Photographic Industry-Generic Scenario for Estimating Occupational Exposures Environmental Releases

Draft

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SUBJECT: Photographic Industry Generic Scenario Draft

ERG collected readily available information that could be used to develop a generic scenario to describe the photographic industry, including information on environmental releases and potential worker exposures. This memorandum presents a summary of current trends in the photographic industry along with descriptions of widely-used processes involved in photographic film and papermaking, photographic film/paper coating, and development of paper and films. Based on information obtained during this preliminary search, this scoping document recommends an approach for the development of a generic scenario for this industry.

Based on readily available information obtained on the photographic industry, it appears that it would be difficult to accurately describe the entire photographic industry in one generic scenario. While the photographic film and paper manufacturing industry is dominated by larger firms such as Konica, Eastman Kodak, and Fuji Film, thousands of companies and sites develop the film or paper. Most recent PMN submissions provide necessary information to complete an IRER for the film or paper coating process, but do not provide sufficient information to estimate environmental releases of and worker exposures to photographic chemicals during the development of the film or paper. Therefore, this scoping document recommends the development of a generic scenario focusing on photographic film and paper development, but at this time does not recommend an update of the current generic scenario covering photographic film and paper coating. ERG suggests naming the recommended generic scenario "The Development of Photographic Film and Paper at Medical and Commercial Facilities".

The recommended generic scenario would track the use of photographic emulsion chemicals (surfactants, anti-foggants, stabilizers, couplers, hardeners, and chemical and spectral sensitizers) throughout the development process. Development of photographic paper and film may take place at commercial one hour photo stands, hospitals, large-scale production facilities (films are shipped to these sites), and in private dark rooms. While the generic scenario may cover releases and exposures at each of these facilities, the scenario would focus on the most likely sites for use, one hour photo stands and hospitals. Process baths used in the developing process typically include: developers, antioxidants, pH-regulating agents, fixing agents, anti-foggants, and stabilizers. The materials used during the developing process and their concentrations depend on the developing method that is used, negative to positive or reversal processes. ERG recommends that further research on the releases and exposures to

photosensitive emulsion chemicals take precedence over chemicals used in developer solutions. The number of workers potentially exposed to emulsion coatings chemicals and the number of sites using these chemicals is greater than that for developers.

A list of the readily available resources found during this preliminary search and a brief description of the information provided is also included. Where information has been taken from a particular source, that source has been provided in parentheses at the end of the sentence.

Industry Background and Process Summary

The photographic process begins by choosing a supporting substrate that photosensitive materials can be applied to, normally film or paper. Film and paper coating supports are manufactured via different processes. At a separate manufacturing site, photosensitive emulsion coatings are formulated in batch vessels. These coatings are then applied to the film or paper substrate via coating hoppers or troughs containing the emulsion; however, it is uncertain wether the coating takes place at the paper manufacturing or coating formulation site. After the film is exposed to capture an image, it is developed at developing sites to create a final image on photographic paper.

Film Making

Two types of films dominate today's photography market, polyester and cellulose triacetate based substrates. Polyester film is used as a support base for photosensitive emulsions in X-ray film, graphic arts film, instant film, professional still film, and original microfilm (SRI). In 1998 the United States produced approximately 619 thousand tons of polyester film; however, Asia is the largest polyester film producing region in the world. Only 25% of the polyester film consumed in the United States is used in the photographic industry. These films are also used for magnetic media, packaging, and electrical/electronic applications.

Polyester films are derived from polyethylene teraphthalate resins (PET) which is produced from the polycondensation of ethylene glycol with dimethyl teraphthalate. During this polymerization reaction, other additives are added to modify or enhance the physical features of the final film products. Slip additives are commonly added during the reaction to give the film a rough surface. This prevents thin film layers from sticking together during storage. Color modifiers are also added to the batch. An advantage of polyester film over cellulose triacetate film is that no other additives, such as plasticizers, are needed in the preparation of this product. This cuts production costs as well as the potential for chemical releases.

After the polymerization reaction is completed, the PET is extruded into a rod-like shape. These rods are stretched into a thin-layer film between 5 and 7 millimeters in thickness. Stretching the PET is fundamental to producing many of the desired end use properties of the film (i.e, thickness, toughness, crystallinity). Most polyester film is produced using a cast-center

stretching process. During this process, PET rods are stretched longitudinally along the length of the polyester sample. Afterwards, a lateral strain is applied to the rods to produce a thin film sheet. In 1994, Dupont and Bruckner GmbH designed a bi-axial stretching device which stretched the film along both axes simultaneously (SRI). Many film manufacturers have begun to use a bubble blown process to stretch PET rods. This process generates high speed air to expand the PET in a bubble shape from which the film is later cut.

Overall, the releases associated with polyester film manufacturing are minimal. The total non-reusable scrap generated from this process ranges from 1 to 5% of the PET production volume (SRI). Solid PET scrap from the stretching process can be remelted and extruded for further use.

Cellulose triacetate (CA) film shares the film market with polyester films. All amateur photographic film used for negatives for prints, instant film, and color transparencies are CA based (SRI). This cellulosic film dominated the market share until recently when polyester films were created. Polyester films are more durable and provide a tougher support for photosensitive emulsions, but are more expensive than CA based films. CA films are produced through two methods: sheet extrusion or casting. In 2002, the United States consumed 31 million pounds of cellulose ester film and sheet (SRI). Approximately 77% of this film was extruded as a film sheet.

The film industry continues to show marginal growth rates. Over the next four years, consumption of polyester and CA films is expected to grow at a rate of 0.5% (SRI). This rate will continue to diminish as digital imagining and digital photography increases in popularity. The use of film shows higher annual growth rates in some foreign countries as digital imaging and digital photography are not yet a common technology.

Photographic Papermaking

Paper is another commonly used support for photosensitive emulsions. Most photographic paper is derived from wood pulps. The pulps used in photographic paper manufacturing must be highly purified to ensure permanent brightness and to enhance the strength of the final product (Neblettes). Photographic paper is different from commercial paper because it cannot include chemicals which might affect or interact with the photosensitive layers that will be applied on top of the substrate. Many paper making processes use chemicals to increase the resistance to penetration of photosensitive coating layers and developer solutions in later processing. These chemicals may be incorporated into the pulp or coated unto the final paper product.

The papermaking process can be broken down into the following major operations: preparation of stock for papermaking, paper manufacture “wet end” operations, and paper manufacture “dry end” operations. Although there are a number of types of papermaking

machines, the concept behind each is similar (Neblettes). The Fourdrinier paper machine is commonly used to manufacture the photographic paper support. The releases and exposures associated with papermaking are discussed in the *Draft CEB Generic Scenario for Papermaking*. The generic scenario states that more than 85% of papermaking chemicals are released to wastewater. Exposures associated with the transfer of papermaking chemicals and mists generated from the papermaking machine are also quantified in this scenario.

Photographic Film/Paper Coating Materials

Both film and photographic paper are coated with light-sensitive materials. The preparation of light-sensitive photographic materials begins with the growth of silver halide grains. Silver halide nuclei originate from the introduction of silver and halide ions derived from silver nitrate solutions and alkali halide salts, respectively (Othmer). These crystals are usually grown in an aqueous environment which keep the individual silver halide nuclei separated from one another. A gelatin material is added to the reaction vessel to prevent nuclei clumping and to maintain a uniform concentration of crystal growth. The final products of this precipitation are a silver halide dispersion in the gelatin along with byproduct potassium, sodium, and nitrate counterions (Othmer).

Impurities are often added to the silver halide and gelatin emulsion to impart various photographic properties to the mixture. These additives are often incorporated into the emulsion in very small concentrations, often the ppm or ppb range (Othmer). The following is a list of dopants used in the photographic industry and their specific function:

- Surfactants - Added to facilitate uniform coating of the emulsion on the film or paper;
- Antifoggants - Added to improve the signal to noise performance of the photographic film or paper;
- Stabilizers - Added to improve the stability of the emulsion over time;
- Couplers - Organic compounds added to allow for the production colored images; and
- Hardeners - Added to produce thermally stable gelatin matrices

Other materials have been found to effect the light adsorption, ionic and electronic properties, and catalytic properties of silver halide crystals.

Prior to the addition of chemicals that enhance the photographic sensitivity of the silver halide crystals, the emulsion is washed to remove the byproduct counterions. Water is used to remove the potassium, sodium, and nitrate counterions (Othmer). The emulsion product is then refrigerated until it is used to coat the photographic paper of film.

The photographic sensitivity of silver halide crystals diminishes greatly above 500 nanometers which does not include all colors visible to the human eye. Spectral sensitization is used to extend the wavelength sensitivity of the crystals beyond 700 nanometers (red colors). Typical spectral sensitizing chemicals include amidinium ions and carboxyl ions (Othmer). Upon completion of spectral sensitization, the emulsion undergoes chemical sensitization. Chemical sensitizers such as thiorurea or gold thiocyanate are added to the emulsion to increase the light sensitivity of the crystal grains. These chemicals are added as the emulsion is melted prior to coating the support.

Coating the Photographic Paper/Film

The final step in preparing the photographic film/ paper is coating the support with the emulsion. The emulsion coating must be applied uniformly across the support (Othmer). As mentioned above, the emulsion is melted prior to coating and spectral and chemical sensitizers are added to the mixture. By melting and mixing the emulsion, uniform concentration of all chemicals is achieved within the mixture.

Due to the light-sensitive nature of materials within the emulsion, all coating operations are performed in near or total darkness. Most of the coating application techniques use a flexible support which is transported on rollers past a coating station where the emulsion is delivered (Othmer). The method of coating application varies from site to site. Some companies have coating hoppers from which the liquid emulsion is delivered to the moving coating support by pumps or gravity flow. Another way that emulsions are applied to papers is by the use of troughs containing the liquid coating. The paper or film is moved over the trough where the emulsion is contained and the coating is applied to the paper surface. As the coating rises from the trough, excess emulsion is removed by air jets or a knife-edge to ensure uniformity across the support surface.

After the coating has been applied to the support, it is cooled to harden the emulsion coating. Finally, the paper or film is dried to remove excess water. After drying the emulsion thickness is reduced by 90% of the original thickness due to the evaporated water (Othmer).

The current generic scenario for photographic paper making indicates that worker exposure to any chemicals during the coating application is limited to transferring chemicals because the coating is applied in a closed system (GS). Information found from readily available sources indicates that emulsions are supplied to the coating support via hoppers or coating troughs. This information does not mention the spray application of the emulsion coatings to the support, but does not discount it as a viable option.

Potential releases from the coating process include the disposal excess emulsion that is removed from the support by knife-edge or air jets and spent coating materials held in coating

troughs. No information quantifying the magnitude of these releases or the media to which these wastes are released to was found in readily available sources.

Developing Papers and Films

When a picture is taken the silver halide crystals become exposed; however, the exposure of these crystals does not produce visible images on the film or paper. Developer solutions are used to promote the conversion of the silver halide that has been exposed to light into silver centers visible to the unaided eye (Othmer). There are two basic types of photographic processes that are used to develop photographic material: negative/positive processes and reversal processes (OECD). Both of these processes are used to develop black-and-white and color film. Negative/positive processes first provide a negative that is later copied unto a positive material, normally photographic paper. Reversal development processes provide a positive image in a direct manner; a final product is formed as a result of the development process. Photographers normally choose film that is developed by the negative/positive process if significant editing or special effects will be added to the final image. Each of these processes is described in more detail below.

Black and White Film Development - Negative to Positive Process

The steps of negative/positive development are slightly different for black-and-white film and color film. Black-and-white film requires fewer processing steps to produce a final product. The following steps are standard for black-and-white developing:

- Developing or reducing: The silver halide crystals that are exposed to light are converted to silver ions as the picture is being taken. The developer reduces these silver ions into metallic silver (How). The developer solution is oxidized upon reaction with the silver ions. All unexposed regions of the film remain as silver halide within the emulsion.
- Stop bath or washing: Black-and-white films use a water wash to stop the development process (How). A stop bath with other chemicals may be used as well. The conversion of silver ions into pure metallic silver is halted by this wash.
- Fixing: The fixing process extracts the unexposed silver halide from the emulsion coating on the film or paper. The fixer solution dissolves the silver halide leaving the silver image on the film or paper behind.
- Final wash: In the final step, the film is washed with water to remove all the processing chemicals. The film strip is dried, and the individual exposures are cut into negatives (How).

Color Film Development - Negative to Positive Process

The development of color film requires more steps than those require for black-and-white film. Like black-and-white film and paper development, color photographic processing utilizes a developing bath to reduce the exposed silver ions to metallic silver. Color photographic substrates are then sent to a stop bath. Usually a solution of acetic acid stops the development process (Neblettes); however, a water rinse could also be used to stop the conversion of silver ions to metallic silver. The fixing process for color film development is identical to and serves the same purpose as that in black-and-white development. After the fixing bath black-and-white film development is nearly completed; however, color film requires additional processing.

During the developing process, the developer solution oxidizes as it reacts with the exposed silver halide crystals. The oxidized developer solution is used in additional processing that makes the color film development process more extensive than that used for black-and-white:

- Chromagenic developing: As discussed earlier, color couplers are often added to the silver halide and gelatin emulsion during the coating formulation process. The oxidized developer solution reacts with the color coupler, adding color to the negative. The colors introduced to the film or paper depend on how the silver halide grains were spectrally sensitized earlier (How).
- Bleaching: Unlike black-and-white film processing, the silver image is removed from the emulsion using a bleaching solution. Bleaching solutions typically contain oxidizers like ammonium ferric (III)-EDTA to reoxidize the metallic silver into silver ions (OECD).

The negatives produced from black-and-white and color processes are then projected onto a positive material, usually photographic paper. Light is passed through the negatives, which acts as a filter media, and exposes silver halide crystals on the larger photographic paper. The positive is then developed using one of the methods discussed above.

Reversal Process

Reversal film development is a method of producing a positive image directly on the exposed film. During the reversal process, the film is first developed as a negative and the exposed silver halide is converted to metallic silver. The negative is then bleached to remove the

developed silver image, leaving the undeveloped silver halide emulsion on the coating support. Unlike negative to positive film processing, the reversal process does not use a fixer bath to remove the undeveloped silver halide. Instead, the film is reintroduced to light, exposing the remaining the silver halide crystals. Finally, the film is sent to a second developer where the silver halide is converted to a positive image.

Releases from the Development Process

Wastes generated during the photographic paper or film development process include: spent developer solutions, scrap photographic paper and film, and silver generated during development and fixation. Once photographic paper is processed, silver is either retained in the film and paper emulsion or transferred to development solutions. The silver that remains in photographic processing solutions is recovered using on-site recovery equipment or sent off-site for recovery (Kodak). Undeveloped film scraps are often soaked in spent fixer solutions to remove unexposed silver halide from the film. Refiners recover silver from photographic film scrap in two ways. Most silver recovery operations do not attempt to recover the paper base (Kodak). When film base recycling is not performed, photographic film scraps are heated to remove organic compounds and water. The film base is then introduced into a smelting process where the metallic silver is separated. Sometimes the photographic paper and film is recovered by washing the paper to remove the silver-bearing emulsion. The emulsion is then introduced into a smelting process. Overall, about 95% of all photochemical processing baths in Europe are sent for silver recovery (OECD).

While some photographic processing chemicals may evaporate during the silver recovery process, the majority of these materials are released to water. Throughout the development process, the photographic chemicals are released to water during film rinsing (OECD). The amount of the chemical that is released to the environment depends on the placement of the water washes along the process line and the carry over rate of the chemical to different processing baths. These releases occur continuously throughout the photographic development process; however, the release from water rinses is not the largest release from these processes. After extended use, the photochemicals used in development baths must be replaced. These baths are often sent to special disposal companies where the waste is released to water. In some European countries (e.g., the Netherlands), the return rate of used photo baths to disposal companies is as high as 90 percent. In other European countries this rate is much lower. Sometimes more than 80% of the used baths are emitted directly into the environment (OECD).

PMN Database Search

To help identify and narrow the scope of the generic scenario, ERG conducted a search of the PMN database. ERG identified approximately 250 photographic chemicals were received since 1995. Table 1 presents a breakdown of these submissions by year. Approximately 15% of these submissions were components of developing solutions, 35% were film coatings additives,

25% were paper coating additives, and 25% were film or paper coating additives. From these cases 30 IRERs were reviewed for specific information (5 developing solutions, 14 film coatings, 8 paper coatings, and 3 film or paper coatings). Highlights from this review are as follows:

- All were non-volatile (VP > 0.001 torr);
- Almost all of the film/paper coating cases required an assessment for film or paper coating;
- 17 of the 25 film/paper coating cases were coated onto film or paper by the submitter. Submitter estimates for use rate and number of workers were used. The only occasional reference to past cases was for media of release;
- 18 of the 25 film/paper coating cases assessed exposures and releases from development (all 5 of the developing solution cases also did). The 7 cases that did not generally assumed that the PMN was bound to the paper or film, or that development was not required based on a past case;
- Of the 18 film/paper cases assessing development, 5 cases were medical x-ray film. The remainder assumed commercial/one-hour photo shops. (Note that one company submitted 8 PMNs for x-ray film chemicals in 2001, potentially affecting this data).
- All the developing solutions also assumed commercial/one-hour photo shops.
- No large scale production facilities or private-dark room assessments were made.
- The number of commercial/one-hour photo sites ranged from 220 to 2500. Almost all of the assessments for the development use could be traced back to a few past cases.
- Inhalation exposure during coating or developing operations was assume to be negligible.

Table 1. Volume of PMN Submissions by Fiscal Year*

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	To 5/2004	Total
# of Submissions	39	31	34	26	19	18	28	21	25	8	249

*Based on a PMN database search of the following key words: photographic, film, photosensive emulsion, Kodak, Konica, and Fuji.

Recommendations for Further Work

Based on the readily available information obtained on the photographic industry, it appears that it would be difficult to accurately describe the entire industry in one generic scenario. Photographic paper making, coating, and development are essential steps in the overall process; however, the creation of a document encompassing each of these intricate processes

would generate a scope that is too large for a single generic scenario. The physical processing steps in each of the operations (i.e., equipment, worker activities, etc) lack the similarities to concisely classify the photographic industry. The manufacturing of a coating substrate involves polymer extrusion to form a film or the use of a Fourdrinier machine to make the paper, while emulsion coating and film development involve the addition or removal of an entirely different subset of chemicals from the paper surface.

ERG proposes a generic scenario for the development of photographic film and paper coatings after the film has been exposed. Releases associated with the film and paper making process are of importance, a draft generic scenario already exists for making paper substrates. The only difference between copier paper and photographic grade paper is that photographic paper must not contain chemicals that will interact with the photosensitive coatings. While a generic scenario for film development (polymer extrusion) does not exist, the total non-reusable scrap generated from this process ranges from 1 to 5% of the polymer use rate (SRI), and could be covered in the generic scenarios for plastic compounding and converting.

Based on ERG's preliminary research, the application of photosensitive chemicals to the support is performed through a simple coating operation where several emulsion layers are coated onto the substrate one at a time, or the emulsions are mixed together and applied as one single coating (GS). Worker exposure to any chemicals during the coating application is limited to transferring chemicals to the emulsion formulation vessel as the coating is applied in a closed system (GS). ERG did not find any information in readily available sources to quantify the amount of emulsion coating that actually adheres to the paper and whether waste coatings are recycled for further use or released to the environment. The current generic scenario for photographic papermaking states that some unused coated paper is often recycled where the coatings are removed and released to wastewater from the deinking process; however, a quantitative estimate for this release is still unavailable. While the generic scenario covering the application of photosensitive could be updated, recent PMN submissions generally contain the required information for IRER completion.

The coating and developing operations are similar in that the same set of chemicals applied to the coating support may be removed during the photographic development process; however, the processes are very different. The chemicals present in the photographic coating may be removed during the development process. As mentioned above, the development of film involves the transfer of the coating substrate to various baths where separate reactions take place. During the development process, exposed silver halide is converted to metallic silver. Depending on the type of development that is used, negative to positive or reversal, silver halide crystals or metallic silver may be removed from the emulsion using various chemicals. Information quantifying the amount of photographic coating chemicals, if any, that precipitate from the emulsion during the development process was not found readily available sources. Development of photographic paper and film may take place at commercial one hour photo stands, hospitals, large-scale production facilities (films are shipped to these sites), and in private

dark rooms. While the generic scenario may cover releases and exposures at each of these facilities, the scenario would focus on the most likely sites for use, one hour photo stands and hospitals. Users of the scenario would be able to chose between the facilities; however, a default option would be identified if the end use is unknown (most recent PMN assumed commercial one hour photo stands if the submission did not say the chemical was for x-ray film).

While information regarding the releases and exposures of coating chemicals during the development process needs further research, information regarding the releases of development solution chemicals is available. The Organisation for Economic Co-operation and Development drafted an Emission Scenario Document dated February 2002 that quantifies releases of development chemicals to water. The scenario states that photographic development solutions are released to water from the rinsing of films between baths and spent development chemicals. These baths are either sent to special disposal companies where the waste is released to water or emitted directly into the environment. ERG recommends the use of the Emission Scenario Document as it presents release estimation parameters for various chemicals used in all types of development processes.

As discussed above, the development process generates a considerable amount of silver as a waste product. Overall, 95% of all photo processing baths are sent for desilvering. ERG recommends that the generic scenario address the releases and exposures attributed to the silver recovering process for both photo processing solutions and scrap paper from the emulsion application process. The silver recovery process often involves the addition of heat to the photographic solution or paper to remove volatile photographic chemicals. The magnitude of releases associated with this process would need to be investigated.

Data quantifying worker exposures during the photographic coating and development process was not found during the preliminary research. An article entitled *"Safe Handling of Photographic Processing Chemicals"* developed by Kodak addresses the personal protective equipment worn by photo processing workers but does not discuss individual worker activities. Monitoring data for exposures associated with coating and development would be beneficial in the development of this scenario

Several companies (Kodak, Konica, Fuji Film) and the Trade Association for Pulp and Paper Industry have collected data on the photographic industry and have published reports that might be useful in the development of a generic scenario. None of these reports are available free of charge. ERG feels that the sources listed in the next section adequately describe the photographic industry; however, more information regarding the specific releases and exposures associated with coatings and development is required. These pay sites may provide the information needed to draft a more accurate scenario.

Readily Available Resources Searched

ERG performed a literature search for articles in journals relating to the photographic industry. The search performed and the results are provided in Appendix A of this memorandum. ERG also searched readily available and Internet resources for information on the various processing steps used in the photographic industry. Most of the information used to generate the process description listed above was taken from sources found in the Chemical Engineering Branch library. Most of the internet sources that were found are not free of charge and are predominately limited to articles published by film production companies. The following list of resources does not go into great detail about the specific contents of each article as most of the information found during this search is presented in the process description above.

Internet and CEB Library Sources:

How Stuff Works, Website: http://www.howstuffworks.com/film5.htm , "How Photographic Film Works".
This website describes the differences between color and black-and-white film emulsions. The site provides basic information about how film is developed and could be used for process description information regarding film development.

Ilford Application Sheet Reversal Processing, Website:
http://www.ilford.com/html/us_english/pdf/reversalproc.pdf
This website provides a process description of reversal development.

Kirk-Othmer Encyclopedia of Chemical Technology, "Photography", 4th ed., 1991.
This encyclopedia provides a detailed description of the creation of the photosensitive emulsion, its application to the coating support, and how the photographic image is developed. The document provides specific chemicals used in the photographic industry along with a market summary of the large role players in the photographic chemical industry.

Neblettes Handbook of Photography and Reprography, Chapter 7.
This book provides a detailed overview of the entire photographic industry. Chapter 7 describes the development of photographic film and paper. This could be useful in describing the process as well as the chemicals used to develop photographs.
Organisation for Economic Co-operation and Development (OECD) Emission Scenario Documents. ERG checked the OECD Emission Scenario Document web site (http://www.oecd.org/EN/document/0,,EN-document-522-14-no-21-8249-522,00.html) and the *OECD Database on Use and Releases of Chemicals* (http://appli1.oecd.org/ehs/urchem.nsf/). ERG also checked the *European Chemical Bureau* and the *University of Dortmund* web sites (via the "Useful Links" listed on the *OECD Emission Scenario Document* web page). An Emission Scenario Document on the Photographic Industry was found which discusses the development of film or paper by negative to positive processes. This scenario estimates releases to water for various chemicals used in the developing process and will be useful in developing a release model.

Reversal Processing, Website: http://members.iinet.net.au/~forbes/reversal.html.
This website describes the reversal processing development procedure. Specific details about how reversal development works and chemicals used in this process are presented by this website.

U.S. Census Bureau, *1997 Economic Census, Photographic Film, Paper, Plate and Chemical Manufacturing,* http://www.census.gov/epcd/www/econ97.html. This report contains 1997 statistics on the number of establishments involved in photographic material manufacturing as well as annual sales and employees.

Other Economic Census Reports, as well as County Business Patterns reports on the specific industry sector(e.g., Photographic film, paper, plate and chemical mfg. NAICS, 325992) could be used to gather information on the employee size class at each site.

SRI Handbook, "Plastics"
This source discusses the manufacturing processes for polyester and cellulose triacetate film. It also presents an in depth discussion of the film manufacturing market and where it will be in the coming years.

Film Manufacturers:

Environment Information From Kodak, Website:
http://www.kodak.ca/global/en/corp/environment/kes/pubs/pdfs/J98A.pdf;jsessionid=UGFILO2EWQIRBQHIO3JHWGQ, "Safe Handling of Photographic Processing Chemicals".
This website presents some of the personal protective equipment and precautions taken by workers in the photographic industry.

Environment Information from Kodak, Website:
http://www.kodak.ca/global/en/corp/environment/kes/pubs/pdfs/J210.pdf;jsessionid=UGFILO2EWQIRBQHIO3JHWGQ, "Sources of Silver in Photographic Processing Facilities"
This article discusses the silver recovery process from spent developer solutions as well as scrap film. The article presents a method for calculating the amount of silver that may be recovered from various media.

The Fuji Film Environmental Report, Website:
http://home.fujifilm.com/info/env/indexe.html?nav=3
This site presents Fuji's annual environmental reports from 2000 to 2002. These reports discuss the actions that Fuji film is taking towards improving environmental performance. It includes a discussion of control technologies that presents the cost of the technology as well as its pollution reduction potential.

Kodak Environmental Services, Website:
http://www.kodak.ca/US/en/corp/environment/kes/index.jhtml
This is Kodak's environmental website. It presents many publications on waste management and silver management and Kodak facilities. Many of this articles are available for a small fee.

Other Chemical Engineering Branch Generic Scenarios:

Draft Generic Scenario for Papermaking, ERG, Inc., September 2002.
This document is a draft generic scenario which addresses the releases and exposures associated with paper making. It could be referenced or used if the generic scenario were developed to cover the manufacture of a supporting media (paper).

Generic Scenario for the Manufacture of Photographic Paper/Film, CEB, Date unknown.
This is the current CEB generic scenario for the photographic industry. It could be used as a reference for generating a more recent draft.

Trade Associations:

Pulp and Paper Industry, http://www.tappi.org
This website is contains a large amount of information on the pulp and paper industry. It contains information on products and suppliers, newsletters, trade publications, and market research reports. The site has specific links to environmental concerns associated with paper making, and also has a link dedicated to paper coatings. All publications on this site require a fee to download but may be useful in obtaining exposure and release data.

Technical Contacts:

ERG has technical contacts who work for Eastman Kodak Company that might be used in generic scenario development and review. Carol Fisher is a CIH who works for Kodak at their Rochester, NY facility. Her phone number is 716-588-6488.