appreciable amounts of ozone under multi-day stagnation conditions as can occur in summer. 42 FR 35314.

The Board finds that the scientific data presented to date is inadequate to justify exclusion of ink solvents from regulation as ozone precursors. While the data presented does show that ink solvent reactivity is close to that of ethane, it is so only under certain conditions. Additionally, the data is too limited to draw broad conclusions on ink solvent reactivity throughout the spectrum of atmospheric conditions. This limited data, in combination with the present lack of knowledge on the photochemical behavior of the ink solvents, cannot support regulatory exclusion since ink solvents are emitted to the atmosphere and they are photochemically reactive. While the ink solvents are generally slower reacting, their emission to the

atmosphere contributes to the formation of atmospheric ozone and is of special concern during multi-day stagnation scenarios. Under atmospheric conditions experienced in Illinois and southeast Wisconsin, gaseous ink solvent emissions slowly react to form ozone. Under the current regulatory strategy adopted by Illinois, it is appropriate and necessary to control ink solvent emissions.

Where the record before the Board demonstrates that a source category has substantial emissions of hydrocarbons to the atmosphere and that those particular hydrocarbons are photochemically reactive and will probably lead to the formation of ozone under usual atmospheric conditions, the Board is justified in adopting technically feasible and economically reasonable regulations to control those emissions. The Board finds that during the heatset printing process, ink solvents are volatilized and emitted to the atmosphere in a gaseous state and in quantities that are of regulatory concern. While condensation can occur, it has not been shown to significantly reduce the gaseous emissions. Data presented to date shows that ink solvents are photochemically reactive. Their rate of reactivity is close to that of ethane but varies depending on experimental conditions. It is unclear how reactive ink solvents are under actual atmospheric conditions as the existing test data is limited and little is known about the reaction mechanisms of the higher alkanes, which are principal components of ink solvents. Test data does indicate that greater reactivity is exhibited under conditions approaching probable atmospheric concentrations of ink solvents. Because the data does not show that ink solvents are of such low reactivity to warrant exclusion based on limited impact on air quality, especially during prolonged irradiation under multi-day stagnation conditions, the Board will establish RACT controls for both fountain solutions and ink solvents.

4. Geographic Applicability

When the first regulations controlling heatset web offset printing were proposed as part of the RACT III regulatory package, they were intended to apply on a statewide basis. This was consistent with the strategy undertaken in the RACT I (R 79-2, 3) and RACT II (R 80-5) proceedings. Several years ago, when these proceedings were completed and RACT III was proposed, much of the state was designated as non-attainment. When RACT I was initiated, 25 counties in Illinois were non-attainment for ozone. The rationale for statewide applicability was based on the pervasive statewide ozone problem, the atmospheric transport of ozone and ozone precursors from sources in attainment areas to non-attainment areas, and the need to provide for growth in the SIP (R. 40-63). At present, many areas of the state have achieved attainment for ozone and the major non-attainment areas, with one exception, are concentrated in the Chicago and East St.

Louis major urbanized areas (R. 3204-5). Macoupin County is not located in a major urbanized area but continues to experience violations of the NAAQS for ozone.

Recent regulatory proposals have focused on implementing RACT in the nine counties that comprise the Chicago and East St. Louis major urbanized regions and Macoupin County. Eight of these counties are currently designated non-attainment for ozone. Will and McHenry counties are currently designated attainment for ozone but are part of the Chicago urbanized area. The SIP must, in addition to imposing RACT on major stationary sources in non-attainment areas, provide for ultimate attainment of the ozone NAAQS. To that end, sources in Will and McHenry still need to be RACT controlled in order to ensure adequate emission reductions because of the transport of ozone and ozone precursors from these geographically contiguous counties.

During the course of the various Agency, Board and PII regulatory proposals for the heatset web offset category, no participant has raised the issue of changing the geographic applicability in light of the current SIP strategy. Consequently, the Board will limit the geographic applicability of RACT controls to the ten counties designated either non-attainment for ozone or that are a part of the Chicago urbanized area. The Board is cognizant that this action will greatly decrease the economic impact of emission reduction contemplated in previous proposals. World Color Press Inc. was identified in the EcIS as potentially bearing 62% of the total statewide cost of the regulation at four of its facilities located in attainment areas (Ex. 71). These facilities will not be subject to RACT limitations that require the installation of add-on pollution control equipment. However, the Board will require some level of control of fountain solution VOM on a statewide basis. This level of control will be something less than full RACT controls but will nonetheless limit VOM emissions.

The rationale for requiring some level of statewide control is based on, first, the need to maintain the current attainment status throughout most of the state. Approximately eight major stationary sources are located in areas that are currently in attainment (excluding Will and McHenry counties which are considered part of the Chicago urbanized non-attainment area). Total estimated organic emissions from these facilities range from 2600 tons/year to 5200 tons/year (Ex. 71). Many of these facilities are extremely large sources of organic emissions to the atmosphere. Second, emissions from these facilities, although located in attainment areas, can contribute to ozone in non-attainment areas through atmospheric transport of ozone and ozone precursors. One facility, located in Randolph County, is contiguous to the East St. Louis major urbanized non-attainment area. Emission reductions on a statewide basis will help reduce the ambient ozone and ozone precursor concentration loadings that can impact non-attainment areas.

5. Content of Regulation - Level of Control

The RACT control options for heatset web offset printing that can be prescribed in a regulation are summarized as follows: (1) reduction of VOM in the fountain solution through reformulation; (2) installation and operation of a thermal or catalytic incinerator to control dryer emissions; and (3) installation and operation of a condenser/filter system that selectively removes ink solvents and other low volatility materials such as isopropanol substitutes, but does not effectively remove isopropanol. Ink reformulation is not currently a RACT option (P.C. 62).

During the course of this proceeding, there have been numerous regulatory proposals for the control of the heatset web offset printing process. At least four separate proposals merit discussion: (1) the Agency's proposal which was analyzed in the EcIS; (2) the Board's first First Notice proposal of August 10, 1984; (3) the PII's proposal (P.C. 62); and (4) the Board's second First Notice proposal of May 30, 1985, based on the terminated draft CTG. This proposal has been adopted, with modifications, by the Agency as its current proposal (Ex. 103). Certain elements of these various proposals are not technically feasible or economically reasonable. Many of these deficiencies have been raised at hearing or in public comments and will be discussed further below.

The Agency's proposal, which was analyzed in the EcIS, called for statewide regulation of facilities emitting 100 tons/year or more of organic material. Three control options were prescribed: (1) installation and operation of an afterburner which oxidizes 90 percent of the organic material; or (2) the fountain solution contain no more than five percent of volatile organic material and a condensation recovery system is installed and operated that removes at least 75 percent of the organic materials from the airstream; or an alternative control system equivalent to either of the previous control options. The major problem with this rule is that a limitation of five percent VOM in the fountain does not appear to be technically feasible for many heatset web offset presses.

The Board's first First Notice rule proposed on August 10, 1984, applied statewide to facilities whose emissions of VOM exceeded 25 tons/year. The rule required one of three options: (1) installation of an afterburner system which oxidizes 90 percent of captured non-methane VOM; or (2) reduction of VOM concentration in the fountain solution to no more than five percent and installation of a condensation recovery system which removes at least 75 percent of VOMs from the airstream or reformulation of the ink to a high solid/low solvent; or (3) an alternative control system demonstrated to have an equivalent

emission reduction efficiency equal to either of the first two options.

This proposal presented a number of conceptual problems. First, the proposed rule attempted to regulate only VOM emissions yet prescribed control of ink solvents. The various control strategies were not equivalent. Certain options were not technically feasible, such as the VOM content of the fountain solution and the ink reformulation option.

The PII proposal provided for statewide regulation at a 40 tons/year VOM threshold (R. 4119). Alternatively, PII requested a 40 tons/year/press threshold (P.C. 82). No justification for this level has been provided. The PII rule would require use of an afterburner which oxidizes 90 percent of the VOM emissions presented to the control equipment; or (2) a VOM limitation of 8 percent in the fountain solution; or (3) an equivalent alternative control system. The main problems with this proposal were the exclusion of ink solvents from regulation and control and the forty tons/year/press threshold.

The Board's second First Notice provided statewide regulation of sources emitting over 100 tons/year of VOM. The proposal provided four alternative control strategies: (1) total elimination of VOMs in the fountain solution; or (2) reduction of VOM concentration in the fountain solution to 12 percent and installation and operation of an incinerator; or (3) reduction of VOM concentrations in the fountain solution to seven percent and installation and operation of a condenser/filter system; or (4) an alternative emission control system equivalent to any of the first three options. This proposal had a number of problems associated with it. First, total elimination of VOM in the fountain solution is not technically feasible, nor is a limitation of seven percent. Second, the structure of the regulation favored the incineration control option. Third, the various levels of fountain solution VOM which corresponded to and triggered application of add-on controls were arbitrary.

All of the regulatory proposals to date have allowed an unspecified alternative equivalent control strategy. Preliminary comments from USEPA indicate that such an option is probably not federally approvable (R. 3898-3901; Ex. 110).

As discussed in Section 1 of this Opinion, while the Board is required to adopt RACT regulations controlling the heatset web offset category, the specified level of control that is RACT has not been federally defined. Thus, the Board is at liberty to define a level of control that is RACT, based on the regulatory record. The regulatory controls must also be technically feasible and economically reasonable as a matter of state law. Reconciling what is RACT and what is technically feasible and economically reasonable is possible, as the concept of RACT

incorporates elements of reasonableness, cost effectiveness and technical feasibility and availability of control options.

The Board adopts regulations that it believes meet these federal and state standards, based on the regulatory record. The threshold for regulation will be 100 tons per year of organic material. This threshold is consistent with the CAA definition of major stationary source. This will include organic materials that are considered volatile at standard temperatures and pressures, as well as non-volatile organic materials, such as the ink solvents, that are volatilized during the printing process.

As a first control alternative, Section 215.408(a) (1) will require installation and operation of an incinerator that oxidizes at least 90 percent of the organic material present in the airstream from the dryer. This approach will control nearly all of the volatilized ink solvent emissions. A majority of the fountain solution VOMs will also be controlled through the use of an incinerator. While the terminated draft CTG estimates that half of the fountain solution VOM emission occur in the pressroom, the Agency has presented evidence that from 75 to 99.2 percent of the fountain solution VOM emissions occur in the dryer (Ex. 28). Thus, even if higher levels of VOM are used under this control option, a large fraction of the fountain solution VOM emissions will be captured and controlled. This option will provide flexibility in the printing process to accommodate high quality printing jobs while ensuring a high level of control. Because the process involves a high heat dryer that volatilizes the vast majority of fountain solution and ink solvent emissions directly into the dryer vent, no capture efficiency is needed or specified. The Board envisions a situation where the control device is directly connected to receive the dryer vent airstream, thus obviating the need for a capture device. This will also obviate the practical problems of specifying a capture efficiency for this particular application of control technology.

The second alternative control option, Section 215.408(a) (2), will include control of VOM in the fountain solution to eight percent and the installation and operation of a condenser/filter system that captures and removes at least 75 percent of the non-isopropanol organic emissions from the dryer airstream. Condensation recovery systems can effectively remove ink solvents and, possibly, low volatility isopropanol substitutes, but will not effectively control isopropanol. Consequently, it is necessary to reduce VOMs in the fountain solution in order to control their emission to the atmosphere. The record indicates that fountain solution VOM can feasibly be reduced to eight percent without negatively impacting print quality. Once again, no capture efficiency is needed or specified for the condensation control system as it is envisioned that dryer vent emission will be directly routed to the control device. A removal efficiency of 75 percent of non-isopropanol

organic emission from the dryer airstream appears reasonable as nearly all of the organic emissions will be ink solvents and, therefore, recoverable.

As a separate control requirement, proposed Section 215.408(b) will provide an eight percent VOM limitation for fountain solution at facilities located outside the ten counties designated either as non-attainment or part of the Chicago urbanized area. This limitation is technically feasible, according to PII, and will cost industry nothing. The level of control required by Section 215.408(b) is less stringent than RACT and should be easily met by the eight impacted facilities.

No unspecified alternative equivalent control option is provided as it would probably not be federally approvable.

PII has objected to most of the regulations proposed to date as being economically unreasonable and technically infeasible. First, the Board believes that the rules adopted today are technically feasible. Many concepts and levels of control advocated by PII have been incorporated in the rule such as the eight percent limitation on fountain solution VOM and the use of afterburners without a specified capture efficiency. Second, regarding economic reasonableness, the Board believes that the rule provides flexibility in the choice of control options either through incinerators or fountain solution reformulation and a condensation system. Both these options are cost effective and are compatible with existing industry controls (R. 4124-4127). Condensation recovery systems are identified as the most cost effective control option because of the revenue derived from the sale or combustion of recovered solvent (Ex. 71). Reduction of expensive isopropanol and other fountain solution VOMs will reduce costs to printers. The incineration option allows higher VOM fountain solution, if needed for print quality, but still results in effective control. Additionally, there are other factors that support the economic reasonableness of the rule proposed today.

The levels of control specified in the adopted rule are very close to the Agency rule that was analyzed in the EcIS. The EcIS found that, even on a statewide basis, the cost of controls ranged from \$808 to \$1,738 per ton, which was in a reasonable cost effectiveness range. Revised and updated cost estimates for the incinerator control option were \$300 to \$1,300. Revised cost estimates for the condenser/filter option were \$170 to \$450 (Ex. 107). The rule will have a much smaller economic impact than that envisioned by the EcIS. First, the geographic applicability of Section 215.408(a) is limited to ten counties which will exclude the four World Color Press Inc. facilities from add-on control requirements. The EcIS found that World Color Press Inc. would bear 62 percent of the statewide cost of control as a result of add-on control costs. Second, the approximately nine

facilities and sixty-four presses that will be controlled under 251.408(a) are already controlled by either incinerators or condensers (P.C. 82). These controls are believed to be already in place because of smoke and odor regulations. The record indicates that the control options are compatible with control equipment now in use. This will further reduce the cost of regulation from that estimated in the EcIS as initial purchase and installation capital costs will not be incurred.

Calculating emissions and potential emission reductions under the adopted rule involves a number of assumptions. Because of the variability in emission factors and the lack of data on current VOM content of fountain solutions, especially isopropanol substitutes, the emission and emission reduction figures are best estimates. As such, the values are rounded off to two significant figures. Based on data supplied by the PII for major stationary sources in non-attainment areas, it appears that approximately 2400 tons/year of ink oils are used at nine facilities that would be regulated under Section 215.408(a) and (b) (P.C. 82). Depending on the emission factor used, this would result in an emission range of 1,700 tons/year (at 0.70 emission factor) to 1,900 tons/year (at 0.80 emission factor). PII only provided data on IPA usage at these nine facilities. As noted earlier, there are other VOM constituents in fountain solutions other than isopropanol and, according to PII witnesses, there is a trend in the industry towards replacing isopropanol with lower volatility VOMs. Consequently, it is necessary to estimate fountain solution VOM. PII estimated an emission distribution ratio for the entire printing process of 60:40 at current fountain solution VOM concentrations between 15-25 percent (Ex. 24(k)). In other words, at present ink and isopropanol-based fountain solution usage, 60 percent of the VOM emissions are from the fountain solution and 40 percent of the VOM emissions are attributable to the ink solvents (Ex. 24(k), Ex. 71). Based on this ratio and the ink solvent data, the estimated fountain solution VOMs is 2,800 tons/year at a 0.80 emission factor for ink solvents. Combining ink solvent and fountain solution VOM emissions results in estimated total emissions from the nine potentially regulated facilities of 4700 tons/year.

Emission reductions under Section 215.408(a)(1), the incinerator option, are estimated by multiplying the removal efficiency (RE) by the quantity of emissions. The RE for fountain solutions is calculated by multiplying the fraction of the fountain solution VOM presented to the incinerator by the destruction efficiency of that incinerator. Emission factor estimates for the fraction of fountain solution VOM presented to the incinerator, via the dryer, range from 0.5 to 0.99. Multiplying these figures by the 0.90 destruction efficiency of the incinerator results in a RE range of 0.45 to 0.89. Multiplying these REs by the estimated fountain solution VOM usage results in a range of emission reductions of 1,300 tons/year to 3,500 tons/year.

The RE for the ink solvents is calculated by multiplying the emission factor by the destruction efficiency. The RE for the ink solvents is 0.72 at 0.80 emission factor. Multiplying this RE by the total ink solvent usage results in an ink solvent emission reduction of 1,700 tons/year. Combining the reductions in fountain solution VOM and ink solvent emission results in a range of potential emission reductions from 3,000 tons/year to 4,200 tons/year. Actual emission reductions would vary within this range.

Emission reductions under Section 215.408(a)(2), i.e. the fountain solution reformulation and condensation option, are estimated somewhat differently than for 215.408(a)(1). Section 215.408(a)(2) calls for a reduction in fountain solution VOM from current usage levels of 15 to 25 percent down to eight percent. In this circumstance, emission reductions must be estimated through the use of emission distribution ratios. A reduction of fountain solution VOM from 25 percent to eight percent would change the emission distribution ratio of fountain solution to ink solvents from 60:40 to 32:68. A reduction of fountain solution VOM from 15 percent to eight percent would change the emission distribution ratio of fountain solution to ink solvents from 60:40 to 44:56. These ratios can be used in combination with known ink solvent usage to estimate the quantity of VOMs in the fountain solution at an eight percent level. While it is impossible to determine what level fountain solution VOMs are actually presently being used, a range of reductions can be estimated. A reduction from 25 percent to 8 percent VOM in the fountain solution would result in a 68% reduction in VOM usage. This corresponds to a 1,900 tons/year reduction in fountain solution VOM. A reduction from 15 percent to 8 percent VOM in the fountain solution would result in a 47% reduction in VOM usage. This corresponds to a 1300 tons/year reduction in fountain solution VOM.

Ink solvent emission reductions achievable through the use of a condenser/filter are calculated by multiplying the quantity of emissions presented to the control equipment by the RE. The RE for the condenser/filter is determined by multiplying the emission factor of 0.80 by the capture and removal efficiency of the condenser/filter, which is 0.75. The RE is, thus, 0.6. The RE is then multiplied by the total ink solvent usage at the nine facilities of 2,400 tons/year. This results in 1,400 tons/year of ink solvent emission reductions in the condenser/filter. Total emission reductions under Section 215.608(a)(2), which includes both fountain solution VOM reductions and reductions from the condenser/filter option, range from 2,700 tons/year to 3,300 tons/year.

There are eight facilities located in attainment areas (and not considered part of the Chicago urbanized area) that would be subject to Section 215.408(b), the fountain solution VOM

limitation of eight percent. Total organic emissions (fountain solution VOM and ink solvents) from these facilities range from 2,700 to 5200 tons/year (Ex. 71). Assuming the 60:40 distribution between fountain solution VOM and ink solvents when traditional fountain solution is used results in total fountain solution VOM emissions of 1500 to 3100 tons/year. A reduction of fountain solution VOM from 25 percent to eight percent results in removal of 1,100 to 2100 tons/year. A reduction of fountain solution VOM from 15 percent to eight percent results in removal of 750 to 1,500 tons/year. While it is impossible to determine the actual present fountain solution VOM content, these figures provide a reasonable estimated range of reduction.

The estimates of potential organic material emission reductions under the two RACT alternatives, that involve the use of add-on controls, demonstrate that the alternatives are roughly comparable. Because the actual emission reductions at any one facility can only be estimated, it is not possible to demonstrate exact equivalency either in terms of reduced emission or cost. However, the potential emission reductions and costs do appear to be in at least a comparable range.

Comments received from the Agency and USEPA during first notice raised two substantive issues. First, the commentors raised a concern that Section 215.408(a)(1) which requires the use of an incinerator connected to the dryer stack, contains no caps or upper limit on the percentage of VOM in the fountain solution. The commentors recommended a 12 percent cap be imposed. Second, the commentors maintained the cap for fountain solution VOM in Section 215.408(a)(2) should be seven percent rather than eight percent. In the second notice Opinion, dated August 6, 1987, the Board rejected the modification proposed by the Agency and USEPA as they were unsupported by the record. A more complete discussion of the issues raised and rationale of the Board's disposition is found in the August 6, 1987, Opinion in this matter. The rule adopted today is substantively unchanged from that proposed for first notice on April 30, 1987. No comments were received from PII regarding the rule during the comment period.

The Board believes that the adopted rule represents RACT. Fountain solution VOM reduction through reformulation, as required under Section 215.408(a)(2) and (b) are essentially no cost options and, in fact, will save printers money through overall reduction in isopropanol and isopropanol substitutes. The eight percent limit is considered technically feasible by the PII. The add-on control options required under either 215.408(a)(1) (afterburners) or 215.408(a)(2) (condenser/filter) are clearly available control technology, as the record indicates that such controls are already in place at the regulated facilities. Costs for the afterburner option have been estimated in the range of \$300 - \$1300 per ton of VOM removed. Costs for a

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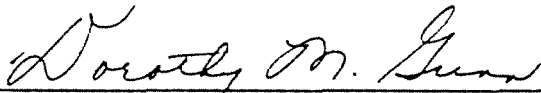
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condenser/filter are estimated in the range of \$170 - \$450 per ton of VOM removed (Ex. 107). These costs are clearly within a reasonable range. The potential emission reductions from today's adopted rule are large when compared with many other RACT industrial categories. The additional emission reductions that will occur due to the attainment area fountain solution VOM reduction are justified by the record. While this level of control is not as stringent as the application of RACT in non-attainment counties, the emission reductions are achieved at essentially no cost. General background ambient HC and ozone levels will be reduced. This will help maintain ozone attainment throughout much of the state and also reduce the quantity of ozone and ozone precursors available for atmospheric transport to non-attainment areas. At least one major facility in Randolph County is contiguous to the East St. Louis Metropolitan ozone non-attainment region. Cost effective controls in such circumstances are, therefore, prudent and justified.

IT IS SO ORDERED

Board Member J. Theodore Meyer concurred.

I, Dorothy M. Gunn, Clerk of the Illinois Pollution Control Board, hereby certify that the above Opinion was adopted on the 14 day of October, 1987, by a vote of 6-0.



Dorothy M. Gunn, Clerk
Illinois Pollution Control Board