



Project Summary

Paper Production and Processing—Occupational Exposure and Environmental Release Study

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This report presents an analysis of chemicals and processes used during the production and processing of paper and paper goods with emphasis on the workplace exposure and environmental release of chemicals from these operations. Reviews of chemical substances in the report are intended for use in developing realistic exposure and release scenarios associated with the review of new chemical substances used in the industry.

In this report, a description of the industry is presented along with profiles of the various process subcategories occurring in the industry. A literature search and discussions with knowledgeable persons in the industry during the development of the report have been aimed at developing process descriptions that address occupational exposures to workers, as well as information on the concentration of the release of chemicals to the environment. Process characteristics for each study area, including raw materials and chemicals used, are presented along with the description of chemicals in wastestreams and other effluent characteristics. Discussion of waste control and treatment technologies used throughout the industry are also presented. The sources, effects and control of worker exposure to chemicals are described on an industry-wide basis. Specific case studies have also been reviewed to address detail information on occupational exposures to workers (including the number of workers involved, duration of exposure, and workplace concentrations).

This Project Summary was developed by EPA's Industrial Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The full report presents the results of a study to characterize the chemicals and processes used during the production of paper and paper goods, with emphasis on work place exposure and environmental release from these operations. This information will assist in the U.S. Environmental Protection Agency's (EPA's) review of Premanufacture Notices (PMN) under the Toxic Substances Control Act (PL94-469). PMN review includes a review of exposure to humans and to the environment during the manufacturing and processing of chemicals.

For this study, the pulp and paper industry has been described in terms of this industry's major processing technologies. This division of technologies is based on the definition of the paper industry as presented in recent EPA studies to develop effluent limitation guidelines and new source performance standards, and to analyze related economic impacts. For this study, subcategories established by EPA have been further grouped into study areas best suited to the organization of the investigation of process and waste chemicals.

General crewing and exposure patterns in each study area were

developed during this study from a National Institute for Occupational Safety and Health (NIOSH) project conducted to survey, evaluate and document worker exposure to toxic chemicals and harmful physical stresses and related controls to exposure used in the pulp and paper industry. Detailed exposure scenarios were also developed during this study from case studies which review the most documented occurrences of worker exposures to specific chemicals and associated processes. These exposure scenarios provide detailed information on the process characteristics, number of workers and their activities associated with the process and associated chemicals and the concentrations of these chemicals that are likely to occur in the work place during operator activities. Since the case studies presented may serve to supplement the approach taken to establish general crewing and exposure patterns, the reader is often referred to appropriate case studies during discussions on the development of general crewing and exposure patterns.

Additional information was obtained from NIOSH and the Occupational Safety and Health Administration (OSHA) for a broad review of the sources and extent to which workers are exposed to specific chemicals. The review includes a listing of known carcinogens to which workers may be exposed and information on accidents and fatalities due to chemical hazards and acute exposures as well as a description of human factors contributing to such chemical hazards.

Of the various sources of data used to identify process and waste chemicals, the most comprehensive is the NIOSH National Occupational Hazard Survey (NOHS) database for pulp and paper mills. To establish this database, NIOSH made visits to many facilities throughout the industry where over 800 chemical agents were identified and related to the various production and manufacturing operations and associated worker occupations.

Each chemical identified during this project is presented in the Chemical Profiles (Appendix A of the full report) along with pertinent information summarizing discussions in the text as well as other information which characterizes the chemical. This information includes its occurrence in the industry as a use or waste chemical, its description and physical properties, permissible air and water concentrations, synonyms and health effects and safety data for those chemicals known to be

hazardous to workers. For many of these chemicals, additional discussion on their occurrence throughout the industry and/or health effects is presented in the main body of the text.

To acquaint the reader with general aspects of the pulp and paper industry, the full report presents a brief overview of this industry's technology, production, economics and projected growth, and presents a definition of product sector divisions which are based on grade descriptions defined by the American Paper Institute.

Discussion

In the full report, an industry description is presented in Section 3 which consists of a brief overview of the pulp and paper industry's technology, production, economics and projected growth. An operations analysis is presented in Sections 4 and 5 for pulping and papermaking, respectively. These analyses include a description of process equipment, raw materials, and process chemicals, including water consumption and other operating characteristics. The analyses include a description of the environmental release of chemical pollutants including an identification of chemical by-products and effluent characteristics. Occupational exposure is discussed in Section 6 for the sources, effects and control of exposure on an industry-wide basis. In addition, a review of previous case studies and general crewing and exposure patterns investigates specific occupational exposure problems. In Appendix A, chemical profiles are presented for process and waste chemical species identified in Sections 4, 5, and 6. In Appendix B, process control measures used to reduce waste loads and improve process efficiencies are discussed. In Appendix C, specific waste treatment technologies used to treat 'end of the pipe' effluents are discussed. A copy of OSHA regulations governing pulp and paper mills (29 CFR 1910.261) is presented in Appendix D. The full report also includes a glossary of terms commonly used throughout the text.

For many papermaking process and waste chemicals, a qualitative and quantitative description of their occurrence throughout the industry is presented in the main body of the text and is based on the nature and limitations of information made available in the literature. Each chemical identified during this research is again presented in the Chemical Profiles (Appendix A of the full report) along with

pertinent information summarizing discussions in the text as well as other information which characterizes the chemical. In Appendix A of the full report and throughout the text, environmental and toxicity data are not emphasized; rather, scientific criteria from which impacts can be determined are emphasized. For each chemical in Appendix A of the full report, available data have been used to profile a chemical's occurrence in the industry as a use or waste chemical, its description and physical properties, permissible air and water concentrations, and synonyms. For those chemical species known to be hazardous to workers, additional items of information profiled include symptoms, target organs, routes of entry, protective equipment, respirator requirements, first aid and medical surveillance, as well as any appropriate information on leaks, spills and waste disposal.

For many chemicals identified as significant in terms of occupational exposure, additional discussion of their health effects to workers is presented in Section 6 of the full report. The selection of chemicals for which this additional discussion is presented is based on several criteria. Many of these chemicals may be considered potential hazards because of their known toxic effects and the existence of Federal standards limiting work place exposure, including recommended NIOSH and American Conference of Governmental Industrial Hygienists (ACGIH) exposure levels. The health effects of other chemicals are discussed because of their wide-spread occurrence throughout industry in general, and because of the resulting actual or anticipated chronic worker exposure. Some of these chemicals may not produce specific toxic effects but may be considered potentially hazardous due to their ability to produce allergic reactions or due to their possible presence in the workplace as respirable dusts. In the full report, Section 6 discussions are, therefore, intended to expound the identification of health effects of selected chemical agents presented in Appendix A.

To supplement the development of general crewing and exposure patterns, detailed exposure scenarios were developed during this study from case studies which review the most documented occurrences of worker exposures to specific chemicals and associated processes. The case studies are based on Health Hazard Evaluation (HHE) reports developed by NIOSH which were

performed following written requests by employers or employee representatives to NIOSH to investigate specific occupational exposure problems. The HHE investigations are aimed at components of processes suspected of localized impacts to workers. One such HHE, for example, addresses worker exposure hazards at the paper coating preparation station of a printing paper production process. The general crewing and exposure patterns and case studies provide detailed information on the process characteristics, number of workers and their activities associated with the process and associated chemicals and the concentrations of these chemicals that are likely to occur in the workplace during operator activities. Environmental monitoring data is often used to quantify the findings. In addition, the use or misuse of protective equipment, engineering controls and procedures typically used to limit exposure are described. Most of the case studies include medical histories of worker health problems associated with each process.

Since the detailed exposure scenarios developed in this study account for only segments of the paper industry, additional information has been obtained from NIOSH and OSHA for a broad review of the sources and extent to which workers are exposed to specific chemicals and other significant material agents. This broad review includes a listing of known carcinogens to which workers may be exposed and the identification of specific occupations involving exposure to these chemicals. A broad review of accidents and fatalities due to chemical hazards and acute exposures is also derived from NIOSH and OSHA literature and includes a description of human factors contributing to such chemical hazards.

In the full report, specific aspects of the environmental release of chemicals are addressed in discussions on occupational exposure (Section 6). A general description of the environmental release of chemicals is presented in Sections 4 and 5 in terms of the paper industry's major processing technologies. This division of technologies is based on the definition of the paper industry as presented in recent EPA studies to develop effluent limitation guidelines and new source performance standards, and to analyze related economic impacts. These studies are based on the process subcategories of the pulp, paper and paperboard industry as established in 40

CFR, Part 430, by grouping mills which employ similar production and process techniques. Such a grouping has been established so that EPA can develop uniform national effluent limitations and standards which would affect similar mills in a similar fashion in terms of modifications required and costs incurred. For this study, subcategories established by EPA have been further grouped into study areas best suited to the organization of this study's investigation of process and waste chemicals. To make such a grouping, attention has been given to similarities and dissimilarities in process components (stages) occurring throughout the various subcategories. In this regard, consideration has been given to significant variations in materials used, wastes created and other process characteristics.

For each study area, a generic process flow diagram has been developed to illustrate overall process characteristics. With each flow diagram, a set of tables has been developed to characterize process and waste chemicals and materials, effluent conditions and process control technologies used throughout the process. All process components listed within the prescribed formats of these tables are shown on the flow diagram in the full report. The generic flow diagram and corresponding table sets serve to develop a context in which detailed profiles of the product processes are illustrated.

For each study area, internal process control technologies are itemized and illustrated on the process flow diagram. These technologies which are also discussed in Appendix B of the full report, are commonly employed within the industry to control pulping, bleaching, washing, liquor recovery and papermaking operations. Their occurrences and general effectiveness as described in this report have been identified in various effluent limitations development documents.

For each study area, the investigation of effluent BOD, TSS, and other conventional, nonconventional, toxic, and priority pollutants occurring as multimedia emissions, includes efforts to quantify these materials in process waste streams. A discussion of effluent characteristics is presented to illustrate the relative and qualitative relationship between BOD and TSS and the occurrences of associated waste chemicals. Chemicals are listed which are generated (pollutants, by-products) by the process, as well as those which are

used by the process. The effectiveness of external waste treatment to reduce the final concentrations of chemicals in effluent streams is addressed in the full report (Sections 4 and 5 and Appendix C). Appendix C discusses effluent treatment technologies and describes the many types of wastewater treatment systems used throughout the industry and presents examples of existing commercial applications as well as pilot-scale case studies.

Conclusions and Recommendations

Of the many chemicals used and released during pulp and paper processing, some are important in terms of both occupational exposure (as process and waste chemicals) and environmental release (emission, effluent and solid waste chemicals). However, many chemicals are known to be significant in only one of these areas.

Among the chemicals released to the environment, many toxic, nonconventional and priority pollutants have been identified in pulp and paper industry discharge waters. Their occurrences throughout the industry have been reviewed in the full report. This review includes discussions illustrating the relationship between these pollutants and conventional pollutants (Biological Oxygen Demand, Total Suspended Solids and pH) and water usage. These discussions are centered on data obtained from previous effluent guidelines development studies designed to verify and quantify the presence of conventional, nonconventional, toxic, and priority chemical pollutants in industry discharges. Data (when available) are expressed in ranges to account for variations in process conditions.

Information obtained from the industry broad review of chemicals and associated processes indicates that the most significant occupational exposure problems associated with papermaking chemicals include fatal exposures to high concentrations of hydrogen sulfide and other sulfur compound emissions, as well as carbon monoxide and chlorine exposures. OSHA sampling tests have revealed that these chemicals frequently exceed OSHA standards, thus contributing to problems of short-term, accidental and acute exposure. Regarding long-term illness in pulp and paper mill workers, more information is needed due to a lack of relevant epidemiologic studies. In addition, plant visits are essential to assess quantitatively the

uses and hazards of the numerous chemical additives used throughout the industry.

Although the literature discusses general categories of additives, the problem is to determine which are in wide-spread use and, of those in wide-spread use, which are toxic under the conditions of use. In short, there is a surprising lack of quantitative information on the use and exposure effects of additives throughout the industry.

Moreover, the distinction is seldom made between the quantity of such materials applied and the quantity present in the final product. Most additives are furnished to the mills by chemical suppliers who have technical service representatives to advise on the proper methods for handling and application. Since each pulp furnish and each paper machine has individual characteristics that must be understood for best results, the quantity of additives used may be quite variable. Extensive, additional study is therefore required to quantify the ranges of usage and describe the process variations contributing to such ranges for the many additives used throughout the industry.

For the vast majority of chemicals, information on work place emission sources, worker exposure and other characteristics is scarce. Needs to gather such data have been tempered by the fact that many chemicals occur in such small quantities that worker exposure problems have not been seriously considered.

Regarding the development of generalized job descriptions and crewing patterns, it should be noted that wide variations in these categories create job descriptions that are generally not comparable, since mills combine work tasks depending on equipment layout,

automation and complexity. Hence, the number of required workers and the tasks they perform vary considerably throughout the industry. Occupational exposure characteristics for each machine type might therefore be most accurately determined on a plant by plant basis for each paper type. The study area analyses presented in Sections 4 and 5 of the full report include discussions and illustrations of equipment, machinery and process operations that can serve as a guide to assess the need for further work to characterize occupational exposure in operations not addressed fully by the development of general crewing and exposure patterns, or in the case studies of specific occupational problems presented in Section 6 of the full report.

Studies similar to that described in Section 6 (Gas Concentrations in Kraft Mill Work Areas) of the full report, can be applied throughout the industry to quantify worker exposures to the wide

range of organic and inorganic process chemicals and by-products, escaping to the work area. This type of investigation can also be used to assist the development of training programs and safety procedures designed to control or limit worker exposure. Such activities would serve to bolster the benefits obtained from the existing training programs and safety procedures discussed in this report.

For many of the chemicals presented in Appendix A of the full report, certain items of data are not available in the literature and are therefore missing from the Chemical Profiles. Moreover, the exact nature of the industrial occurrence of many chemicals (many of which are identified by the NOHS walk through) is not characterized. For these chemicals, additional research is required to establish completely the items of information presented by the Chemical Profiles.

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The complete report, entitled "Paper Production and Processing—Occupational Exposure and Environmental Release Study," (Order No. PB 84-215 730; Cost: \$46.00, subject to change) will be available only from:

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