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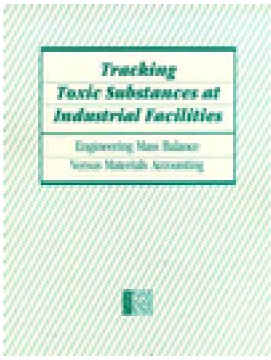

Tracking Toxic Substances at Industrial Facilities: Engineering Mass Balance Versus Materials Accounting

Committee to Evaluate Mass Balance Information for Facilities Handling Toxic Substances, National Research Council

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THE NATIONAL ACADEMIES
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Tracking Toxic Substances at Industrial Facilities

Engineering Mass Balance Versus Materials Accounting

Committee to Evaluate Mass Balance Information for Facilities Handling Toxic Substances
Board on Environmental Studies and Toxicology
Commission on Geosciences, Environment, and Resources

NATIONAL ACADEMY PRESS
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This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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[*] This study was begun under the Commission on Physical Sciences, Mathematics, and Resources, whose members are listed in Appendix K; and completed under the successor Commission on Geosciences, Environment, and Resources.

Preface

The toxics right-to-know movement in the United States stems from increased demands by broad segments of the public for information about the potential for routine and accidental releases of toxic substances into the environment, especially releases from industrial facilities. Citizens have organized advocacy groups, become educated about environmental health and contamination, and begun to participate more actively in environmental decision making. Mass balance information has been thought by some to be a means of understanding and accounting for actual and potential releases of chemicals from industrial facilities. Others doubt that collection of mass balance information could provide data of sufficient certainty and value to justify its cost.

The potential usefulness of mass balance information surfaced as an issue during the 1986 reauthorization of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980. The reauthorized legislation, the Superfund Amendments and Reauthorization Act (SARA) of 1986, includes a free-standing section—Title III—known as the Emergency Planning and Community Right-to-Know Law. This law established several federal, state, and local programs for reporting and emergency planning with regard to hazardous or toxic substances. One of those programs is the Toxics Release Inventory (TRI), which was devised to help governments and communities on the local, regional, and national levels obtain knowledge about releases of toxic substances. Title III requires manufacturing facilities that handle more than specified amounts of any of more than 300 specified chemicals or 20 chemical categories to submit information on environmental releases to the U.S. Environmental Protection Agency (EPA).

The congressional negotiations that led to SARA also demonstrate interest in other kinds of information, including mass balance information. As a result of conflicting views on the usefulness of nationally collecting mass balance data, the House-Senate Conference that led to SARA eliminated a Senate requirement to report mass balance data and directed EPA to obtain independent advice from the National Academy of Sciences about the potential usefulness of mass balance information and the feasibility of its collection. In response to a request from EPA, the National Research Council (NRC) Board on Environmental Studies and Toxicology convened the Committee to Evaluate Mass Balance Information for Facilities Handling Toxic Substances and charged it to evaluate issues relevant to the collection and use of mass balance information. The NRC suggested two phases of study: the first phase was to use currently available data to address the utility of mass balance information for the following information needs:

- Judging the accuracy of information on toxic chemical releases.
- Determining the waste-reduction efficiency of facilities.
- Evaluating toxic chemical management practices at facilities that report to the TRI.

In addition, the committee was to determine the implications of collecting mass balance information on a national scale and using the information in connection with the TRI. The second phase would be carried out if additional data and analyses were needed to address adequately the questions remaining from the first phase of the study. This report presents the results of the first phase.

In producing this report, the committee tackled an ambitious charge, encompassing small and large manufacturing facilities of a diverse nature that provide information to the TRI on a chemical-specific basis. In carrying out this study, the committee recognized the concern of society for protecting human health and the environment, which in turn leads to questions about human exposure, health risks, and environmental effects. To address such questions, data in the form of *concentrations* in environmental media are more useful and accurate than are data in the form of *mass*. Therefore, concerns regarding actual exposures of people living or working in the vicinity of facilities handling toxic substances could not be addressed in this report. Also, the committee did not include considerations of fate and environmental effects of the chemicals released by manufacturing facilities in its analyses and evaluations.

The 1987 NRC report, *Multimedia Approaches to Pollution Control: A Symposium Proceedings*, noted that public interest in a unified approach to pollution control is emerging. The present committee recognized that the TRI is a step toward a multimedia approach and considered the capabilities and limitations of mass balance data in this light.

The committee evaluated the potential benefits of mass balance reporting against the cost of collection, burdens on reporting facilities, and how the data could provide society with a greater understanding of relationships between industrial facilities and the release of chemicals into the environment. It compared the usefulness of mass balance data for various applications with the magnitude of data uncertainties, using what can be considered rudimentary error analyses—deemed necessary and sufficient for these comparisons. More rigorous quantitative methods (e.g., probability density functions) were not considered necessary. The committee's analysis focused on engineering and technical issues; a detailed economic analysis of costs and benefits was not within its purview.

The committee's efforts were greatly facilitated by the many individuals who submitted information and participated in an information-gathering workshop held in Washington, D.C., in March 1988. A list of the participants is presented in Appendix E of this report.

This report would not have been possible without the diligence of the committee members and the dedicated efforts of the staff, particularly Raymond A. Wassel, Karen L. Hulebak, and James J. Reisa. The report also had the great benefit of editorial revision and review by Lee R. Paulson and layout and proofreading by Ruth E. Crossgrove. Felita S. Buckher is thanked for her dedicated and able administrative and report-production skills. Warren R. Muir provided valuable input as a consultant to the committee during its deliberations. The National Governors' Association, the New Jersey Department of Environmental Protection, and the Maryland Department of Environment all provided useful information on experiences with the use of mass balance information.

CLAYTON F. CALLIS
CHAIRMAN

Contents

Executive Summary

The 1984 accidental release of more than 25 tons of methyl isocyanate in Bhopal, India, had profound consequences. In the United States, public concern about possibilities of similar releases led to the enactment of Title III of the Superfund Amendments and Reauthorization Act (SARA) of 1986. Title III, a free-standing part of SARA known as the Emergency Planning and Community Right-to-Know Law, established several federal, state, and local programs for reporting and emergency planning with regard to industrial releases of hazardous or toxic substances. Title III also requires manufacturing facilities handling more than specified threshold amounts of any of 309 specified chemicals or 20 chemical categories to submit information on environmental releases to the U.S. Environmental Protection Agency (EPA); the first and second annual reports were submitted to EPA on July 1, 1988 and 1989, respectively. EPA was charged with compiling and maintaining a database of these reports to help government agencies and citizens obtain information about releases of toxic substances on the local, regional, and national levels. This database is known as the Toxics Release Inventory (TRI).

Although current TRI reporting requirements focus on information about toxic releases, the legislative history of SARA also showed some Congressional interest in other kinds of information, including "mass balance"[*] information. The Senate bill leading to SARA would have required manufacturing facilities to report mass balance information in order to help track flows and assess releases of toxic materials. Proponents of such reporting requirements argued that mass accounting procedures would provide essential reference data against which to compare TRI data on waste generation and environmental releases. Further, they argued that such mass accounting data also would provide a means of determining whether TRI reporting forms were understood and properly filled out, much as ledger-sheet procedures and data provide valuable checks for financial managers. In contrast, opponents of this requirement questioned the need for anything more than release data,

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[*] Section 313(1) of SARA defines mass balance as "an accumulation of the annual quantities of chemicals transported to a facility, produced at a facility, consumed at a facility, used at a facility, accumulated at a facility, released from a facility, and transported from a facility as a waste or as a commercial product or byproduct or component of a commercial product or byproduct." Refer to the Glossary for definitions of terms used in this report.

and they expressed concerns over trade secrets and the cost of generating mass balance data. As a result of these conflicting views, the House-Senate conference that led to SARA eliminated the requirement for nationwide mass balance data reporting and directed EPA to obtain independent advice from the National Academy of Sciences on the value and feasibility of collecting mass balance information.

The Academy's National Research Council (NRC) was asked the following:

- To assess the utility of mass balance analysis for judging the accuracy of information on toxic chemical releases (e.g., information reported in the TRI).
- To assess the utility of mass balance information for determining the waste-reduction efficiency of facilities, or categories of facilities.
- To assess the utility of mass balance information for evaluating toxic chemical management practices at facilities or categories of facilities that report to the TRI.
- To determine relevant implications of collecting mass balance information on a national scale and using the information in connection with the TRI.

The NRC suggested two phases of study: the first phase was to address the questions listed above to the extent practicable using currently available nonconfidential information; the second phase of study would be carried out if additional data and analyses were needed to address adequately the questions remaining from the first phase of the study. This report presents the results of the first phase of study.

The Committee to Evaluate Mass Balance Information for Facilities Handling Toxic Substances was convened by the NRC Board on Environmental Studies and Toxicology in November 1987. The committee comprised members with expertise in chemistry, chemical and environmental engineering, waste management, environmental policy, information management, and economics. In performing its charge, the committee reviewed relevant technical literature, unpublished information, and available databases. It also held a workshop in March 1988 to obtain information from other persons and organizations with special expertise. Further, the committee reviewed relevant practices and experiences of state agencies with the assistance of EPA, the National Governors' Association, the New Jersey Department of Environmental Protection, and the Maryland Department of the Environment.

The term "mass balance" has been used—and sometimes misused—by different people to mean different things. The differences usually involve the exactitude of the data and of the data collection procedures. The committee recognized, therefore, that it should take into account differing perspectives on mass balance in addressing its charge.

To most scientists and engineers, the collection and application of mass balance data is an exacting exercise; obtaining measured data with minimal uncertainty is emphasized. A mass balance analysis provides a rigorous accounting of toxic chemicals flowing through a manufacturing facility. The committee termed this analysis an *engineering mass balance*. This type of analysis may be applied to a chemical processing unit or facility. The mass of inputs, outputs, and accumulations is determined by measurement. For each unit or for a whole facility, the masses of inputs should equal—or closely approximate—the masses of outputs plus accumulations (i.e., mass balance requires "closure"). The masses used may be total mass, masses of individual non-reacting chemicals, or masses of individual chemical elements or combinations of elements. Valid application of engineering mass balance requires that measurements be made with precision (i.e., agreement among repeated individual measurements of the same sample) and accuracy (i.e., close approximation of the actual quantities being measured). Such measurements must be made by skilled technical personnel.

The other school of thought about mass balance information, advocated in recent years by some policy analysts and others, argues that there is value in obtaining a more approximate level of information on chemical quantities. This approach requires less resource-intensive accounting.

Although proponents have called this also a mass balance, the committee termed it *materials accounting*, since it is not truly a mass balance approach in the technical sense. Materials accounting relies on information that is likely to be collected routinely at a facility for business or inventory management purposes, such as records of shipments of raw materials into a facility or records of the specific amounts of chemicals in products. Materials accounting data also can include manifest records and data required by existing environmental regulations. Materials accounting usually refers only to the flows of chemicals across facility boundaries; it does not require that all input and output data be determined (i.e., it is not focused on closure).

Materials accounting data are usually what is meant by proponents of nationwide collection of industrial mass balance data. For example, at the workshop organized by the committee, representatives from EPA and various state governments described materials accounting data to be what they meant when referring to mass balance data. A materials accounting approach to collection of mass balance data was also described during the Senate deliberations leading to SARA.

GENERAL CONCLUSIONS

In general, the committee concluded that both engineering mass balance and materials accounting can contribute to understanding mass flows of toxic substances into and out of a manufacturing facility. However, inevitable limits of precision and accuracy can make the closure required by engineering mass balance an unachievable objective, except for individual processing steps or simple production processes. Because many TRI-listed chemicals that flow through reporting facilities occur in multiple phases and are routed through complex processes, engineering mass balance is of limited practicality in the context of the TRI. Materials accounting data are much more easily and less expensively obtained than engineering mass balance data. The committee concluded that materials accounting data, properly validated and interpreted by persons with sufficient technical knowledge, may have better potential for achieving the goals for the national uses of mass balance information listed in Section 313(1) of SARA, even though such data are less accurate and precise than engineering mass balance data.

The committee's assessments of engineering mass balance and materials accounting information are discussed in the following sections with respect to each type of potential use described in Section 313(1) of SARA.

ASSESSING THE ACCURACY OF CHEMICAL RELEASE ESTIMATES

The committee evaluated the usefulness of engineering mass balance and materials accounting for providing a ledger-sheet check upon release estimates. Accuracy could be checked by looking for agreement between the summed quantity of inputs of a chemical and the sum of the outputs from a facility. The committee also evaluated the use of engineering mass balance and materials accounting for assessing the reasonableness of reported releases, in the context of understanding the way manufacturing facilities produce and use toxic chemicals.

Engineering mass balance would only be useful as a check on the accuracy of release estimates if all input and output quantities could be independently quantified and if they were in the same general range. However, the errors inherent in engineering mass balance data can represent large, unaccountable amounts of chemical mass. Even small degrees of uncertainty can represent large actual amounts of chemical mass that can greatly exceed the confirmed releases. For example, in one case considered by the committee, a facility that produces 5 million lb of ethylene per day, with more than 200 monitoring points, reported ethylene measurements as accurate to within 1%—or 50,000 lb of ethylene per day. But this figure is much higher than the calculated emissions from the facility—191 lb of ethylene per day—that was confirmed by monitoring. Therefore, engineering mass balance would not provide a useful check on the accuracy of release estimates for this facility, because the difference between the sum of inputs and the sum of outputs would greatly exceed the magnitude of releases.

For materials accounting data, the lack of accuracy and precision generally precludes gaining useful information on the accuracy of chemical release estimates. However, materials accounting could be useful in comparing operations in a given industry or in different industries that use the same listed chemical. It could also be useful for assessing the reasonableness of reported release estimates. For these reasons, the committee concluded that the materials accounting approach warrants further consideration.

Release data alone generally do not permit reliable determination of whether a greater release of a given chemical reported by one of two facilities occurred because more of the chemical was processed by that facility or because that facility was less efficient. However, materials accounting information on the quantities that enter both facilities and the quantities that are shipped out as product could assist in such a determination.

Differences in releases among different types of industries that use identical chemicals might be elucidated by the use of materials accounting data if such data were supported by information about the manufacturing processes involved. For example, if a facility uses a chemical as a degreaser, materials accounting data showing that none of the chemical is shipped out as product, together with general knowledge of how the chemical is used, might help explain why all of the chemical that is purchased becomes released into the environment. In contrast, another facility whose product contains the same chemical might release a lower percentage of the chemical purchased, at least partially because it uses the chemical differently.

New Jersey has reported that the materials accounting data for its Industrial Survey can be used to assess whether reported release estimates are valid and complete. For example, knowing the quantities of raw materials used and the products manufactured might enable recognition of a discharge overestimate from a facility that mistakenly reports a total discharge, which includes water, instead of just a specific chemical in the water. Unfortunately, underestimates are difficult to detect unless they are drastic underestimates, such as those that might occur if a facility using open vats of toxic solvents reports negligible emissions to the atmosphere.

In general, the committee concluded that neither engineering mass balance nor materials accounting are strictly adequate for assessing the accuracy of estimates of chemical releases from manufacturing facilities. However, both of these approaches, supplemented by expert data validation and technical knowledge, might be helpful for detecting gross errors in reported estimates of environmental releases and for improving understanding of chemical-use patterns and environmental releases. Because materials accounting data are potentially useful and typically less difficult and less expensive to obtain than engineering mass balance data, further consideration of materials accounting information for this purpose is warranted.

EVALUATING WASTE-REDUCTION EFFICIENCY

The committee evaluated engineering mass balance and materials accounting for use in helping to track waste-reduction progress. Both were assessed for their potential as an aid to evaluating (a) the amount of waste generated and its relation to the level of manufacturing activity; (b) the extent of waste reduction at the source of generation (versus reduction after treatment, such as by incineration); and (c) the comparability of the collected data among a wide variety of facilities.

Engineering mass balance data can be useful in identifying and characterizing sources of waste within a facility, but materials accounting data—specifically production data—are better for practical applications to assess waste-reduction efficiency. Production data can be used to normalize quantities of generated waste; normalization gives a ratio, for example, of pounds of waste to pounds of chemical product or manufactured goods. Normalization can help determine whether a decrease in the waste generated at a facility from one year to the next is due to actual progress in waste reduction or to a decrease in the proportion of production capacity used. However, the diversity of chemical products and manufactured goods that involve the use of toxic chemicals often makes it difficult to normalize waste data on a consistent and comparable basis. Furthermore, the relationship between waste generation and production might not be linearly correlated.

As an adjunct to a materials accounting data collection program, expert analytical assistance would be helpful in addressing related questions, such as whether a facility's current limited waste-reduction progress might be the result of previous substantial waste-reduction success, thus leaving the facility with less opportunity for further waste reduction. Another question to be considered is whether waste-reduction progress has been accomplished by replacing a chemical of known health effects with a different chemical of unknown health effects.

The committee concluded that neither engineering mass balance nor materials accounting is generally useful for strict determination of waste-reduction efficiency or progress in waste reduction. Both methods fail to address technological and economic limitations in achieving waste reduction. However, data on manufacturing activity and waste generation coupled with expert knowledge of waste-handling practices and technological options for reduction of waste generation could, in some cases, contribute to a useful picture of waste-reduction progress at individual facilities. Such data could also provide new information to help guide additional reduction techniques. Such facility data could not be meaningfully aggregated at the national or industry levels, because too much information on individual production processes would be lost, and waste-reduction progress would likely be obscured. Collection of data on each production process in multiproduct facilities nationwide would avoid such information loss, but assembling the data would be difficult.

EVALUATING CHEMICAL MANAGEMENT PRACTICES

The committee evaluated engineering mass balance and materials accounting for their value in providing data on (a) the types and amounts of toxic chemicals managed by a facility, (b) the extent to which changes in amounts of toxic substances are attributable to changes in levels of manufacturing activity, (c) the comparability among facilities, (d) the usefulness to chemical managers for enhancing the safety of their management practices, and (e) the usefulness to the public and government in evaluating whether effective practices are being used to minimize releases of toxic chemicals into the environment.

Materials accounting analysis of chemical management practices could use available records, such as invoices and shipping manifest records; the most relevant data would be the annual quantity of a specific chemical transported across facility boundaries. Expert knowledge would be required on changes in physical and chemical properties (e.g., from a liquid to a solid material and from a more hazardous to a less hazardous form) or changes in transport methods. This information could be valuable to a community for assessing the potential hazards associated with transport practices and for developing emergency-response plans.

The greatest quantity of a chemical stored on site, as reported to the TRI, is another important factor in chemical release assessment. Data on amounts stored should be normalized for comparison among facilities, especially if they have very different production rates.

Chemical properties and reactivity, equipment design and safeguards, operating procedures, operator training, and quality of maintenance and monitoring all affect the likelihood of accidental releases. Such information is not reported in the TRI and would not be provided through the additional reporting of materials accounting data alone. Public access to such data could be achieved if the reported materials accounting data were supplemented with information furnished by technical experts knowledgeable about the chemical management practices at specific facilities.

The committee concluded that engineering mass balance and materials accounting are conceptually useful for assessing and sometimes improving management practices, including storage, waste treatment, handling, waste reduction, on-site tracking of toxic chemicals, and transportation into and out of a facility. However, information obtained through either engineering mass balance or materials accounting is generally inappropriate from a practical perspective. For example, engineering mass balance and materials accounting might be grossly inadequate for assessing transportation and storage practices, because processes differ widely within manufacturing facilities, thereby limiting data comparability. Engineering mass balance would be more useful than materials accounting for assessing waste-treatment practices, but the practical difficulty and cost of achieving closure restricts its application. Materials accounting does not provide the necessary process-specific data.

Information currently reported to the TRI does not closely link release data to chemical management practices, except for waste management. Additional facility-specific information on management practices could assist the public in evaluating whether the most effective practices are being used to control or prevent releases of toxic chemicals.

COLLECTING MASS BALANCE INFORMATION ON A NATIONAL SCALE

Regarding the desirability of national collection of engineering mass balance or materials accounting data, the committee was charged with considering relevant potential benefits to government and society, including the potential uses explicitly stated in SARA Section 313(1). The committee also considered the costs of collection and analysis, the complexity and interpretability of the data, the way the data could enhance the public's and government's understanding of relationships between industrial manufacturing activities and the release of chemicals into the environment, and the potential reporting costs to facilities providing the data, including matters of confidentiality.

For specific technical applications, the usefulness of engineering mass balance is well established. However, it is typically complicated and expensive, and its data collection requirements go beyond the kinds of assessments at issue here, so the collection of engineering mass balance data was not judged by the committee to be feasible for a national mass balance collection program.

At the committee's request, the National Governors' Association surveyed all 50 states about their experiences with mass balance information. (All the reported mass balance analysis relied on materials accounting data.) To date, seven states have performed a onetime collection of mass balance information; established a mass balance program, such as comprehensive reporting for whole industrial sectors; or collected mass balance data as a means of demonstrating compliance with air-pollution programs. Five other states have plans for future mass balance efforts. Eight states have rejected the collection of mass balance data because of the expense and difficulty. The remaining 29 states that responded to the survey appear to want a clearer demonstration that mass balance data compilation will be cost-effective before they commit resources for data collection.

The New Jersey Industrial Survey and Maryland's Toxic Substances Registry System are the two most extensive mass balance studies that have been carried out at the state level. New Jersey, which pioneered the use of materials accounting data, has used data from its survey for health assessment and surveillance. The data reportedly have been useful in occupational health surveillance for identifying workplaces in which toxic substances are used and the numbers of workers potentially exposed. (The New Jersey Department of Health reported that more than 80% of the workplaces with potential exposures to mercury could not have been identified without materials accounting data.) New Jersey also reports that its materials accounting data helped focus the development of its Environmental Cleanup and Responsibility Act, Toxic Catastrophe Prevention Act, and Pollution Discharge Elimination System. Furthermore, New Jersey plans to use materials accounting information to set priorities among facilities and industries for waste-reduction attention.

Recognizing the complexity of the materials accounting data it had collected and the substantial potential for inaccurate reporting, New Jersey provided expert assistance to its survey respondents and conducted routine field audits. Through its extensive validation program, New Jersey found it necessary to revise the original release estimates for approximately 25% of the survey respondents due to gross errors in release estimates. New Jersey officials have stressed that, in the absence of direct field audits or monitoring data and additional materials accounting information, it would have been impossible to ensure that reported release information was valid. New Jersey's experience with data validation was a major factor in convincing the committee that data obtained through a national materials accounting program can be useful only if augmented with expert technical assistance for verification and analysis.

Reporting of materials accounting data can disclose information on chemical releases, recycling, and production, as well as a fairly complete description of chemical methods used, yields, and sales. Experience with data collection through the New Jersey Industrial Survey and the New Jersey Worker and Community Right-to-Know Act indicates that these types of business information can be kept confidential. Nonetheless, the collection and use of confidential information remain issues of great concern for any potential national collection of materials accounting data.

Maryland has reported that its Toxic Substances Registry System provided a multimedia database that was used to establish priorities for regulation of airborne toxic substances and to develop a list of toxic air pollutants for which facilities must report environmental releases. Maryland plans to use the data in conjunction with statewide cancer and birth defects registries and with its occupational disease reporting system in support of epidemiologic studies.

In general, the committee concluded that materials accounting information, collected and disseminated on a national scale without the benefit of data validation and assistance from persons with suitable expertise, would be of little use and could potentially mislead regulators and the public. However, a materials accounting program might help regulators and the public understand better where chemicals of concern are released into the environment *provided that the data are properly validated and interpreted by persons with appropriate technical knowledge about industrial processes and chemical distribution pathways from production to end use*. Such a materials accounting program could also aid in the evaluation of waste-reduction efficiency and the setting of national priorities for waste reduction and chemical management practices.

As the logical next step in considering a national materials accounting program supported by expert validation and interpretation, a pilot study should be conducted on a nationwide basis to test the feasibility and utility of collecting materials accounting information for at least two or three chemicals.

PILOT STUDY RECOMMENDATION

The committee recommends that a pilot study be conducted to test the feasibility of the national collection of materials accounting information and that the study include a technical support group. The committee considers a technically supported materials accounting program as potentially a useful application of materials accounting data that could enhance the public and government understanding of relationships between manufacturing and the environmental release of chemicals, which in turn might lead to reductions in the releases of toxic substances into the environment.

This recommendation grows out of the original plan for this study as suggested by the NRC, which led to the present committee's deliberative process and review. This plan envisioned a two-phase investigation that would begin with a review of currently available, non-confidential information to evaluate mass balance options. The present report completes the first phase. The second phase, as recommended by the committee, should be a pilot study involving a national materials accounting data collection program; it should be performed by a contractor or through a cooperative agreement with one or several engineering schools or research groups, with appropriately qualified, independent oversight of the study design and evaluation of results.

The pilot study is suggested as a prudent step in further considering a national materials accounting data collection for all TRI-listed chemicals from thousands of facilities. The pilot study would obtain information to weigh the benefits and costs of materials accounting, and thus enable a reasoned decision on a national materials accounting program. It also would indicate the following:

- The general feasibility of a nationwide collection and public dissemination of materials accounting data designed, analyzed, and interpreted by technical experts.
- The utility of such nationwide materials accounting information (beyond the value of TRI data) for the applications discussed in this report.
- The potential cost of such a program.
- The feasibility of conducting a national program that involves the collection of

possibly sensitive or proprietary data for eventual public use.

Any collection of materials accounting information, even at the level of a pilot study, will be time-consuming and expensive. The data selection should be a rigorous test of the complexity and interpretability of materials accounting data. To maximize the information yield relative to resources expended, the pilot study should focus on just two or three chemicals from the TRI list. (Pilot study investigators could consider studying more chemicals if resources are available to support a larger study; however, adding more chemicals to the pilot study would not necessarily provide a more complete answer.) It might be specified that the selected chemicals should have important known adverse health or environmental effects. Or it might be better to select chemicals used in large volumes, for two reasons: chemicals used in large volumes theoretically have a greater potential for significant amounts of releases, and the collection of materials accounting information on chemicals used in large volumes would provide a rigorous test of information collection. Additional chemical-specific questions might be designed to focus on particular risks or chemical use patterns or to address metropolitan or regional issues. Comparisons might be made within a single industrial category or between industrial categories.

The pilot study should build on the experience of the New Jersey Industrial Survey by evaluating a national-scale testing of all the characteristics of a materials accounting program, assisted by a technical support group. It should consider all possible important releases of the few chemicals selected (i.e., from chemical uses by consumers and nonmanufacturing industries, in addition to those currently reporting to the TRI).

The pilot study should include an experimental public dissemination program designed to maximize the accessibility of a materials accounting database supplemented with technical support. In evaluating the potential utility of such a materials accounting program, pilot study investigators should solicit public comments on the disseminated information.

The pilot study should be designed to test ways to achieve the potential benefits of materials accounting with technical support as cost-effectively as possible. Reliance on data that are likely to be routinely collected is another aspect to be evaluated. The pilot study should address the utility of materials accounting data aggregated at the national or regional level, for example, as inputs to environmental economic models used to develop strategies for managing environmental quality.

Existing nonconfidential data include all release-related data currently available to EPA, such as permit data, TRI data, and facility management data (e.g., production and sales information, purchase records, and waste manifest records). They also include monitoring data that are already being obtained by federal or state programs, emission inventories conducted under the Clean Air Act, water quality information obtained under the Clean Water Act, information on the Resource Conservation and Recovery Act hazardous waste manifests, population densities, and information from trade associations (e.g., production volumes and intermediate commercial uses). Materials accounting data collected on a regular basis under the New Jersey Worker and Community Right-to-Know Act of 1983 should also be considered. Validation checks are likely to be required for some of the data. Such checks would probably include visits to facilities and interviews of their personnel.

In summary, mass balance information, and in particular materials accounting supplemented by expert data validation and technical assistance, has potential utility for addressing the information needs specified in SARA Section 313. However, the potential usefulness of a national program cannot be clearly established without conducting the recommended second phase of the study. It is the committee's consensus that a nationwide pilot data collection performed for a few chemicals would be the appropriate next step in pursuing the environmental protection and public-information goals of Title III of SARA.

1

Introduction

In 1984, more than 25 tons of methyl isocyanate was released in Bhopal, India, with devastating effects. Concern began to focus on toxic chemical release prevention and response strategies should a similar release happen in the United States. The U.S. Environmental Protection Agency (EPA) initiated a comprehensive evaluation of the design and operating practices of the methyl isocyanate production and storage units at the one facility that manufactures the chemical in the United States (EPA, 1985a). In August 1985, the accidental release of aldicarb oxime and several other chemical releases from another part of that same facility received national attention and led to state legislation for improved prevention and response approaches. The Bhopal disaster and the U.S. releases underscored the paucity of data on uses and releases of toxic substances and the need to obtain more and better data.

Title III of the Superfund Amendments and Reauthorization Act (SARA) of 1986 (P.L. 99-499; 42 USC 11001—11050) established several federal, state, and local programs to address concerns about toxic chemicals, including emergency planning, emergency notification, and community information needs; SARA also specified that EPA create a toxic release inventory.

The development of Title III of SARA was affected profoundly by the right-to-know movement. Labor and environmental organizations view right-to-know laws as important to workers' and the public's understanding of toxic releases as well as to the development of sound approaches for reducing occupational and community exposures. New Jersey and several local governments already had enacted or developed right-to-know laws before SARA was passed in 1986.

SARA SECTION 313

Section 313 of Title III under SARA requires industrial manufacturing facilities using toxic chemicals to report release information to EPA. Initial requirements for submission of this information are specified by EPA in the Toxic Chemical Release Reporting Final Rule (Federal Register, 1988a). The database resulting from the information reported to EPA is referred to as the Toxics Release Inventory (TRI).

TRI was devised to inform the public and government officials of total routine and accidental releases to the environment of certain chemicals from manufacturing facilities (Federal Register, 1988a). Section 313(h) of SARA states that information collected under the TRI

> shall be available . . . to inform persons about releases of toxic chemicals to the environment; to assist government agencies, researchers, and other persons in the conduct of research and data gathering; to aid in the development of appropriate regulations, guidelines, and standards; and for other similar purposes.

The initial list of toxic chemicals for TRI reporting (see Appendix A) was generated from toxic chemical lists developed by Maryland and New Jersey. This list contains 308 specific chemical compounds and 20 chemical categories and can be modified only by a rulemaking, such as the deletion of titanium dioxide (Federal Register, 1988b). The reporting requirement also applies to chemicals transported from a facility as waste for off-site treatment or disposal. Reporting is optional for chemical quantities sent off site for recycle or reuse.

A facility must report the annual releases of any of the listed chemicals it handles if the facility has the following characteristics for the specific reporting year:

- Has Standard Industrial Classification (SIC) Code with the first two digits in the range from 20 through 39 (manufacturing division) (see Appendix B).
- Employs 10 or more full-time workers.
- Handles an annual quantity of at least one TRI-listed chemical above the following threshold amounts: 75,000 lb/yr in 1987, 50,000 lb/yr in 1988, or 25,000 lb/yr in 1989 and after for listed chemicals that are manufactured, imported, or processed; or 10,000 lb/yr for listed chemicals used in any other manner, such as for blending, degreasing, and coating.

Definitions for "manufacture," "process," and "use" of TRI-listed chemicals are broad and wide ranging. These definitions are presented in 40 CFR 372.3 of the Community Right-to-Know Final Rule as follows:

> "Manufacture" means to produce, prepare, import or compound a toxic chemical. . . .
>
> "Process" means the preparation of a toxic chemical, after its manufacture, for distribution in commerce:
>
> (1) in the same form or physical state as, or in a different form or physical state from, that in which it was received by the person so preparing such chemical, or
>
> (2) as part of an article containing the toxic chemical.
>
> "Otherwise use" or "use" means any use of a toxic chemical that is not covered by the terms "manufacture" or "process" and includes use of a toxic chemical contained in a mixture or trade name product.

The definition of "use" for this report (refer to Glossary) is much broader than the one given in the Community Right-to-Know Final Rule.

For TRI reporting, release of a listed chemical is the discharge into the environment of the chemical through such actions as any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment (including the abandonment or discarding of barrels, containers, and other closed receptacles).

Chemical manufacturing facilities that produce TRI-listed chemicals in amounts greater than the threshold are required to report the estimated chemical releases to the TRI. Similarly, facilities that use such chemicals above the threshold amount must report estimated releases. For example, a facility that produces polyvinyl chloride from vinyl chloride (a TRI-listed chemical) to manufacture PVC water pipe must report to TRI.

Reporting also is required for facilities that use TRI-listed chemicals above threshold amounts in manufacturing processes that require no transformation of listed chemicals. For example, toluene is used as a solvent in blending surface coatings, such as paint. Toluene that is shipped into a facility as a pure solvent is shipped out of the facil ity as the same chemical, but within a coating mixture, and must be reported to TRI.

Facilities that receive TRI-listed chemicals present as raw material contaminants (e.g., arsenic contaminants in copper ore) or that generate byproducts during processing (e.g., cyanide as a byproduct from coking) are also required to report release estimates to the TRI, if the contaminants or byproducts are present above the threshold amounts.

TRI information is provided by facilities annually using EPA's Form R (see Appendix C), compiled in a computerized database, and made available to the public. The first reporting date for toxic releases in 1987 was July 1, 1988. The reported information includes the following:

- Facility identification.
- Information on manufacturing, processing, or otherwise using TRI-listed chemicals.
- Data on chemical identity.
- Estimated quantities of environmental releases.
- Types of waste-treatment methods and efficiencies.
- Information on waste minimization (optional).
- Identification of all off-site locations to which TRI-listed chemicals are transferred.

Facilities are not required to perform any additional monitoring or to make additional measurements for TRI reporting beyond those already obtained for other purposes. EPA provided an overview of four general methods that can be used to estimate releases subject to TRI reporting (EPA, 1987). EPA described these approaches as follows:

- Calculations based on measured concentrations of the chemical in a waste stream and the volumetric flow rate of that stream.
- Mass balance around entire processes or pieces of process equipment. If input and output (i.e., product) streams are known (based on measured values), a waste stream can be calculated as the difference between input and product (accounting for accumulation or depletion of the chemical in the equipment).
- Emission factors, which usually express release as a ratio of amount released to the amount of chemical flowing through the process. (Release estimates are obtained by multiplying the emission factor by the amount of chemical flowing through the process for which estimates are needed.) Emission factors, which are commonly used for air emissions, are based on the average measured emissions at several facilities in the same industry.
- Engineering calculations and/or judgment based on physical and chemical properties and relationships, such as the ideal gas law.

PURPOSE OF THIS STUDY

The Senate version of the bill that led to SARA required reporting mass balance information in addition to information submitted by each facility reporting to the TRI. SARA Section 313(1) defines mass balance as "an accumulation of the annual quantities of chemicals transported to a facility, produced at a facility, consumed at a facility, used at a facility, accumulated at a facility, released from a facility, and transported from a facility as a waste or as a commercial product or byproduct or component of a commercial product or byproduct." For the purpose of this report, this definition is considered to refer to mass balance data or mass balance information. The final SARA Section 313(1) directed EPA to obtain the assistance of the National Academy of Sciences (NAS) in evaluating the value and feasibility of collecting mass balance information to meet several national information needs regarding hazardous chemicals (see Appendix D).

Section 313(1)(2) of SARA lists four purposes of the NAS study:

1. *Assess accuracy of information*: "To assess the value of mass balance analysis in determining the accuracy of information on toxic chemical releases" (such as data collected for the TRI).
2. *Relevance to waste reduction*: "To assess the value of obtaining mass balance information, or portions thereof, to determine the waste-reduction efficiency of different facilities, or categories of facilities, including the effectiveness of toxic chemical

regulations promulgated under laws other than this title."

3. *Utility of information for chemical management*: "To assess the utility of such information for evaluating toxic chemical management practices at facilities, or categories of facilities, covered by this section."
4. *Implications for national data development*: "To determine the implications of mass balance information collection on a national scale similar to the mass balance information collection carried out by the [EPA] Administrator under paragraph (3) [mass balance information collected by states], including implications of the use of such collection as part of a national annual quantity toxic chemical release program."

The implications of mass balance information collection on a national scale relate not only to the three other purposes mentioned in the charge but also to any other relevant implications of national collection. The study was designed by the Academy's National Research Council (NRC) to include an evaluation of whether additional data and analyses are needed to address adequately the issues posed for the study. If the committee determined that the potential utility of collecting mass balance information warranted further analysis, it would then propose a second phase of the study. The second phase would call for additional information to be gathered to test rigorously the utility of a national mass balance program. The NRC design of the study is separate from SARA Section 313(1)(3), (see Appendix D), which provides that the EPA Administrator may "acquire mass balance information necessary for the study from a representative number of facilities" if currently available information "provides an inadequate representation of industry classes and categories to carry out the purposes of the study." A distinction is made between the NRC study design and Section 313(1)(3), because a recommendation for a second phase would not necessarily be based upon the conditions of that section.

The Committee to Evaluate Mass Balance Information for Facilities Handling Toxic Substances was convened by the NRC Board on Environmental Studies and Toxicology in November 1987. The committee comprised members with expertise in chemistry, chemical and environmental engineering, waste management, environmental policy, information management, and economics. In performing its charge, the committee reviewed relevant technical literature, unpublished information, and available databases. It also held a workshop in March 1988 to obtain information from other persons and organizations with special expertise (see Appendix E). Further, the committee reviewed relevant practices and experiences of state agencies with the assistance of EPA, the National Governors' Association (NGA), the New Jersey Department of Environmental Protection, and the Maryland Department of the Environment.

The term mass balance has been used—and some would say misused—by different people to mean different things. The differences usually involve the exactitude of the data and of the data collection procedures. The committee recognized, therefore, that it should take into account differing perspectives on mass balance in addressing its charge.

To most scientists and engineers, the collection and application of mass balance data is an exacting exercise; obtaining measured data with minimal uncertainty is emphasized. A mass balance analysis provides a rigorous accounting of toxic chemicals flowing through a manufacturing facility. The committee termed this analysis an *engineering mass balance (EMB)*. This type of analysis may be applied to a chemical processing unit or facility. The mass of inputs, outputs, and accumulations is determined by measurement. For each unit or for a whole facility, the masses of inputs should equal—or closely approximate—the masses of outputs plus accumulations (i.e., mass balance requires "closure"). The masses used may be total mass, masses of individual nonreacting chemicals, or masses of individual chemical elements or combinations of elements. Valid application of EMB requires that measurements be made with precision (i.e., agreement among repeated individual measurements of the same sample) and accuracy (i.e., close approximation of the actual quantities being measured). Such measurements must be made by skilled technical personnel.

The other school of thought about mass balance information, advocated in recent years by some policy analysts and others, argues that there is value in obtaining a more approximate level of information on chemi cal quantities. This approach requires less resource-intensive accounting.

Although proponents have called this approach a mass balance also, the committee termed it *materials accounting (MA)*, since it is not truly a mass balance approach in the technical sense. MA relies on information that is likely to be collected routinely at a facility for business or inventory management purposes, such as records of shipments of raw materials into a facility or records of the specific amounts of chemicals in products. MA data also can include manifest records and data required by existing environmental regulations. MA usually refers only to the flows of chemicals across facility boundaries; it does not require that all input and output data be determined (i.e., it is not focused on "closure"). Examples of information used in MA are shipment records of raw materials into a facility and production records indicating the specific amounts of chemicals contained in products shipped from the facility. Analytical measurement data obtained for an EMB (e.g., gas chromatography measurements of stack emissions) could also be included as MA data.

MA data are usually what is meant by proponents of nationwide collection of industrial "mass balance data." For example, at the workshop organized by the committee, representatives from EPA and various state governments described MA data to be what they meant when referring to mass balance data. An MA approach to collection of mass balance data was also described during the Senate deliberations leading to SARA.

Although both approaches provide similar types of information, EMB is more accurate and precise and requires greater technical expertise and a greater level of effort than MA does.

ORGANIZATION OF THIS REPORT

Chapter 2 of this report reviews the EMB and MA approaches to collecting mass balance data. Experience with uses of MA information is reviewed in Chapter 3, which provides a basis for the committee's evaluation of the feasibility and utility of such information to address the four information needs posed in SARA Section 313. Chapter 4 addresses whether the accuracy of chemical release estimates can be assessed through EMB and MA, and the usefulness of these two approaches in assessing waste reduction efficiency is explored in Chapter 5. Chapter 6 evaluates the utility of both approaches to toxic chemical management practices, such as minimizing storage, avoiding catastrophic releases, and providing information to the public. The implications of collecting mass balance information on a national scale are discussed in Chapter 7, as well as the potential value of such information to interested parties, including the public; policymakers; industry; and federal, state, and local governments. Chapter 7 also includes the committee's recommended approach to test a national program for toxic substances handled by industrial facilities. A glossary of terms and acronyms is presented after Chapter 7.

2

Approaches to Obtaining Mass Balance Information

INTRODUCTION

Two general approaches are used to obtain mass balance information: the traditional EMB and the MA. Both approaches are described and compared in this chapter as a basis for discussing the potential of mass balance information for the applications described in SARA Section 313(1). A qualitative comparison is made from the perspective of a reporting facility between the two approaches concerning amounts of data, technical skills of personnel to obtain and evaluate the data, and the resulting costs. (Only anecdotal quantitative cost data were available to the committee for its analysis.)

The components of the SARA mass balance definition fit closely with the traditional EMB approach. However, the goals of a mass balance analysis also could be sometimes met through information collection using MA.

ENGINEERING MASS BALANCE

The EMB concept is more than a century old. It has been the subject of numerous books (e.g., Felder and Rousseau, 1978) and is an established tool in engineering practice (Austin, 1984; Perry et al., 1984). The basic goal of EMB is closure—when all chemical inputs to a manufacturing facility, outputs from that facility, and accumulations within have been identified and the masses have been measured. The mass of inputs should equal—or closely approximate—the mass of outputs plus accumulations (i.e., mass balance requires "closure"). Lack of closure indicates that errors have been made in quantifying one or more of the mass balance components or that additional information is needed. However, the errors inherent in any sampling and analysis procedure make attainment of complete closure an unrealistic expectation. All routes or streams for each process step (e.g., distillation) within a facility must be identified and evaluated independently to account for all chemicals entering or leaving a facility. This is a rigorous evaluation procedure requiring accurate and precise measurements, and expert knowledge is needed to use it.

Standard Theory and Practice of EMB

Although EMB does not necessarily track specific chemicals, the committee evaluated chemical-specific applications of EMB, because SARA Section 313 requires report ing releases of specific chemicals. These chemicals enter and exit processes (e.g., blending) within a facility through material streams conducted by pipes, air ducts, barrels, and so on. The chemicals within streams can become partitioned into gas, liquid, or solid phases (and phase mixtures), depending on the thermodynamic conditions within the streams. In addition, in many processes, reactions occur that convert input chemicals to entirely different output chemicals. In such cases, knowledge of the chemical transformations is needed to relate the reacted inputs to the resulting outputs. A further discussion of the implications of such reactive systems for performing a mass balance evaluation is provided in Chapter 5.

EMB uses measurement data and judgment (McMichael, 1988). The measurements require knowledge of conservation of mass and of the standard units for expressing mass data as well as flow rates, determinations of chemical mass, accumulation, and the compositions and concentrations of specific chemicals within streams flowing through a facility. Streams can be multiphase and chemically unstable, and they can contain components that interfere with analytical procedures (Rohlik, 1986).

Engineering judgment must be exercised in selecting the methods for sampling and analysis and in choosing the frequency and duration of data acquisitions on the mass flows within and across facility boundaries. Sampling procedures can range from in situ continuous stream sampling and analysis to instantaneous grab samples at periodic intervals. Judgment is needed to select the appropriate analytical procedure and to collect samples in a manner that adequately accounts for daily and longer-period variability in the concentration of a specific chemical discharged from a facility. Temporal variation in waste-water concentration, for example, can be attributed to normal process variations in raw material content and reaction efficiency (Tischler, 1988).

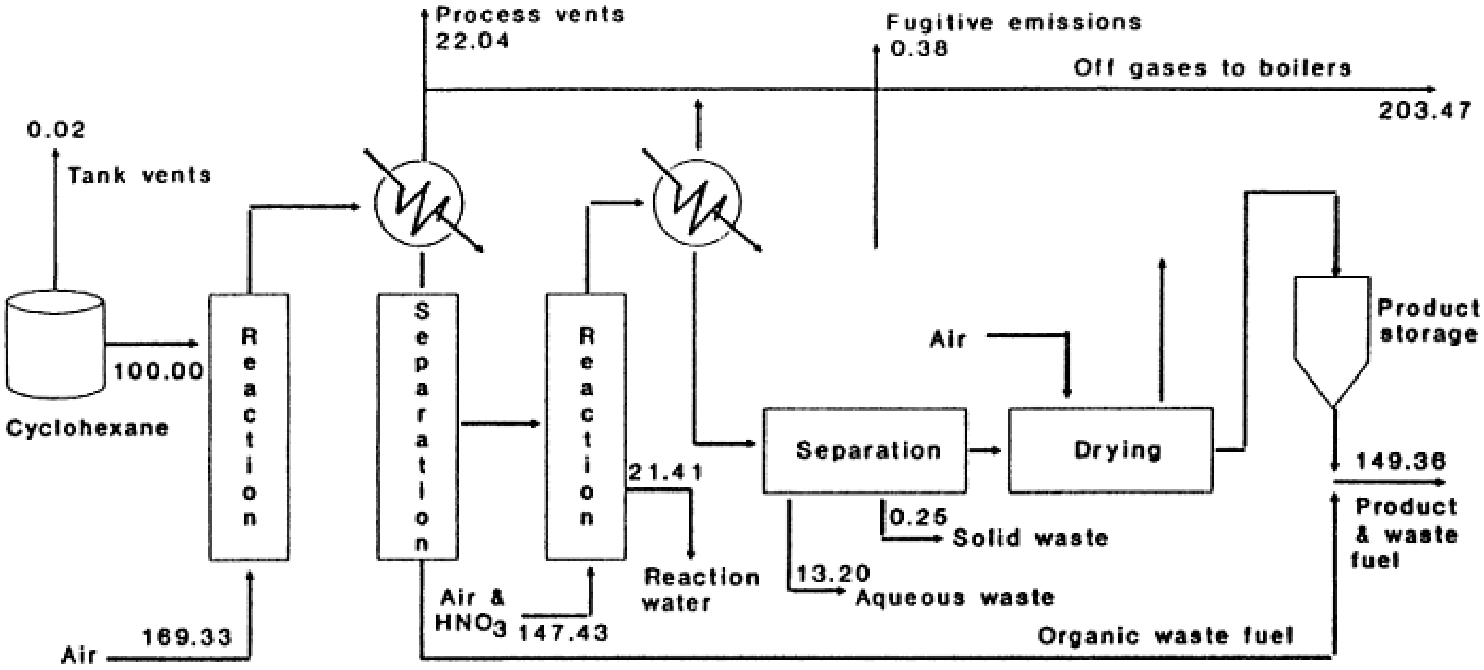
An annual average EMB requires simultaneous evaluation of the variations in chemical concentration and flow rate for the entire year. For a simple EMB on one chemical, such as purchased chlorofluorocarbons used as blowing agents to manufacture open-cell polymeric foams, variability of mass flow through the facility is manageable. In this case, essentially the entire amount of chlorofluorocarbon is released into the atmosphere within several hours after the manufacturing process. Therefore, the mass of chemical input to this facility would be equivalent to the amount released into the atmosphere (assuming insignificant amounts of the chemical remain in the foam product).

EMB generally is difficult to conduct, however, because the number of necessary judgments tends to increase with the complexity of the facility, and because many manufacturing facilities have multiple unit-process components with multiple-process streams. EMB requires an evaluation of each stream, and the total flow rate and the concentration of specific chemicals can vary significantly with the inevitable fluctuations in facility operation. The cost of analytical work required to obtain this information usually is very high, and the paperwork burden in collecting the information would be formidable.

A simplified example of an EMB applied to all material entering and exiting an adipic acid manufacturing facility is shown in Figure 2.1 (Nickolaus, 1988). This EMB example is not chemical-specific and probably involves less-complex analytical methods than would be required if the analysis were performed for a specific chemical. This schematic also does not depict the compositions of streams flowing into and out of process components within the facility. In Figure 2.1, no data were available for the amount of reaction water generated from this process; it was therefore assumed that all of the water theoretically predicted was generated as a byproduct from the reactor.

Measurement Error in EMB Applications

Several factors limit the certainty of data acquired through EMB, including facility size and complexity, instrument accuracy and application, system variability, errors inherent in sampling and analytical procedures, recordkeeping errors, and waste accountability (McMichael, 1988). The magnitude of errors in this information can vary significantly as a function of the types of industry, facility, and technology. For example, analysis to determine the annual quantity of TRI-listed contaminants within



Material in	Amount (lbs)
Cyclohexane and other ingredients	100.00
Air	169.33
Nitric acid (HNO_3) and air	147.43
Total	416.76

% Closure = 410.13/416.76
= 98.4% ± 2.2%

Material out	Amount (lbs)
Product and organic waste fuel	149.36
Off gases to boilers	203.47
Process vents	22.04
Tank vents	.02
Fugitive emissions	.38
Aqueous waste (total solids)	13.20
Solid waste	.25
Reaction water	21.41
Total	410.13

Figure2.1
EMB applied to adipic acid manufacturing facility. (Source: Adapted from Nickolaus, 1988).

the copper ore fed to a smelter facility is more prone to error than is determining the annual quantity of chlorofluorocarbon shipped to a foam-blowing facility, because the copper ore composition is much more heterogeneous and variable than that of the chlorofluorocarbon feed.

The errors in the data acquired through EMB make it virtually impossible to achieve closure of EMB for a manufacturing facility other than one composed of a single small production unit. Even if 99% closure were reached, a large amount of chemical mass would remain unaccounted for, especially at facilities where millions of pounds of chemicals per day are produced or used.

The mass of a chemical flowing through a facility often is not measured directly but instead is calculated from independent measurements, such as total flow rate and chemical concentration within each stream. Mass data thus are obtained by multiplying the total flow rate (e.g., pounds of stream per day) by the concentration of each chemical within the stream (e.g., pounds of benzene per million pounds of stream). Errors can be introduced into the mass balance results from flow rate measurement error and as a result of the precision and accuracy limits of the analytical procedures employed to measure chemical concentrations (Klusek et al., 1983). Sampling methods and analytical procedures have greatly improved in the past decade for many toxic chemicals of concern and could help reduce measurement error. However, these advances can be very costly. For example, the use of gas chromatography for EMB measurements has been estimated to require an annual cost of $15,000 per stream at a multistream adipic acid manufacturing facility (Nickolaus, 1988).

For petroleum refineries and some other industries, material flow rates are measured by volume instead of by mass. This adds uncertainty to EMB data because the measurement units must be converted. For example, crude oil is purchased by volume; to convert the volume to mass requires that the crude oil gravity and temperature at delivery be determined accurately. Furthermore, the amount of sediment and water in suspension must be known. The combined error in measuring volume and converting it to mass can be 0.3-0.4%. The magnitude of this error approaches that of the overall quantity of releases from a refinery, estimated to be 0.5 weight-percent of the crude oil input (T. Yosie, American Petroleum Institute, personal communication, August 29, 1988).

The following example illustrates the significance of how an apparently slight degree of uncertainty affects EMB. An ethylene production facility that incorporates more than 200 state-of-the-art monitoring points in its system reports measurement accuracies that range from ±0.25% to ±1.0%, and closure to within 1% for large volumes of ethylene. When these overall uncertainties are based on daily balances and applied to the facility's current feed rates, they represent an imbalance of ±50,000 lb of ethylene per day. This figure stands in striking contrast to the emissions from this facility, which are estimated to be 191 lb of ethylene per day. A monitoring program was used to confirm that emissions are not underestimated by the calculation procedure (Chlapek, 1988).

A high degree of closure could also be the result of two or more errors negating one another on EMB results. For example, errors in measuring the total amount of a volatile chemical in a stack emission coupled with an error in determining the total amount of that same chemical in the feedstock could result in an apparently accurate balance (Kaakinen and Jorden, 1973).

EMB is limited by analytical measurement error and lack of precise knowledge of chemical process science. For a facility in which a specific chemical undergoes no chemical change and is transferred to only one stream, EMB results are reasonably accurate. However, the processes in many facilities required to report under SARA Section 313 are not that simple. Many listed chemicals flowing through the reporting facilities occur in multiple phases and are routed through multiple process streams.

MATERIALS ACCOUNTING PRACTICES OF POTENTIAL UTILITY

MA is a means of obtaining mass balance information that uses readily available information on material flow across facility boundaries. Unlike EMB, MA does not require closure and therefore does not require detailed measurements of all process streams within facility boundaries. How ever, MA can include measured data; it can include any or all of the SARA mass balance data that are obtained for EMB. Because MA and EMB can obtain similar types of information, the prime distinction between the two approaches is the method by which the information is obtained.

MA draws on the basic accounting and production information of a facility. Such information may include purchase and production records; sales and shipping records; inventories of raw materials, intermediates (materials in process), and products; permit records of waste streams; and manifest and waste facility records.

In comparison with EMB, MA is less accurate and less precise; however, this does not adversely affect MA's potential utility. MA provides an approximation of the quantities of chemicals flowing through a facility for any or all of the same mass balance components that are required for an EMB.

Although the MA approach generally uses information about the quantities crossing facility boundaries, its potential application to assess waste-reduction efficiency (Chapter 5) would require MA data collected from production units within a facility. A facility that produces several products might contain several production units each dedicated to a single product, or it might contain one production unit used to produce multiple products. Therefore, MA for multiproduction unit facilities uses data on chemical quantities crossing the production unit boundaries within a facility.

An illustration of points in a manufacturing facility that can be represented by MA data is shown in Figure 2.2, which was adapted from a case study used in an industrial waste audit and reduction manual (Ontario Waste Management Corp., 1987). This steel-pickling operation is used within a facility that manufactures nuts and bolts for the automobile industry. Before the steel can be drawn into wire for manufacturing, oxidized iron scale first must be removed from the steel with sulfuric acid. (Sulfuric acid is a TRI-listed chemical, and no quantities of the acid released in waste water should be reported if the acid is neutralized to pH 6-9, or if the acid is not transformed into another reportable substance.) Because the sulfuric acid is transformed into sulfate compounds as it flows through the pickling operation, MA can be applied more effectively by an approximate accounting of the sulfate flowing through the pickling operation based on purchase and waste disposal and treatment records.

The facility's purchase records provide the annual usage of sulfuric acid from which the sulfate input can be calculated. Waste disposal records indicate the amounts of spent pickle liquor and sludge (ferrous sulfate) found in the bottom of the pickling tanks. An analysis was performed to characterize the iron and sulfate concentrations in both wastes to determine waste-reduction or treatment options. The disposal records and the analytical results allow annual sulfate outputs to be estimated via spent liquor and sludge. Sulfate is also contained in the scrubber waste water and rinse water that are neutralized before discharge to the sewer. Sulfate releases to the atmosphere from the scrubber can be estimated from measurement data used to design the scrubber and the calculated removal efficiency of the scrubber. The amount of lime purchased and the portion judged to be used for neutralization during the year can be used to calculate the annual amount of sulfate output to the sewer using stoichiometric relationships of the sulfate-lime neutralization reaction.

SUMMARY

Table 2.1 summarizes the differences between EMB and MA approaches for several key parameters. The goal of closure for EMB requires extensive data and personnel with the technical skills to obtain and evaluate the data; therefore, EMB is expensive. The great diversity in the facility operations and in the characteristics of the chemicals handled, however, makes cost generalizations extremely difficult.

MA is less costly and complex because fewer data and less technical expertise are needed. MA is less accurate and precise than EMB, but material that cannot be accounted for does not necessarily reflect releases to the environment. Figure 2.3 presents an example of the difference in data requirements between EMB and MA for arsenic flowing through a primary copper smelting facility and fed into the smelter as a contaminant of the copper ore.

EPA presents the mass balance approach

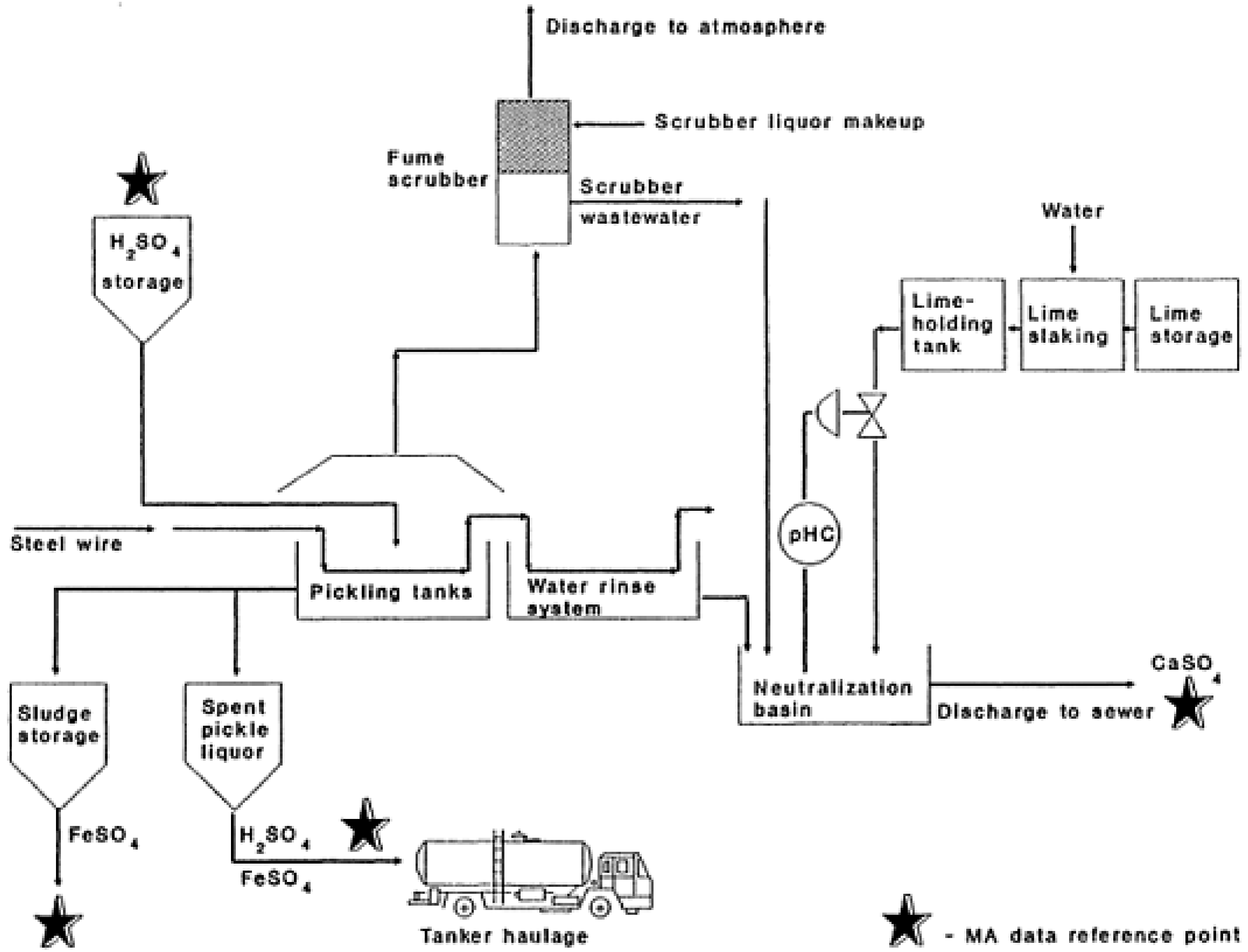


Figure 2.2
Illustration of MA data reference points at a facility using sulfuric acid to pickle steel. (Source: Ontario Waste Management Corp., 1987.)

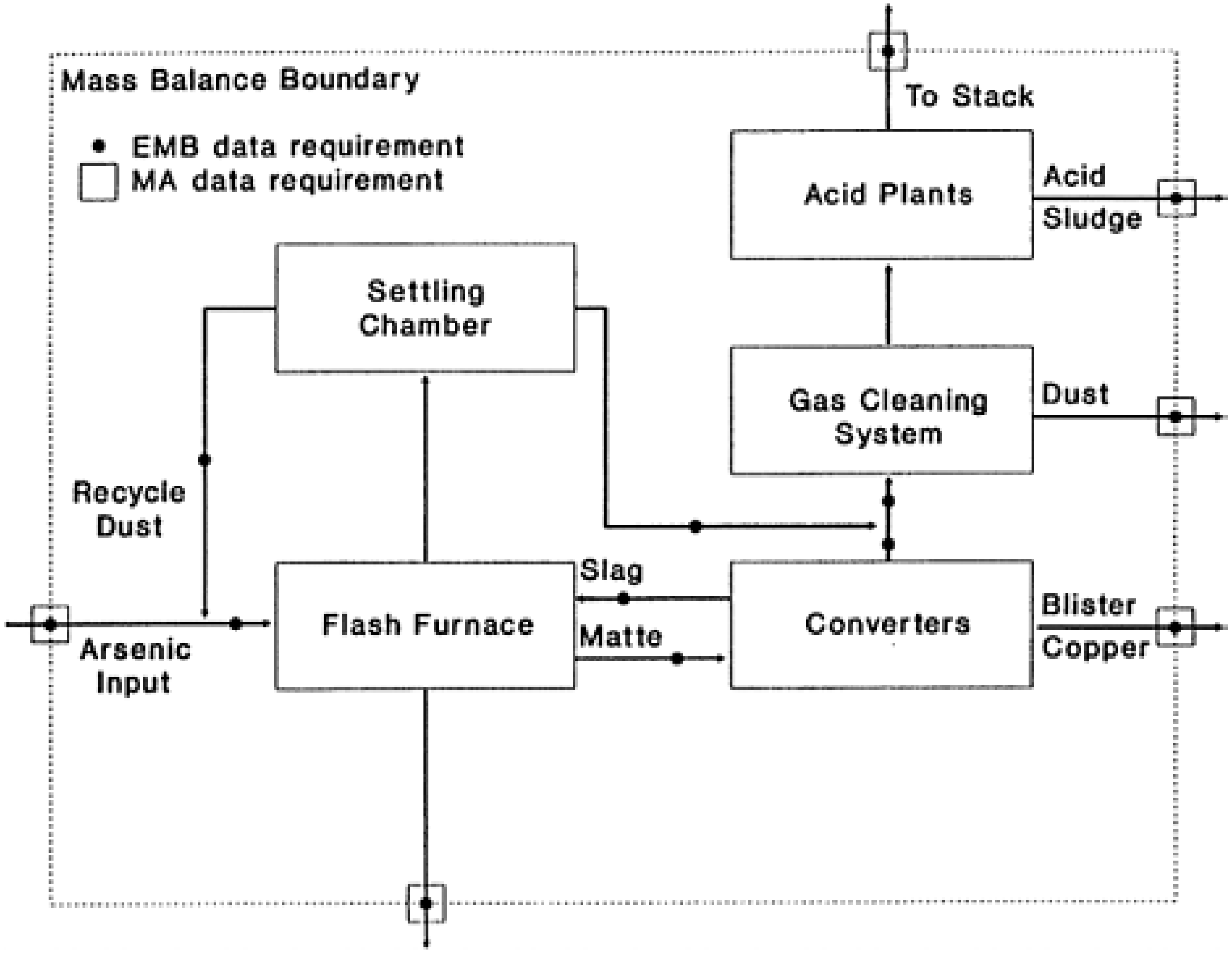


FIGURE 2.3
A comparison of data requirements for EMB and MA approaches for arsenic at a copper smelter. The illustrated EMB approach is considered a traditional approach, because it involves a rigorous evaluation procedure requiring accurate and precise measurements for each process step within the facility. A limited EMB approach obtaining measurements only at the boundary of the facility could be applied, but would provide little indication of likely sources of error, if closure were not achieved. The illustrated MA approach could, ideally, obtain data through the same measurement techniques used for a limited EMB approach, or it could rely on less accurate and precise data, such as purchase records. (Source: EPA, 1986a.)

(including the use of MA data) as a potential method for estimating environmental releases by taking the difference between input and product quantities (EPA, 1987). However, EPA cautions that significant release estimate errors can result from this procedure due to relatively small errors in the quantities used to estimate the releases. A properly designed and executed EMB or MA discourages and avoids the practice of assigning uncertain or erroneous data as being equivalences of environmental releases.

TABLE 2.1 A Comparison of Engineering Characteristics of EMB and MA Approaches

	Approach	
Characteristic	EMB	MA
Closure as objective	Mandatory	Not required
Accuracy of data	High	Variable
Level of detail of data	Each process step	Variable (facility level acceptable)
Data requirements	Extensive new data	Readily available
Skill requirements	Highly technical	Moderately technical
Additional cost	High	Low to moderate

3

Uses Of Materials Accounting Data

Other than efforts in New Jersey and Maryland, little multimedia mass balance information has been collected by federal and state government agencies. This reflects the traditional structure of environmental programs and their responsibilities as defined by most environmental statutes, which usually address specific media. For example, under the Clean Water Act, the potential for movement of pollutants to air or soil as a result of water-treatment measures is not considered in surface-water protection.

In researching mass balance practices by regulatory agencies, the committee was assisted by EPA and NGA. Many federal and state programs were examined through information provided by participants in a workshop held by the committee on March 24-25, 1988 (see Appendix E), but few uses of EMB or MA practices by regulatory agencies could be documented. Likewise, a limited amount of EMB and MA data were obtained from industrial representatives participating in the workshop. All of the relevant data obtained from industry and regulatory agencies were analyzed by the committee and most of these data are described in this report.

The focused scope and authority of major federal environmental statutes have precluded EPA from applying EMB or MA practices to regulatory programs. Some attempts under the Toxic Substances Control Act (TSCA) were made to collect mass balance information for selected substances, but these data were not widely available because of confidentiality restrictions (OTA, 1986).

The committee observed that uses of MA data have been more qualitative than quantitative. MA data were used by New Jersey and Maryland to help guide and rank efforts to understand and regulate toxic substances in the environment.

NATIONAL GOVERNORS' ASSOCIATION MASS BALANCE SURVEY

The committee was aided by NGA in conducting a survey to obtain information from the states about their past or current mass balance data collection (Johnson and Gooch, 1989). A survey questionnaire was sent to chief environmental protection officials in each state (Appendix F). A summary of the responses from NGA's report to the committee is presented in Table 3.1.

Twelve states have initiated or plan to initiate a collection of mass balance-oriented information; nonetheless, respondents com

TABLE 3.1 National Governors' Association Mass Balance Survey of State Governments[a]

States with Mass Balance-Oriented Information Collection, Past or Current	States That Plan Mass Balance Data Collection	States That Do Not Plan or Are Undecided on Mass Balance Data Collection
Connecticut	Delaware	Alabama
Maryland	Massachusetts	Alaska
Nebraska	Ohio	Arizona
New Jersey	Utah	Arkansas
Rhode Island	Wisconsin	California
Vermont		Colorado
Virginia		Florida
		Hawaii
		Idaho
		Indiana
		Iowa
		Kansas
		Kentucky
		Louisiana
		Maine
		Massachusetts
		Michigan
		Minnesota
		Mississippi
		Missouri
		Montana
		Nevada
		New Hampshire
		New Mexico
		North Carolina
		North Dakota
		Oklahoma
		Oregon
		Pennsylvania
		South Carolina
		South Dakota
		Tennessee
		Texas
		Washington
		West Virginia
		Wyoming

[a] Illinois did not respond to the survey.

monly expressed uncertainty about the practicality of mass balance activities and the value of such activities for agency programs. Seven states have performed a one-time survey or regularly collect mass balance data, and five additional states plan to collect these data. Eight states do not plan to collect mass balance data. The remaining respondents believed that the cost-effective-ness of mass balance data compilations needs to be demonstrated before agency resources are budgeted for them.

The few mass balance projects conducted by state agencies range from comprehensive reporting requirements for an entire industry to site-specific mass balance calculations made by state inspectors to determine compliance with air pollution regulations. All these mass balance efforts relied on MA data.

The New Jersey Department of Environmental Protection (NJDEP) maintains a program to collect mass balance information. Under the New Jersey Worker and Community Right-to-Know Act of 1983, the NJDEP compiles mass balance-related data, on a regular basis, from selected manufacturers as a supplement to reported environmental releases. For each substance on a specified list of chemicals, manufacturers must report annually the starting and ending inventory, in pounds; the quantity produced on site; the quantity brought on site; the quantity consumed on site; and the quantity shipped off site (as a substance or as a product). The model for this program was developed through the New Jersey Industrial Survey, which was initiated in 1976.

The Maryland Department of Environment conducted a survey of approximately 1,200 manufacturing sites in 1985 to obtain information on the amounts of specific chemicals flowing through these facilities. This information is referred to as "annual throughput" and is used by Maryland to set priorities for regulatory actions.

Air pollution site-inspection practices conducted by the Connecticut Department of Environmental Protection exemplify the use of mass balance-related data by the five other states reporting the collection of these data. Connecticut inspectors use mass balance data to estimate the quantities of solvents emitted into the atmosphere from industrial operations. Such calculations are used to determine compliance with mass emission limits for the hydrocarbons that react in the atmosphere to form ozone.

Air permits issued by the Virginia Department of Air Pollution Control and the Vermont Air Pollution Control Division also rely on mass balance information. In Virginia, permits to construct and operate a facility that would be a source of air pollution carry requirements to demonstrate (by use of a mass balance calculation) compliance with emission limitations and to indicate the expected level of solvent emissions. The agency also has a long-term survey effort under way to obtain detailed chemical use information from 4,000 to 5,000 sources of toxic chemicals. Mass balance data are sought in this survey from facilities where it is believed to be available. Vermont uses mass balance techniques in its State Emissions Inventory for planning and in case-specific permit activities.

The Rhode Island Department of Environmental Management and the Nebraska Air Quality Division use a form of mass balance information to support their air pollution control programs. In Rhode Island, certain industries are required to complete air pollution inventory questionnaires involving mass balance calculations. The questionnaire for degreasers and dryers, for instance, requires that industries report the amount of certain volatile organic substances purchased, the amount removed for disposal or reclamation, and the quantity recovered in carbon adsorbers. The amount purchased minus the amount removed or recovered is assumed to have entered the atmosphere through evaporation. The Nebraska Air Quality Division uses mass balance data to estimate toxic emissions and plans to use mass balance data in its Toxic Air Emissions Inventory.

Water pollution control programs in state agencies generally do not use mass balance information. This is also true of agencies whose responsibilities involve the regulation of hazardous wastes under the federal Resource Conservation and Recovery Act or comparable state authority.

New Jersey estimated that $75,000—$100,000 would be used for fiscal year 1989 to gather and compile mass balance information. Other states planned expenditures ranging from $2,000 to $275,000; however, the higher expected expenditures had no breakdown for estimates specific to mass balance collection. Maryland had no funds dedicated in fiscal year 1989 for collection of mass balance data. Additional information collection of this type is not planned.

USE OF MATERIALS ACCOUNTING IN NEW JERSEY AND MARYLAND

The potential value and utility of multimedia information long has been recognized by EPA. In 1978, under Section 28 of TSCA, EPA awarded grants to states to improve information on the manufacture, use, and discharge of toxic substances. Grants were received by New Jersey for the Industrial Survey Project and by Maryland for the Toxic Substances Registry System.

Both programs originated in the rising concerns about environmental and public health impacts of toxic pollutants (Maryland Department of Health and Mental Hygiene, 1983; NJDEP, 1986). In the late 1970s, an increasing number of epidemiological studies of the workplace and outdoor environments indicated potential associations between exposure to toxic substances and chronic diseases such as leukemia (Infante et al., 1977) and bladder cancer (Cantor et al., 1978).

The publication of these studies coincided with the release of the *Atlas of Cancer Mortality for U.S. Counties* by the National Cancer Institute (Mason et al., 1975). This atlas graphically presented U.S. cancer mortality by location for the period 1950-1969 and indicated statistically significant elevations in mortality in several industrialized areas. New Jersey led the nation in overall cancer mortality in white males. The National Cancer Institute used a geographic information system to link cancer mortality maps with demographic and industrial data at the county level. This information is used to generate hypotheses on cancer etiology that can be pursued by analytical epidemiological studies (Blot et al., 1979). This technique has suggested that, in addition to cigarette smoking, other environmental determinants (especially industrial exposures) are involved to an extent greater than previously thought.

Furthermore, analytic chemistry capabilities were refined greatly in the late 1970s, allowing identification of trace amounts of widely used toxic substances and pesticides in water supplies, air, and food. However, the cost and difficulty of routinely conducting these analyses could become prohibitive.

Although these new data did not demonstrate unarguable causal links between environmental exposures and disease, they did spur a movement by regulators and health investigators to understand better the manufacture, use, and discharge of toxic substances. Maryland and New Jersey initiated their MA studies with the goal of identifying sources of potential exposure to understand and prevent adverse human health effects (Maryland Department of Health and Mental Hygiene, 1983; NJDEP, 1986) and so pioneered the collection of MA information.

The New Jersey Industrial Survey Project

In 1977, existing information on potential sources of exposure to toxic chemicals was evaluated thoroughly by the newly established Toxic Substances Program (now the Office of Science and Research) of the NJDEP. This evaluation demonstrated the paucity of useful information in federal and state environmental databases and led to the development of the New Jersey Industrial Survey (NJDEP, 1986). The survey was followed by the passage of the New Jersey Worker and Community Right-to-Know Act of 1983, which was the basis of the current mass balance program.

The objectives of the New Jersey Industrial Survey were as follows:

- To establish a database about the manufacture, use, storage, processing, formation, release, disposal, and repackaging of a group of chemical substances selected on the basis of their carcinogenicity or other toxic effects. Of special concern were substances likely to be produced or used in large quantities in the state.
- To identify areas of the state and population groups that might be subject to an increased disease risk due to environmental exposure to toxic agents.
- To use the database to support the study of methods aimed at reducing or eliminating the release of toxic substances into the environment.

A list of 155 chemicals was developed for inclusion in the survey (Appendix G). Three major criteria were used to evaluate chemicals for inclusion:

- Evidence of chronic health effects, such as carcinogenicity, mutagenicity, or teratogenicity.
- Evidence of U.S. production in large-volume, commercial quantities.
- Presence on the EPA Priority Pollutant List.

The New Jersey Industrial Survey focused on the manufacturing sector and several other industry types known to handle large amounts of toxic substances. Approximately 15,000 facilities were surveyed, including those in Standard Industrial Classification major group codes 22 through 39 inclusive (Manufacturing Division), selected facilities in codes 46 through 49 (including pipelines, transportation services, communication, and electric, gas, and sanitary services), code 51 (wholesale, trade, nondurable goods), and code 76 (miscellaneous repair services). Facilities with more than five employees were included.

The New Jersey Industrial Survey contained provisions to protect confidential business information and specified penalties for noncompliance. The following list summarizes the information requested by the survey:

- Facility location, number of employees, and general use of selected substances.
- Operations at the facility involving each selected substance, including the quantities of raw materials used and products manufactured.
- Selected substances released into the atmosphere and the quantities released.
- Selected substances released into waste disposal streams, disposal methods, disposal sites, waste disposal technology employed, and previous disposal practices.
- Selected substances in the waste-water streams, treatment prior to discharge, and quantities discharged to publicly owned treatment works.
- Information on other points of release of the selected substances.

Companies were to report the use or release of any quantity of each substance; no minimum reporting requirement was established. Respondents that were unable to provide actual figures were required to supply estimates derived from engineering estimates; process-related mass balance studies; or field tests conducted by the facility, equipment manufacturers, or governmental agencies. Less than 10% of the respondents requested confidentiality of reported information (NJDEP, 1986).

Validation of Information Reported

Realizing the complexity of the information requested and the substantial potential for inaccurate reporting, New Jersey made a commitment to provide expert assistance to respondents and to conduct routine field audits. An engineering staff reviewed all responses and worked with respondents to improve response quality. At most major manufacturing facilities in the state (several hundred), field audits were conducted after the responses were received. Individual processes were reviewed, and all points of use and release were tracked. As a result of this extensive validation program, original reports were revised for 75% of the survey respondents, which greatly extended the time necessary to develop accurate information. The original release estimates for approximately 25% of the survey respondents were revised due to gross errors in release estimates. In some cases, the 90-day reporting period was extended for several years before responses were made final. Revisions were necessary for a broad range of reasons, including improper identifications (e.g., permit numbers) as well as gross underreporting of releases (e.g., such as small facilities using open tanks of solvents and reporting negligible releases).

Although the New Jersey Industrial Survey is the most comprehensive survey conducted to date, the information has many limitations. The survey response rate was 43%, which constrained data interpretation. New Jersey estimates that the response **rate** would have been approximately 50% if procedural problems had not been encountered in mailing the survey (e.g., inaccurate mailing lists) (NJDEP, 1986). And, although technical reviews and field audits were done to verify reported information, the collected data may underrepresent releases from all relevant facilities in New Jersey, because not all facilities provided data. In many cases, field audits revealed that erroneous information was reported—and audits were not conducted at every facility. New Jersey officials have stressed that, in the absence of field audits or monitoring data to follow up survey responses, it is impossible to ensure the validity of reported emission and discharge information without additional information on the quantities of the raw materials used and the products manufactured (Stevenson, 1988).

New Jersey reports that the Industrial Survey information has been used for several, mainly qualitative, purposes, including the following:

- Occupational health surveillance to help define the number of workplaces in which toxic substances are used and the number of workers who are potentially exposed. More than 80% of the workplaces with potential exposures to mercury would not have been identified without the survey (NJDEP, 1986).
- Identification of specific industrial activities as potential sources of water contamination in a study of hazardous contaminants in New Jersey public water supplies (NJDEP, 1986).
- A statewide dioxin investigation to find several previously undetected industrial sites with workplace and environmental contamination with 2,3,7,8-tetrachlorodibenzo-p-dioxin. Extensive contamination of soils near the Passaic River was discovered, which prompted an investigation of the river and uncovered contaminated sediment and aquatic biota (NJDEP, 1985).
- Refinement of the New Jersey environmental permit process by allowing the state to improve its assessment of discharges and apply more relevant conditions for the issuance of permits (NJDEP, 1986).
- Enforcement and regulatory support to develop the Environmental Cleanup and Responsibility Act, the Toxic Catastrophe Prevention Act, and the New Jersey Pollution Discharge Elimination System. The state is using survey information to assist in the development of the Air Toxics Strategy to revise regulations concerning the emissions of toxic chemicals into the environment (NJDEP, 1986).
- As the precursor to the implementation of the New Jersey Worker and Community Right-to-Know Act. New Jersey relied on experience gained in conducting the survey to determine its approach for implementing portions of this act. For example, two SIC codes were added, because in conducting the survey, New Jersey found that facilities in SIC codes 20 and 21 (food and tobacco manufacturers) use considerable amounts of hazardous substances (NJDEP, 1986).
- By a public-interest group, INFORM, as a basis for a preliminary characterization of waste generated at New Jersey facilities for an extensive study on reduction of waste generated at chemical manufacturing facilities (Sarokin et al., 1985).
- Improved information for risk communication (e.g., statewide and community profiles of chemical use and release). This has greatly assisted in risk communication efforts with community groups.
- Focusing and planning hazardous waste-reduction efforts. New Jersey has begun to develop a program to use MA information, collected through the Industrial Survey and the Worker and Community Right-to-Know Act, to develop approaches that consider efficiency of waste reduction within facilities or across industries. MA data will be used to set priorities among facilities of various industries for waste-reduction attention (Jeanne Herb, NJDEP, personal communication, March 29, 1989).
- Assessment of the potential human exposure to industrial releases within an Elizabeth, N.J., community (NJDEP, 1984).
- Identification of major source facilities of vinyl chloride monomer. Initial on-site inspections of these facilities resulted in one facility being referred for enforcement actions for chemical spillage and discharge problems (NJDEP, 1984).

The Maryland Toxic Substances Registry System

Before Maryland had developed its Toxic Substances Registry System, Baltimore and its surrounding counties were identified by the National Cancer Institute as having elevated mortality rates for several types of cancer. Concerns were heightened by incidents involving accidental or uncontrolled releases of toxic substances from storage tanks.

The paucity of information available on the sources of carcinogens and other toxic substances led Maryland to begin a survey of its industries in 1976 (Maryland Department of Health and Mental Hygiene, 1983). In 1978, an EPA grant authorized by Section 28 of the Toxic Substances Control Act enabled Maryland to expand its survey and combine other related toxic substances information into a common database called the Toxic Substances Registry System.

The system was tested and refined over the next 7 years; it was fully implemented in 1985 to focus on industries that met any of the following criteria:

- SIC Code with the first two digits in the range from 20 through 39.
- Large-scale industries with air pollution control equipment registered by the Maryland Air Management Administration.
- Facilities, regardless of size, identified from Maryland Department of the Environment records as using exclusively or, to a large extent, using one or more of the chemical substances listed in the survey.
- Facilities with a history of violations or experiencing difficulties complying with emission regulations and various types of research laboratories.

Conducted in 1985, the survey covered 274 chemicals divided into two groups with different reporting thresholds in the amounts of chemicals handled by a facility (Appendix H). The following criteria were used to evaluate chemicals for inclusion on this list:

- Evidence of link with carcinogenicity.
- Previously studied as toxic chemicals by other states.
- Evidence of U.S. production in large-volume, commercial quantities.
- Record of production within Maryland.

The survey form was sent to 1,200 facilities in 1985 and is referred to as the Chemical Inventory Report. The response rate was approximately 90%. This form consisted of three parts: general information, a chemical questionnaire, and a storage tank questionnaire. The chemical questionnaire contains the MA information and requested a description of how each listed chemical was used, produced, or handled. Other types of information requested included means by which the chemical was transported to the facility, type of storage used, maximum amount of each listed chemical stored on site at any time, and total amount of each chemical used during the reporting year. No information on chemical releases to the environment was collected through this effort. Any information considered to be confidential by the reporting facility and Maryland was presented so as not to disclose trade secrets or proprietary information.

The Toxic Substances Registry System relied on the use of existing MA-type information and did not require facilities to conduct monitoring or carry out other data collection to validate reported amounts. Files for each facility included cross-references of all permits. Available EPA databases also were used to compile the information.

The Toxic Substances Registry System has provided useful information to guide the state's efforts in air, water, and waste cleanup by providing a means to identify previously unregistered air pollution sources. The data from this system were used to establish priorities for Maryland air toxics regulation and to establish a list of toxic air pollutants for which facilities will be responsible for reporting environmental releases. These regulations were made final on July 29, 1988.

Maryland has linked the Toxic Substances Registry System with the Statewide Cancer and Birth Defects Registries and the Occupational Disease Reporting System in support of various epidemiological studies (Khoury et al., 1986). When geographic clusters of birth defects or occupational diseases are observed, these will be compared with the toxic substances database in a search for correlations.

SUMMARY

The Maryland Toxic Substances Registry System and the New Jersey Industrial Survey together provided the model for the TRI. Both states claim that these MA data projects have benefited their regulatory and public health efforts by providing a focus and ranking within diverse strategies to understand and regulate toxic substances in the environment. In New Jersey, the usefulness of the project would have been reduced greatly if only release information had been collected.

The organizational and resource commitments made by New Jersey during its Indus trial Survey are a major reason for the quality and utility of the collected MA information. This information was accessible and useful to the environmental and health agencies, with dedicated staff available to assist a wide range of applications.

The experiences of New Jersey indicate that MA data can be important, in a qualitative sense, in developing, validating, and assessing information on toxic chemical releases. The New Jersey Industrial Survey provided a means to confirm in overall terms chemical release information obtained from other sources and, in some cases, to provide insights into important, previously undocumented release pathways.

Because neither state's effort was conceived with waste-reduction efficiency as an explicit component, neither state has assessed the relevance of its approach to quantitative waste reduction. The New Jersey information is an important qualitative component of that state's current waste-reduction efforts.

Efforts in both states support the utility of MA information for addressing a variety of issues concerning public and occupational health. Both states have examples of the utility of MA information to the public and policymakers. In addition, with the reporting requirements in place, both states report few requests for confidential business information protection, and therefore the overall utility of the projects were not hindered.

4

Accuracy Of Toxic Chemical Release Estimates

Congress was aware that the toxic chemical release estimates reported under SARA Section 313 might not accurately reflect the amounts actually released from reporting facilities (U.S. Congress, House, 1986). This potential inaccuracy is based on the provision that quantities of chemical releases can be obtained from theoretical calculations, engineering estimates, or by subtracting mass balance quantities (e.g., chemical quantity purchased minus the quantity contained in the product) rather than from measurements of actual releases.

This chapter discusses the applicability of EMB and MA in providing a reference value to assess the accuracy of a toxic chemical release estimate. EMB provides measurement data of releases that have been evaluated through a check for closure. When releases have not been measured directly, the reference value is calculated by taking the difference between the sum of measured inputs and the sum of measured outputs. The committee also considered the use of mass balance data for assessing the nature of reported releases in the context of the way manufacturing facilities produce and use toxic chemicals. Release data from facilities that produce and use TRI-listed chemicals are used to demonstrate how mass balance data could provide information on release estimate reasonableness.

ENGINEERING MASS BALANCE

The use of EMB at industrial facilities is similar to the use of a rigorous, double-entry recordkeeping system. Figure 4.1 is an example of a ledger sheet for mass balance components. The ledger has a credit column for materials transported into or produced at a facility and a debit column for materials consumed at or in some other way subtracted from a facility.

The handling of arsenic (a TRI-listed chemical) at a copper smelter is an example of how mass balance components would be entered on the ledger sheet for a smelter facility. The credit column of the ledger sheet would list arsenic transported into the smelter facility as a contaminant of copper ore. The debit column would include the quantity of arsenic transported from the facility as a product (blister copper) contaminant and released to the environment via the furnace slag, flue dust, and scrubber sludge generated during the smelter operation.

Credit	Debit
1. Transported into facility	1. Consumed at facility (to produce a product or, e.g., to control pollution)
2. Produced at facility as:	
a) product b) byproduct c) raw material contaminant	2. Use at facility
	3. Accumulated at facility
	4. Released from facility, via.
	a) air b) water c) solid waste
	5. Transported from facility

Figure 4.1
Ledger Sheet for Quantities in an EMB

Although it is feasible to perform EMB for individual processing steps or simple production processes, it is almost impossible to obtain complete closure in EMBs for complex industrial facilities. As discussed in Chapter 2, EMB analysis or MA practice is limited by measurement error and the assumptions or judgments necessary to implement the analysis. When the quantities of mass balance components are very different (e.g., thousands of tons versus hundreds of pounds), imbalance between the inputs and outputs likely would be greater than the smallest component quantity. Therefore, to work within the limits inherent in EMB, the smallest component must be at least several times greater than the largest uncertainty in the other mass balance components. This condition often results when the quantity of each mass balance component is approximately equivalent in order of magnitude.

EMB analysis performed on a degreasing operation within a manufacturing facility that does not recover any of its used solvent is an example of input and output quantities being within approximately equivalent orders of magnitude. In this case, the extent to which closure is obtained would provide a good assessment of the validity of the release estimates. The imbalance resulting from EMB likely would be less than any of the amounts quantified—purchases, environmental releases, and spent solvent shipped off site.

Alternatively, consider a facility that produces 5 million lb per day of ethylene as an example of a mass balance analysis on input and output quantities with great differences in orders of magnitude. Even though EMB at this facility achieved closure to within ±1%, an imbalance of ±50,000 lb of ethylene per day remained. Emissions of ethylene from this facility were estimated to be 191 lb per day by recognized calculation techniques—confirmed by monitoring data (Chlapek, 1988). In this case, even a small-percentage imbalance overwhelms the emissions estimate because of the great disparity between the quantity of material fed into the facility and the amount released. This example illustrates that even a high degree of closure is of little use in evaluating the accuracy of release estimates if the orders of magnitude in mass balance components differ greatly.

The committee constructed the 2 × 2 matrix in Fig. 4.2 to illustrate the potential utility of EMB for determining the accuracy of information on toxic chemical releases to the environment. For cases A and B, accuracy of the reported release estimate is assessed by comparing it with measured release data obtained through an EMB. When all EMB components are measured and involve equivalent order-of-magnitude quantities, EMB might have significant utility for determining the accuracy of release estimates (A in Fig. 4.2). When all components are measured but the magnitude of those components is disparate, the potential value of EMB is low (B in Fig. 4.2).

	WAYS TO ASSESS ACCURACY OF REPORTED RELEASES	
EMB data	Measure all quantities; check degree of closure	Determine releases by calculating difference in measured quantities
Order-of-magnitude equivalence for all quantities	High potential value Ⓐ	Limited value; (no potential value when reported releases obtained by difference) Ⓒ
Major disparity in quantities	Low potential value Ⓑ	No potential value Ⓓ

Figure 4.2
Potential value of an EMB approach in determining the accuracy of information on toxic chemical releases to the environment.

When EMB data are not available on environmental releases, they sometimes are estimated by assigning the release as the value of the difference between the sum of the inputs and sum of the outputs other than releases. Congress acknowledged that this approach might be used to estimate mass balance components: "quantities [to apply in the mass balance] . . . will be determined by a variety of methods including . . . estimates derived from differences between measurements . . ." (U.S. Congress, House, 1986). For cases C and D, accuracy is assessed by comparing the release estimate with the release determined by calculating the difference in measured quantities. However, the accuracy of a release estimate cannot be checked by comparing it with the value obtained by taking the difference between inputs and outputs other than the release if the reported estimate was obtained in the same way.

This approach to estimating releases by difference should be applied only to facilities where the input and output streams containing the chemical of interest are readily identified, and the mass balance components are of similar orders of magnitude. The quantity of releases from the facility with the degreasing operation described above probably represents the difference be tween the solvent purchased and the spent solvent shipped off site (C in Fig. 4.2). However, this approach is likely to be a less reliable check on accuracy than the measurement of all EMB data.

Estimating releases by difference can produce misleading information or lead to misapplications, even if the mass balance components are judged to be of similar orders of magnitude. For example, two EMBs were performed for two different facilities that produce methyl chloride and methylchlorosilane (Supple, 1988). To obtain a methyl material balance over both facilities, all components were independently determined, except for emissions to the atmosphere. Closure to within 1% was achieved. Methyl emissions were calculated as the difference between the sum of inputs (18,167,000 lb) and outputs (18,356,000 lb) for a fixed period. Emissions were assigned a value of-189,000 lb of methyl per period, implying that methyl compounds were being recovered from the air, which is obviously false. Calculating the emissions by using factors provided by EPA resulted in an emissions value of approximately 37,000 lb of methyl for the same measurement period (D in Fig. 4.2).

By comparing the magnitude of uncertainty in mass balance data with the magnitude of releases, the committee determined that, in the context of this study, mass balance data are not generally adequate to assess the accuracy of release estimates. Although this approach can be considered a rudimentary error analysis, it was sufficient to answer the question, and more rigorous quantitative methods (e.g., probability density functions) were not necessary.

MATERIALS ACCOUNTING

As discussed in Chapter 2, MA is inherently less accurate and precise than EMB. Therefore, MA practice generally precludes obtaining useful information on the accuracy of chemical release estimates, such as those reported to the TRI. However, MA information could provide improved public insight for understanding the nature of current releases, if the program to collect MA information were well designed and properly conducted. The usefulness of MA, supported by technical assistance and expert analysis, is discussed in detail in Chapter 7. Although EMB could also provide these benefits, the accuracy, precision, and expense of EMB are not necessary for achieving them.

The examples provided below describe the circumstances under which MA information could improve understanding of chemical releases. The illustrations also point out some of the knowledge useful for the analysis and interpretation of MA information and the need for a clear plan for ultimate use and application of information before reporting is implemented. For purposes of discussion in these examples, MA information is the following:

- Quantity of a listed chemical produced at a facility.
- Quantity of a listed chemical brought into a facility.
- Quantity of a listed chemical consumed at a facility.
- Quantity of a listed chemical shipped from a facility as product or in products.

MA: Illustrative Applications

The following scenarios are based on use of a single chemical, although actual conditions probably would be more complex than those presented.

- An adhesive manufacturer uses a chlorinated solvent—1, 1, 1-trichloroethane (TCA)—in adhesive formulations. Very small amounts of TCA are emitted to the atmosphere during the blending process, and only a small amount of adhesive waste-containing TCA is generated. Waste-water releases are also small; most of the TCA is part of the final product.
- In the same city, a lock manufacturer uses TCA in a vapor degreasing operation to remove cutting fluid from locks. Approximately 93% of the TCA is emitted to the atmosphere, and 6.7% is contaminated waste solvent.
- A third facility manufactures TCA. A small amount of the chemical is lost in the process as fugitive emissions. A waste product containing TCA at a low concentration, unreacted precursor chemicals, and other unwanted byproducts is sent off site for disposal.

Each firm must report TCA releases to the TRI, because each exceeds the SARA threshold use or production level for the chemical. A summary of the MA data for each of the three facilities is listed in Table 4.1. (It was assumed that none of the TCA is inventoried; that is, in a given year, all TCA that is purchased or produced is not accumulated at the facility but leaves the facility as a product or is otherwise released.)

The adhesive manufacturer and the lock manufacturer almost certainly would estimate their values for releases to air by difference. Both facilities know the amounts of TCA brought on site to the level of accuracy recorded on their purchase records. The adhesive manufacturer also knows the amount of TCA transported off site as a product with reasonably good accuracy. Both facilities are required to report the amount of TCA sent off site as waste. The adhesive manufacturer probably knows the amount of TCA discharged to water because of sewer regulations. The remaining term in both cases—the amount of TCA released to air—was determined by difference.

Interpreting Release Data

The chemical manufacturer, who has low emissions, makes TCA as a product. When it is sold to firms, such as adhesive manufacturers and lock manufacturers, and used in processing, emissions occur as shown in Table 4.1. Emissions from adhesive and lock production are approximately the same (about 28,000 lb), but they occur at different times and locations.

The people in the community who are unfamiliar with the specifics of production processes might compare the three facilities releasing the same chemical. Why are the releases from the lock manufacturer so high? If the adhesive and chemical manufacturers have such low releases, why can't the lock manufacturer reduce his releases?

In the case of the adhesive manufacturer, most—27,000 lb—of the 30,000 lb of TCA purchased was sent off site in the product. This adhesive product will be purchased by construction facilities or consumers who use the adhesives in homes and buildings. When the adhesive is used at these thousands of different sites, all of the TCA will be emitted into the atmosphere. The adhesive facility's direct releases to the environment are small: 500 lb, or 1.7% of its purchases, is released to the air and water; and 2,000 lb, or 6.7% of purchases, is waste. After accounting for releases resulting from consumer use, however, 27,500 lb is released into the atmosphere.

The lock manufacturer has a very different operation. The facility uses the TCA to clean the locks, and none of the solvent is incorporated into the final product. Production-site air releases are very high—28,000 lb, or 93% of purchases—reflecting the volatility of the chemical, a characteristic that makes it a desirable solvent. TCA waste amounts to 2,000 lb, or 6.7% of purchases.

The chemical manufacturer has yet a different operation. The facility's releases are small (5% of production). Most of the releases occur to the air—l,000 lb, or 3% of production. The remaining losses to the water and as hazardous waste are 0.7% and 1% of production, respectively.

MA Characteristics

Estimates of releases to air and water and waste sent off site reported to the TRI are presented in the three bottom rows in Table 4.1. Additional data that might be required in MA reporting are found in the four top rows of values in Table 4.1. These data might be used to explain measures taken to protect against chemical releases that communities might perceive as posing a threat to human health and the environment. The additional data in the top four rows of Table 4.1 should be examined to determine whether they contribute to a better understanding of TRI data.

Additional MA information could be collected on chemicals of special interest. If it is assumed that TCA is one of these substances, then the data in the four top rows of Table 4.1 are useful for comparing operations between different industries using the same listed chemical and for helping to identify large procedural errors in reported release estimates, particularly overestimates.

First, the additional data would allow better comparisons to be made among manufacturers in a particular industry. For instance, two adhesive manufacturers might purchase 30,000 lb of TCA. If one manu facturer ships 27,000 lb off site in the product and another ships only 20,000 lb, the latter manufacturer might be presumed to have a relatively inefficient operation. If only release data were collected, total releases to the environment in the first case would be known to be 3,000 lb; it would also be known that releases were much larger (10,000 lb) in the second case. With only the release data, it would not be obvious that the manufacturers purchased the same amount of TCA. Indeed, because the losses in the second instance are so much larger, it could be assumed that the facility purchased much more TCA.

TABLE 4.1 Approximate Annual MA Quantities of TCA (lb)

	Facility Type		
MA Components	Adhesive Manufacturer	Lock Manufacturer	Chemical Manufacturer[a]
Transported into, produced on site, or purchased	30,000	30,000	30,000
Consumed or used	30,000	30,000	—
Accumulated	0	0	0
Transported off site as product	27,000	0	28,500
Released to air	500[b]	28,000[c]	1,000
Released to water	500	0	200
Sent off site as waste	2,000[d]	2,000	300

Note: Although the three cases in the table are hypothetical, an attempt has been made to estimate the emissions realistically using information contained in EPA documents. Specific documents are cited in other footnotes to this table.

[a] Maximum losses of TCA based on production process described in Key et al. (1980).

[b] Assumes small fraction of emissions occur in facility.

[c] Assumes about 94% of solvent is emitted during use; the balance is solid waste. See EPA (1985b,c) and Pandullo et al. (1985) for estimates of atmospheric emissions of other, similar chlorinated solvents in degreasing applications.

[d] Assumes that waste losses are those reported as "solid waste" plus "storage/waste disposal/destruction in end product," plus one-third of the TCA recovered and sold as waste solvent.

Second, the additional data demonstrate differences among types of industry in which identical chemicals are involved. Table 4.1 shows that none of the solvent leaves the lock manufacturer's facility in the product. In fact, since the TCA is used only to clean locks, all of it is lost through releases, and the additional data demonstrate that none of the TCA is put into the product. This information contrasts with that for adhesive manufacturing, in which nearly all of the solvent ends up in the product.

Third, the additional data can be used to enhance efforts to validate reported releases by helping to identify large overestimates. For example, the adhesive manufacturer could mistakenly report the total mass of water and contaminants discharged, instead of reporting the mass of TCA contained in the water. In this case, the total mass of waste water would significantly exceed the TCA mass transported into the facility and the amount transported off site as product, thus appearing as an obvious reporting error. However, without the additional information shown in Table 4.1, it would be much more difficult to detect this overestimate.

CONCLUSIONS

Neither EMB nor MA is generally adequate, in the context of this study, to assess the accuracy of estimates of toxic chemical releases. Although direct measurement of releases is the best approach, this might not always be feasible because of the potential lack of satisfactory analytical procedures for some TRI-listed chemicals.

EMB approaches have only limited applicability for assessing the accuracy of toxic chemical releases. Only in circumstances in which all quantities can be independently measured and are within an equivalent quantitative order of magnitude can EMB serve as a check on the accuracy of methods of estimating toxic chemical releases.

MA is even less precise and less accurate than EMB. MA also does not have the potential to assess the accuracy of estimates of toxic chemical releases.

However, EMB or MA information might be helpful for detecting gross errors in reported estimates of environmental releases and for improving understanding of chemical use patterns and environmental releases, provided that data collection is accompanied by expert technical knowledge, data validation, and analysis. MA has a better potential for these applications than EMB, because MA typically is less difficult and less expensive to obtain. Therefore, further consideration of MA information is warranted.

5

Assessing Waste-Reduction Efficiency

INTRODUCTION

SARA Section 313(1) charged NAS "to assess the value of obtaining mass balance information, or portions thereof [e.g., production rate], to determine the waste reduction efficiency of different facilities, or categories of facilities, including the effectiveness of toxic chemical regulations promulgated under laws other than this title." In analyzing the use of mass balance data for this purpose, the committee defined efficiency as progress made by a facility in reducing its waste (see below). The waste under consideration could be contained on site, released to the environment from the facility, or contained and shipped off site to another facility. This chapter evaluates both EMB and MA practices for use in a program to track waste-reduction progress according to their potential for providing indicators of (a) the amount of waste generated and the association between the level of manufacturing activity, (b) the amount of reduction at the source of generation (versus reduction before treatment, such as by incineration), and (c) the comparability of the collected data among a wide variety of manufacturing facilities.

Regarding the "effectiveness of toxic chemical regulations promulgated under laws other than this title," the committee assessed mass balance data for its usefulness as a generic indicator of the effectiveness of any relevant regulations while accounting for changes in production rate at a reporting facility. This approach is consistent with discussions of this part of the charge by Congress (U.S. Congress, House, 1986).

Waste Reduction

In the absence of a widely accepted definition for waste reduction, the committee assigned to waste reduction the same definition given for waste minimization in Form R (see Appendix C) for TRI reporting. In this report, therefore, waste reduction includes any of the following activities performed on wastes generated within a facility: recycling or reuse on site; recycling or reuse off site; equipment or technology modifications, production procedure modifications, and redesign (modification) or reformation of a product; substitution of raw materials; and improved housekeeping, training, and inventory control, as well as any other technique that results in reduction or elimination of waste released to any environmental medium.

This definition is consistent with that presented in a previous NRC report (NRC, 1985). Waste reduction was defined in that report to include "both changes in the production processes and recycling and reuse of hazardous materials either at or away from the site of generation." Recycling, particularly recycling within manufacturing facilities, is included in this report's definition of waste reduction, because it is a technique that usually cannot be divorced from the manufacturing activity. Furthermore, recycling is clearly different from the treatment of waste before environmental release.

The committee acknowledges that this definition of waste reduction is broader than those others have proposed (e.g., Sarokin et al., 1985; OTA, 1986, 1987; see Appendix I). However, the committee chose a broad definition of waste reduction to allow analysis of mass balance information to be applied to any facility reporting waste information, regardless of the way the facility deals with the waste it generates. In discussing the OTA's findings and conclusions on waste reduction, the committee acknowledges that the OTA's definition of waste reduction differs from that used in this report.

Waste-Reduction Efficiency

Some measure of waste-reduction efficiency assists in comparing the waste-reduction efforts of different facilities and in determining whether waste reduction is limited by the type and rate of operation. Congress defined waste-reduction efficiency by example: "For example, can this [mass balance] information reasonably be used to compare different facilities in the same business to determine whether one is applying more rigorous environmental control than another, or delineate whether reduced releases of chemicals reflect improved control or limited operation" (U.S. Congress, House, 1986).

For this report, the committee defined waste-reduction efficiency as a quantitative measure of progress in waste reduction. A waste-reduction-efficiency measure is most useful when it is generally applicable among facilities of many types.

A consistent definition of the waste that is subject to reduction is essential to establishing any waste-reduction-efficiency measure, especially for different regulations that affect similar facilities. Waste definitions in regulations developed under SARA and the Resource Conservation and Recovery Act (RCRA) differ, although they affect similar manufacturing facilities; therefore, waste-reduction measures developed from these facilities might vary as a result.

Total waste is the object of RCRA, but individual chemicals contained in waste are the object of SARA. Reductions in total waste could occur and be documented under RCRA without being documented under SARA if specific waste components were not produced by the manufacturer. Furthermore, no information is collected under either regulation to indicate whether a reduction in total waste quantities generally correlates with reductions in the listed chemicals within the wastes (see Appendix I).

DATA FOR ASSESSING WASTE-REDUCTION EFFICIENCY

Amounts of waste generated as the result of specific activities from specific sources within facilities can be reported in three ways:

- For each *source*, such as a single mixing tank.
- For each *production unit*, such as phosgene production within a chemical production facility.
- For an entire *facility*, such as each waste stream exiting the facility into air, water, or land.

Many different activities (and therefore, many different sources) make up a single production unit, and one or more production units are present at any facility. Collecting data from each individual source theoretically would achieve the most accurate reporting. Such source-specific information often is required for EMB. However, collecting, reporting, producing, and evaluating such extensive and detailed information for all regulated facilities in the United States would be an enormous task.

Collecting production-unit operation and flow data is a less detailed way to assess waste reduction. Such data include describing each step of an activity associated with each production unit and tracing the flow of material through each step. The data also include the amount of material handled in the entire production unit and the total amount lost at each step. Production-unit data can disclose minute changes in waste-stream composition and flow rate. Although less detailed than source-specific data, production-unit data are much more detailed than data typically collected through pollution-control programs, which often focus on limiting overall releases from facilities (e.g., discharges from an on-site waste-water treatment facility handling waste streams from multiple production units). Despite accurate monitoring of waste-reduction practices, these data are difficult to use for comparative analysis for several reasons. No standard nomenclature exists for production units. Furthermore, production units do not have fixed boundaries; some facilities consider transfer activities as part of a production-unit process and other facilities consider these as activities outside of the production unit. Also, production units with identical names can vary extensively among different facilities.

Facility-level data, the least detailed type of data considered, are collected through TRI reporting and many pollution-control programs. For specific chemical reporting (as for the TRI), facility-level data are sufficient to allow measurement of the facility's waste-reduction efficiency, because all sources and production units generating waste within the facility are represented. If progress were made in reducing the amount of waste generated from a specific production unit, then there would likely be less waste contributed to streams exiting the facility.

The committee evaluated only MA information for practical applications to assess waste-reduction efficiency. EMB was not evaluated because it requires a detailed analysis of all material streams within and across facility boundaries in order to attain closure for all mass flows into and out of a facility. Closure, however, is not a criterion for assessment of waste-reduction efficiency. As discussed later in this chapter, individual components (e.g., production rate) of mass balance data are evaluated for assessing waste-reduction efficiency, and these data can be obtained through the MA approach. Instead of assessing waste-reduction efficiency, EMB can be useful in the identification and characterization of sources of waste within a facility. For example, E.I. du Pont de Nemours & Co. at Beaumont, Texas, has used EMB for a mass balance of total carbon in its acrylonitrile manufacturing facility to trace the steps in the process in which byproducts with high boiling temperatures are formed (Jordan, 1988); Oman and Ham (1988) describe how the foundry industry uses EMB to locate sources of waste within the foundry production. However, OTA concluded (1986) that for an entire facility EMB typically would have a level of error such that it would give little information on where substances appear as waste in the facility.

REPORTING REQUIREMENTS

A facility-level MA approach was used as part of the New Jersey Industrial Survey. Because the survey was not conceived with waste-reduction efficiency as an explicit component, the state did not assess the relevance of the MA data for this purpose. Several organizations, however, have used these MA data for waste-reduction investigations.

Based on data collected through the New Jersey Industrial Survey, the Natural Resources Defense Council (NRDC) has proposed a single waste-reduction performance standard that would require facilities to manufacture, produce, or otherwise use specified chemicals with a minimum level of *efficiency* (Clarence-Smith, 1988a; see Appendix J). In this case, efficiency is defined as the ratio of the total amount of a chemical released to the environment from a facility to the total amount of that chemical routed through the facility in one year. In addition, INFORM, Inc. (a nonprofit research organization that identifies and reports on practical actions to protect and conserve natural resources), used MA data collected under the New Jersey Industrial Survey for a preliminary characterization of waste generation in organic chemical manufacturing facilities located in New Jersey (Sarokin et al., 1985).

INFORM, Inc., and OTA concluded that the government files containing information are too fragmented and incomplete to assess waste-reduction progress adequately (Sarokin et al., 1985; OTA, 1986). Under the New Jersey Worker and Community Right-to-Know Act of 1983, the state now requires the reporting of waste-minimization information, but reporting this same information on TRI's Form R is optional. As mentioned in Chapter 3, New Jersey plans to use this MA information in developing waste-reduction efforts that consider levels of efficiency within facilities or across industries. MA data will be used to set priorities among industries and facilities for waste-reduction attention.

The optional "Waste Minimization Section" on TRI's Form R requests the following information:

- Type of modification (waste-minimization activity).
- Quantity of the chemical in the waste stream before treatment or disposal.
- Index (ratio of reporting year production to base year production).
- Reason for minimization action.

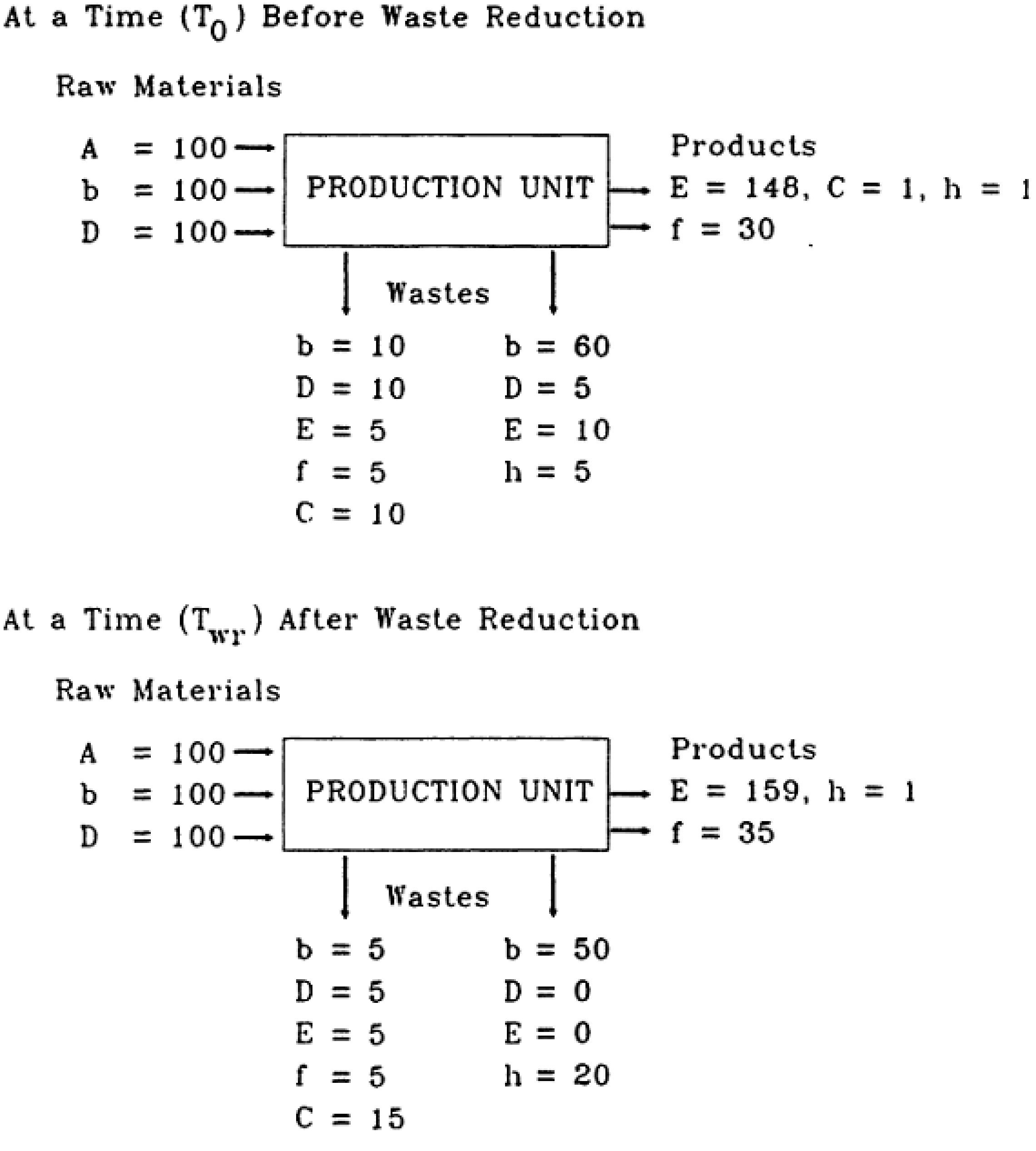
However, Form R instructions suggest that the database will contain an aggregation of different types of information that could be used to assess waste-reduction efficiency. The instructions indicate that the amounts of waste from cleanups of areas associated with abandoned operations should not be reported separately from waste generated from ongoing operations. Therefore, reported amounts of cleanup wastes and other onetime wastes will mask the amounts of, and trends in, wastes generated from ongoing operations. In addition, facilities are allowed to present data based on estimates, and any one facility could use different estimation methods for reporting in succeeding years. Trends in wastes reported from one year to the next, therefore, could be the result of changes in estimates rather than changes in operations.

Under RCRA, generators of hazardous wastes certify on a manifest associated with each shipment that they have a program to minimize their wastes. In 1984, Congress passed the Hazardous and Solid Waste Amendments (HSWA) (P.L. 98-616; 42 USC 6901), which served to amend RCRA. Under HSWA, generators have been required to describe their hazardous-waste-minimization program as part of a biennial report on their hazardous-waste generation. Until recently, there was little guidance or structure for this waste-minimization report. Now, however, EPA has released a 1987 Hazardous Waste Report, the Waste-Minimization Package [EPA Form 8700-13A(5-80) (Rev. 11-85) (Rev. 12-87)]. The quantities of RCRA waste in 1986 and 1987 are reported with a production ratio for the two years. Qualitative information is also requested on any resulting change in the toxicity of the waste and any change in the impact on air emissions and water discharges. The focus of this biennial reporting is on RCRA waste codes, not on specific chemical constituents, and therefore would not add any information for assessing the efficiency of reducing the amount of specific chemicals in waste streams from facilities reporting to the TRI.

NORMALIZATION OF WASTE-RELATED DATA

Normalization is a procedure for adjusting the reported amount of waste by dividing it with such MA components as amount of input (e.g., raw material) or output (e.g., product). This procedure can help account for changes in the amount of waste generated that are due to changes in the rate of production, i.e., a decrease in the amount of waste generated at a facility from one year to the next could be due to manufacturing less product, instead of real progress in waste reduction. Typically, some measure of product output is used as the normalization factor (Eberhardt, 1987; Delcambre, 1987; Hollod and McCartney, 1988). Waste-generation data not correlated to production can mask waste-reduction successes as well as failures (OTA, 1987). Other types of normalization factors are discussed later in this chapter.

Figure 5.1 presents idealized "black-box" mass balance diagrams to illustrate how waste-reduction reporting might proceed if either total waste or waste-component (toxic chemical) options were pursued and the MA data were sufficiently accurate to make quantitative distinctions. This hypothetical example illustrates that data interpretation is not straightforward, and interpretation can



NOTE: Capital letters refer to TRI-listed chemicals, and lowercase letters refer to unlisted chemicals.

Figure 5.1
Idealized mass balance diagrams for production units or facilities before and after waste reduction.

become difficult as the number of compounds and processes increases. Each box represents a production unit or an entire facility that may use and produce a number of chemicals. In this example, the processes are presumed to be nonconservative, which means that chemicals in raw materials react to form an entirely different set of chemical products. In contrast, conservative processes result in no transformations of the input chemical (e.g., use of a solvent for cleaning).

The upper box in Figure 5.1 shows three raw material streams going in, and the outflow of two product streams and two waste streams. The specific chemicals involved are referred to by letters. Capital letters refer to chemicals that are TRI-listed; lowercase letters refer to unlisted chemicals. Quantities have been assigned to each chemical to show how waste-reduction statistics might be developed. Since separation processes are not perfect, some byproducts found in wastes are also present in the product, and some of the product chemicals are also found in the waste. TRI-listed chemicals not fed into the facility may be produced in the process, appearing in the waste or product streams. The lower box depicts the effects on the same production unit or facility of waste reduction through production changes to improve product yield. The number of input and output streams remains the same.

Table 5.1 presents the results of three different approaches to calculating waste-reduction efficiency for the two situations presented in Figure 5.1. The approaches represent reduction-efficiency calculations based on the total amount of waste generated, an aggregation of all TRI-listed chemicals contained in the waste, and each TRI-listed chemical. For each approach the amount of waste generated is normalized for production changes by dividing the amount of waste by the amount of product made or, alternatively, by the amount of TRI-listed chemical in the product. Percent changes in these waste/product ratios are then compared between the initial (T_0) and waste-reduced (T_{WR}) cases. Substantially different figures for percentage of improvement in reducing the normalized waste amounts were obtained, ranging from-30% to +70%, depending on the basis of the calculation. The minus percentage indicates that waste generation had increased for chemical C as a result of waste-reduction efforts. Also, although large-percent reductions for the majority of TRI-listed chemicals might be achieved, overall waste reduction might be less.

After a common point of comparison, such as production, is chosen, the decision must be made whether the toxic release is to be compared with the entire stream or with the quantity of the same toxic chemical in that stream. Calculating waste-reduction efficiency based on some chemical-specific normalization ratio would lead to significant nonuniformity in reporting. In some cases, no interpretation is possible. For example, chemical D appears in the waste, but not in the product; no ratio of the compound in waste to production is possible, although a ratio based on input is. On the other hand, chemical C, not present in the input material, appears in the waste and, in this case, only a product-based ratio is possible. Thus, there is a higher likelihood of obtaining consistent and useful ratios if the denominator is based on the total stream rather than a chemical component therein.

For cases when waste-reduction efforts include a fundamental production change to use new input chemicals, evaluation by examining changes in reduction efficiency would be meaningless because the composition and therefore the potential toxicity of the waste would likely change. Normalized data by themselves might show a reduction in waste, but they would not indicate whether any change in potential toxicity had occurred.

MA Data Selection for Normalization

In assessing the utility of any normalizing factor, several questions must be asked. Are the relevant data on chemical components currently collected; if not, can they be collected without an extensive effort? How would the burden of additional measuring and monitoring requirements affect efforts to make progress in waste reduction?

Among production units, facilities, or industries, is there some commonality among the chemicals that are to be measured? The greater the diversity of chemicals, the less meaning such comparisons may have.

Are the points of measurement suf

ficiently similar among production units, facilities, or industries to make valid comparisons? As the diversity of processes used to manufacture a product increases, the likelihood diminishes for obtaining comparable data among the different processes.

TABLE 5.1 Variations in Waste-Reduction Efficiency Calculation

			Normalized Waste Amounts					
	Waste Amounts Generated (lb)		Waste (lb)/Product (lb)			TRI-Listed Chemical in Waste (lb)/ TRI-Listed Chemical in Product (lb)		
Waste Description	T_0	T_{WR}	T_0	T_{WR}	Δ%	T_0	T_{WR}	Δ%
Whole waste	120	105	.67	.54	19	—	—	—
All TRI-listed chemicals	40	25	.22	.13	41	—	—	—
Chemical C	10	15	.06	.08	-30	10.0	NP	—
Chemical D	15	5	.08	.03	60	NP	NP	—
Chemical E	15	5	.08	.03	60	.10	.03	70

Note: Calculations performed on data presented in Figure 5.1.

Key: T_0 = Initial process with a production of 180 lb.
T_{WR} Waste-reduced process with a production of 195 lb.
Δ% = Percent improvement in reducing the Normalized Waste Amounts.
NP = Chemical "not present" in product system.

Are the measurements used for normalization performed on the same chemical? In other words, is the chemical measured in a waste stream also present in the stream (e.g., product stream) where measurement is made for the normalization factor? This question illustrates the problem of constructing a normalization ratio for nonconservative processes in which a given chemical is not necessarily present at all points in the process.

An evaluation of these practical considerations is presented in Table 5.2. The relative merit of using different MA components (input, mass flow rate within the facility, and production) for normalization is given for each consideration. Input would encompass all data for which inputs are normally measured; mass flow rate within the facility would encompass data collected at some point between the flow of chemicals into and out of the facility; production would encompass all data for which outputs are normally measured. It is assumed that the amount of waste chemical generated is known and would be the numerator for a normalization ratio based on one of the MA components, which would be the denominator. Although data collected through MA practice do not require high levels of accuracy, if the accuracy of the data is poor, the utility of the waste-reduction assessment is diminished.

The merit of each MA component for normalization shown in Table 5.2 is presented in two different ways. In one ("Total"), the denominator is the total MA component (input, production, etc.), and the second ("Compound") is one chemical of interest of that component. A qualitative assessment of the usefulness of each MA component is presented to indicate that dif ferences in the way data are collected must be understood before any attempt is made to standardize waste-reduction accounting procedures.

TABLE 5.2 The Relative Merit of MA Components for Normalization

	Ranking by MA Component					
	Input		Flow Rate within the Facility		Production	
Consideration	Total	Chemical Compound	Total	Chemical Compound	Total	Chemical Compound
Currently measured?	4	2	2	1	4	1
Measurable?	4	3	2	2	4	2
Commonality of compounds						
Between production units?	3	2	3	3	4	3
Between industries?	1	1	1	1	1	1
Commonality of measuring point?	4	4	1	1	4	4
Required reporting?	1	1	1	1	4	1
Consistent ratios at measuring point?	2	1	3	2	3	2
Key:	1 = Seldom. 2 = Sometimes. 3 = Often. 4 = Usually.					

Comparability of Normalized Data

A primary goal in comparative waste-reduction assessments among facilities and industries is that reduction progress be compared, through the normalization of chemical-specific waste data, to determine whether one facility or industry is less efficient than another in the handling and use of a chemical. Comparison of normalized waste-related data between facilities must be done with caution. INFORM, Inc., found that facilities using similar quantities of hazardous chemicals generated greatly different quantities of waste. However, some of the observed differences in quantities of waste generated were due in part to different processes and uses of chemicals at each facility (Sarokin et al., 1985).

Normalization with any of the types of MA component data listed in Table 5.2 poses problems. Manufacturing industries vary considerably in the types of information typically obtained and obtainable. Although most manufacturers usually obtain some measure of raw material input and product output, the units can be in pounds or in products such as refrigerators, automobiles, spools of tape, or square feet of film. This difference in units imposes a high degree of nonuniformity in available data.

Even for facilities that manufacture the same product, raw material inputs can be diverse, depending on the exact process used. Different manufacturing routes also might result in significant differences in product contaminants and waste-stream compositions even in those cases in which a standard product, such as a commodity chemical, is produced. For example, aniline can be manufactured through the reduction of nitrobenzene by using iron and hydrochloric acid; through ammonolysis with chlorobenzene, ammonia, and cuprous oxide; or through vapor-phase hydrogenation of nitrobenzene. Each method uses a different group of TRI-listed chemicals.

For any industry that produces manufactured goods, more often than not there are significant differences in the chemical content of the product (e.g., the use of various alcohols and dyes or the use of mercury in glass thermometers). When measuring a chemical flowing through some point within a facility that produces manufactured goods, one finds that common chemicals (among facilities) become even less likely because of the number and degree of material transformations within the facility as a function of the manufacturing process.

If meaningful comparisons in waste-reduction progress are to be made, even between similar facilities that manufacture the same product, the point at which normalization data are measured must be the same or very similar. Because all manufacturing facilities have material inputs and product outputs, these would be the obvious points to consider for obtaining data relevant to waste-reduction progress.

As indicated in Table 5.2, product output is the only point required to be reported under current environmental regulations. As discussed previously, total production can be reported to the TRI as an index and in the RCRA biennial report as a production ratio so that confidential business information is not disclosed. OTA concluded that to provide a reliable measure of waste reduction, data must be correlated with production (OTA, 1986).

An alternative to using points of input or output is to measure some point of material flow within a facility. However, this alternative could lead to nonuniformity because the diversity of manufacturing processes would result in the inability to establish a common appropriate point of reference within the facility. Some meaningful measuring point might be found in a linear production line in which all the chemicals of concern could be measured; however, the problem becomes increasingly intractable when multiple conversions take place in complex interconnected manufacturing systems. For example, Bodwitch (1988) states that "in an automotive assembly facility there may be a single chemical component which is contained in over 2,000 separate chemical mixtures used as part of the hundreds of specific assembly operations required to manufacture motor vehicles." A similar problem arises in a complex chemical manufacturing operation, in which chemical transfers and transformations take place throughout. When highly controlled studies of the internal workings of a process have been undertaken, difficulties in obtaining chemical-specific data forced the use of surrogates, such as carbon (Jordan, 1988; Nickolaus, 1988), equivalent pounds (Redington, 1988), or methyl group (Supple, 1988).

Although Table 5.2 presents qualitative figures, it indicates that a normalizing factor based on a total stream MA component would be more practicable than one based on individual chemicals. The concentration of individual chemicals can vary, even among facilities manufacturing the same product, because of the diversity of processes used. Furthermore, the concentration of individual chemicals in raw materials or products rarely is monitored, except when quality control for that component is important, and the mass streams are relatively homogeneous. In petroleum refining, for example, the content of trace metals in the crude petroleum input or in the products typically would not be measured because the heterogeneous nature of the material handled makes such measurement highly impractical. The foundry industry provides another example of variable feedstock composition: it is virtually impossible to measure reliably the lead concentration of scrap metal input (Oman and Ham, 1988). Likewise, measurement of the constituents in the product becomes less practical when nonhomogeneous products, such as automobiles, are involved (e.g., the amount of heavy metals in the paint or chrome on the bumpers and accessories exiting in each different automobile).

No one method of normalization is generally applicable. Comparisons among production units, facilities, and industries become meaningless if the normalization factor is based on the specific chemicals. In addition, no particular advantage is apparent in using the input component or an internal measure of mass flow rate compared with using the production component to normalize reduction reporting.

AGGREGATION OF WASTE-REDUCTION-EFFICIENCY DATA

A normalizing factor could be used in many ways to measure progress. The most obvious way is to compare waste generation between different periods by comparing the waste-generation ratios (e.g., waste generation/production). A decrease in this ratio indicates a reduction in waste generation. This method of assessment provides unambiguous results for specific waste streams generated within a single production unit. Such ratios become less meaningful as waste data are aggregated from various production units within one facility.

Table 5.3 shows how the waste-generation ratio could be calculated for the wastes generated in different production units (designated 1, 2, and 3) and for the entire facility when the data are combined. This hypothetical example illustrates the limitations of using aggregated data even though it is normalized. The generation ratio for each production unit is shown in Table 5.3 for a base (starting) year and for a comparison (later) year. Even though the generation ratio decreased for each production unit, there was no change in the overall generation ratio, which could lead to the erroneous conclusion that the facility as a whole did not improve its waste-reduction efficiency. The same phenomenon may occur when multiple wastes are aggregated for all the waste generated from a production unit where multiple products are produced (Benforado, 1988) and, on a larger scale, when facility statistics are combined to form industry-wide and national statistics.

If such accounting procedures are to be of benefit in managing wastes, they should be maintained at the smallest practical production-unit level. A more general nationwide statistic developed by weighting individual facility information would probably cause progress to appear to be slower than it truly was. OTA (1986) also concluded that waste-reduction data should be process-specific or production-unit-specific, because facility-level reporting would be too complex to obtain meaningful data.

Waste-Reduction Efficiency-Weighting Statistics

The problem of masking waste-reduction progress through data aggregation can be mitigated by using either of two calculation procedures that weights annual changes in generation ratios (e.g., waste generation/ production) for each production unit according to either (1) relative amounts of waste generated or (2) amount of waste generation expected, based on changes in annual production. These options are demonstrated in Figure 5.2, using the hypothetical numerical information from Table 5.3.

The first option described by OTA (1986) allows no credit if, for example, a production unit is changed to produce no waste. As shown in Figure 5.2, if Reporting Unit 1 waste generation drops to zero, the weighted statistic (R) remains approximately the same (11.6% compared with 11.3%).

The second option compares the actual waste generation in the comparison year with the amount of waste generation expected if no change in waste reduction had occurred for the comparison year. This option has the advantage that credit is given for eliminating a waste stream. In this case if Unit 1 waste dropped to zero, the percentage of overall waste reduction would improve to 57%.

Both approaches require that data summations be calculated from the original individual production-unit information. Consequently, the number of calculations that must be performed to compile meaningful facility, industry, and national statistics can escalate enormously. The experience with collecting waste data under RCRA shows that it would be very difficult for the government to collect and analyze accurate and timely data from a very large number of facilities and for an even larger number of processes and waste streams (OTA, 1986). In the context of TRI reporting, each chemical requires a specific normalizing factor (because of different production quantities associated with each chemical at each facility). For example, EPA initially estimated about 320,000 TRI reports from 32,000 facilities (Federal Register, 1988a), which, if

TABLE 5.3 Use of Normalization to Track Waste Reduction Progress-MA Hypothetical Illustration

	Base Year			Comparison Year			
Reporting Unit	Waste Quantity	Normalization Factor[a]	Generation Ratio	Waste Quantity	Normalization Factor[a]	Generation Ratio	Percent Change[b]
1	80	300	0.27	75	310	0.24	11
2	70	100	0.70	65	105	0.62	11
3	10	200	0.05	5	122	0.04	20
Total	160	600	0.27	145	537	0.27	0

[a] This is an MA component, such as annual production, used as the denominator to calculate the Generation Ratio.

[b] Percent improvement in reducing the Generation Ratio from base year to comparison year.

OTA Method

$$R = \frac{\sum_{i=1}^{N} [(\text{Unit}_i \text{ Waste Quantity})_c (\text{Unit}_i \text{ Generation Ratio \% Change})_c]}{\sum_{i=1}^{N} (\text{Unit}_i \text{ Waste Quantity})_c}$$

$$R \quad \frac{(75)(11) + (65)(11) + 5(20)}{75 + 65 + 5} = 11.3\%$$

If Reporting Unit 1 waste generation in comparison year approaches zero,

$$R = \frac{(65)(11) + 5(20)}{65 + 5} = 11.6\%$$

Alternate Method

$$R = \frac{\sum_{i=1}^{N} [(\text{Unit}_i \text{ Production})_c (\text{Unit}_i \text{ Generation Ratio}_b)] - \sum_{i=1}^{N} (\text{Unit}_i \text{ Waste Quantity})_c}{\sum_{i=1}^{N} [(\text{Unit}_i \text{ Waste Quantity})_c (\text{Unit}_i \text{ Generation Ratio})_b]} \times 100$$

$$R = \frac{(310)(.27) + (105)(.70) + (122)(.05) - (75 + 65 + 5)}{(310)(.27) + (105)(.70) + (122)(.05)} \times 100 = 11\%$$

If Reporting Unit I waste generation in comparison year approaches zero,

$$R = \frac{(310)(.27) + (105)(.70) + (122)(.05) - (65 + 5)}{(310)(.27) + (105)(.70) + (122)(.05)} \times 100 = 57\%$$

Where:

R = Weighted waste reduction statistic (%)

c = Comparison year

b = Base year

Figure 5.2
Waste-reduction weighting methods using data from Table 5.3. (Source: OTA, 1986; alternate method adapted from Nowick, 1987)

developed on a production-unit basis, could require annual accounting for millions of production units, or for hundreds of millions of wastes if reported on a chemical-specific basis. For the first cycle of TRI reporting, approximately 18,000 facilities reported. This lower-than-expected response is at least partially due to noncompliance.

Indexing

Normalization factors account for the fact that the amount of chemicals released is often a function of the amount of product made. An increase in waste could reflect an increase in production. On the TRI Form R, normalization factors called indexes can be calculated from virtually any production information that "closely reflect(s) activities involving the chemical" (Appendix c). The instructions to Form R list several acceptable examples of indexes, including the following: the amount of chemical or paint produced in 1987/amount produced in 1986; appliances coated in 1987/appliances coated in 1986; and value of sales in 1987/value of sales in 1986. If the index is based on mass for all manufacturers, then there can be a comparison of information between, for example, facilities or industries (if the previously described problems associated with aggregated data are recognized). The use of an index based on the number of product units simplifies reporting for those industries that traditionally report production in non-mass units, but it prevents the compilation of summary statistics of disparate units, such as automobiles and refrigerators. The use of dollar sales in indexing produces a statistic that can be aggregated, but it is much less dependable as a quantitative measure because prices for various commodities change from year to year.

Several issues related to industrial diversity merit consideration when indexing is used to compile a national waste-reduction database. One option would be to require all facilities to report in the same units, which would result in data that could be compared and aggregated easily. The data would, however, lose substantial accuracy. There would be cases in which forcing the use of the same units would distort the data, although taken as a whole, the data would be in a useful form for policymakers and for revealing general waste reduction trends. A variant of this option would be to specify the measurement units to be used industry by industry, thereby ensuring comparison within an industrial sector at the expense of some cross-industrial comparisons.

Another option would be to allow facilities to choose their own units. This option would most likely result in the most accurate facility-level data. Aggregating these data, however, would be impossible. This approach possibly would decrease the usefulness of the database for policymakers.

It is also possible to assess improvements in waste-reduction efficiency by multiplying the amounts of waste generated by production after both have been indexed to the same base year, for example, waste-reduction efficiency = (production index)(waste index).

Such a calculation, based on mass or other physical-unit production, could be made for progress reporting at the appropriate level (e.g., production unit or facility) without divulging production information. It must be kept in mind that the larger the reporting unit, the greater the problem associated with aggregation of data. If such a system were used for reporting, it could be used as an indication of progress by that reporting unit, but it could not be further aggregated to show progress of a group of reporting units, for example, on a national basis, because of the nearly insurmountable problems of properly compiling an accurate, meaningful national statistic for waste-reduction efficiency.

A national statistic that could be compiled from such data would be of three tallies: (a) those facilities or production units showing improvement in waste-reduction efficiency, (b) those showing no change, and (c) those showing a decrease. Such a statistic would be meaningful from year to year only for a nominal measurement of progress (i.e., low level of information).

Evaluation of Waste-Reduction-Efficiency Data

The previously described concepts for evaluating waste-reduction efficiency are variations of a single approach that might best be described as mass (of waste)-based systems. The two major measurement para meters are (a) the mass of waste per unit of time (e.g., pounds of waste per year) and (b) the mass of waste per unit of manufactured product (e.g., pounds of waste per ton of ethylene produced). Both of these measurements are made on absolute scales because the data can be expressed on a scale that has zero as the lowest value. One limitation of this type of scale is that the focus can be drawn to an endpoint, such as zero, without differentiating the degrees of difficulty in achieving waste reduction progress, as shown in Figure 5.3.

Several significant anomalies must be dealt with when one uses mass-based absolute scales for assessing waste-reduction progress. The first anomaly is that no credit accrues for past implementation of production modification or recycling and reuse to reduce waste. Facilities with past substantial waste reduction successes, therefore, could be perceived as making insufficient progress in subsequent years, if less opportunity were to exist for waste reduction.

A second anomaly derives from the diversity among private-sector manufacturing technologies. The relationship between a particular manufacturing technology and its specific opportunities for waste reduction is an important factor that leads to very different possibilities for waste reduction among industries (Royston, 1979). The differences among processes might substantially affect the waste-generation rate, even when the same product is manufactured. When comparing waste-reduction progress between two facilities making different products, technical expertise is sometimes needed to distinguish actual from apparent progress. For example, one of the facilities could appear to make greater waste-reduction progress because it makes a product that can contain relatively large amounts of waste without affecting quality or performance. The other facility produces a product that cannot tolerate any additional impurities and thus less opportunity exists for waste reduction.

The third anomaly is that the rate at which new modifications are implemented can be related to a series of larger manufacturing and related financial decisions. Those improvements that demonstrate the greatest cost-effectiveness compared with the present technology are instituted first. Waste reduction, therefore, competes on a substantially different basis for capital investment funds from one facility to another and will result in different constraints on the timing of introducing waste-reduction practices and different amounts of waste reduction achieved between facilities.

A fourth anomaly of the mass-based assessment techniques is that they depend heavily on the actual amount of production. The amount of production is controlled by numerous market factors, and therefore variations in production lead to increases or decreases in the amount of waste generation per year. Normalizing waste generation by production does not necessarily remove this anomaly, because there might be a nonlinear relationship between waste and production.

Waste-reduction progress can be more realistically evaluated if the data are coupled with a description of each new reduction technology introduced at a facility. Many factors other than the mass of waste are important in making progress in waste reduction, and a mass-based system does not reflect these other factors. For example, reducing the amount of a trace toxic constituent in a waste stream would indicate little progress in mass waste reduction but might be more beneficial than reducing large amounts of less toxic constituents. Consequently, even though a properly constructed, mass-based waste-reduction-efficiency statistic might allow for some comparisons within and among the manufacturing industries, it would not be proper to require uniform standards of waste-reduction efficiency, irrespective of waste toxicity differences and manufacturing diversity. OTA also concluded that if government were to require waste reduction, it would face major difficulties in determining what is technically and economically feasible or practical for a specific industrial operation (OTA, 1986).

Alternative MA Practice Systems

The approaches to waste-reduction reporting discussed thus far focused on specific mass balance components, such as production, to provide a better understanding of the amounts of waste generated at reporting facilities. This section contains a discussion of three alternatives to the use of specific MA components. The commit tee did not perform any comparative analyses for these alternatives to collecting MA data; in-depth analyses of these alternatives were considered to be beyond the committee's charge.

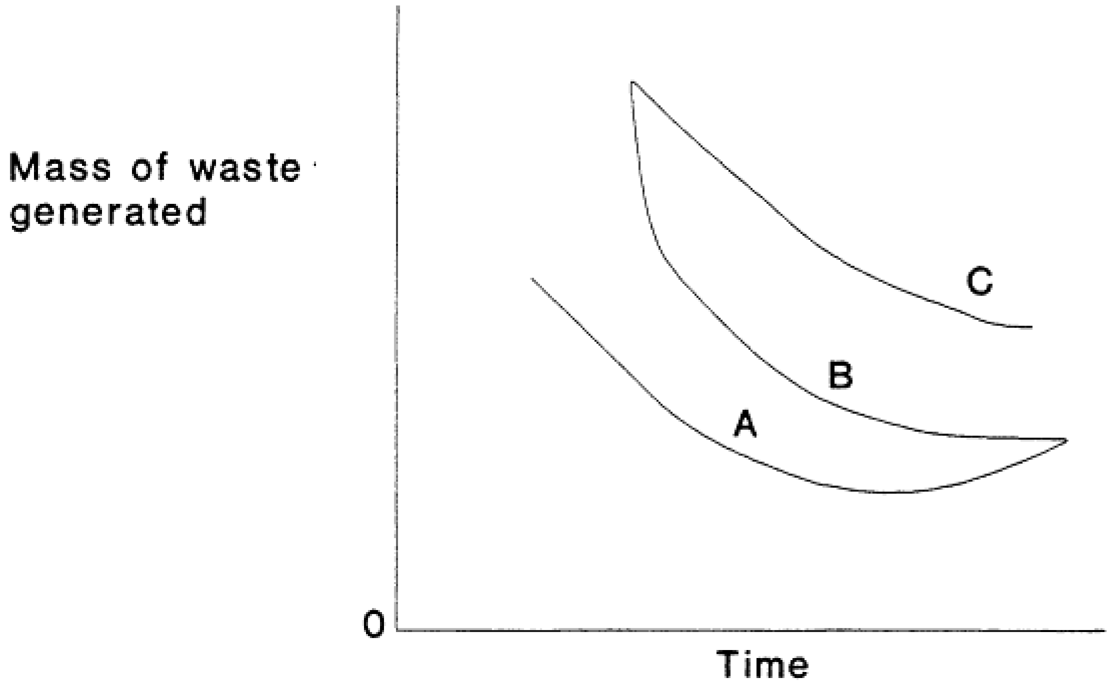


Figure 5.3
Patterns of waste generated over time at different manufacturing facilities. Each curve (A, B, and c) represents a hypothetical facility.

Throughput Systems

A throughput measure, which would have no one point of measurement, was suggested by Clarence-Smith (1988a) as an attempt to address the problem that no one measuring point within a facility is perfectly suitable for normalization of data waste. The throughput accounting procedure is an approach for mandating a waste-reduction standard., as described in Appendix J. In this context, throughput is defined as the sum of all mass quantities flowing out of a facility allowing for chemical conversions and including inventory changes. Obtaining these data in a meaningful way multiplies the problems associated with the individual MA components described earlier in the chapter.

This conceptual approach does little to resolve the problem of nonuniformity of reporting or the analysis of such data when analyses are done on a chemical-specific basis in a nonconservative production. Generally, the throughput model is seriously flawed in its attempt to treat all industries and all facilities uniformly. A discussion of several additional problems with this proposal is given in Appendix J.

Toxicity-Based System

Fatkin (1988) describes an approach to track the reduction or replacement of highly toxic chemicals while reducing the presence of other chemicals in the waste. The amount of chemicals designated as highly toxic that are input to a facility (rather than contained in the waste) is used as the numerator, and the denominator is the quantity of the product derived from the use of those chemicals. For chemicals considered less toxic, the amount of waste generated would constitute the numerator. With this approach, inconsistencies in reporting could occur if a highly toxic chemical were totally replaced with a less toxic one. In this case, the numerator of the statistic would change from the input amount to the amount in the waste. Consequently, progress, or the lack of it, shown in each statistic would have to be explained and documented as these transfers take place from year to year. In addition, such a method requires the construction of a system to classify materials by their relative toxicities. This can be a time-consuming, controversial, and complex task. It would, however, have the advantage of focusing on the most important toxicants and limiting the number of chemicals that must be accounted for if consensus can be reached on the toxicity criteria. OTA concluded that the best way to measure waste reduction is to determine the changes in the absolute amounts of hazardous components. However, government might have to assist waste-generating facilities in selecting the most hazardous components of waste for reduction (OTA, 1986).

Successful Project Reporting

A third approach does not emphasize establishing a baseline or calculating changes from year to year. Rather, this approach would have facilities report their successful projects and estimates of the amount of waste prevented from being generated by those projects (Benforado, 1988). A national collection of this information would help to establish a database on successfully applied methods that reduce toxic chemical releases. Such a database would provide the information needed for a successful technical assistance program. It would be extremely useful to individuals in charge of assistance programs to know methods that work and those that are failures before they recommend them to facility managers. The disadvantage to the reduction database is that, when used alone, it may not supply enough information on the actual changes in waste generation from year to year.

CONCLUSIONS

The necessary components of a program to track waste-reduction progress are knowledge of the waste generated and its relation to the level of manufacturing activity, the extent of waste reduction at the source (versus reduction after treatment), and the comparability of the collected data among a wide variety of facilities.

Mass balance information obtained through EMB or MA practices is not generally useful for strict determination of waste-reduction efficiency or progress in waste reduction. Both practices fail to recognize technological and economic limitations in achieving waste reduction, within and between industries, or the progress that was made before an accounting program was instituted. Consequently, uniform absolute goals such as a fixed rate of reduction of waste per year or a fixed efficiency requirement over a period of a year are inappropriate.

Any measure of waste-reduction efficiency must be based upon an unambiguous definition of the "waste" subject to reduction. Reporting of waste-reduction progress on a chemical-specific basis is most feasible if a normalizing factor is used. Because no single normalizing scheme is generally applicable to all manufacturing facilities, attempts to calculate a ratio of the amount of a chemical in the waste to the amount of the same chemical in one or more mass balance components would lead to a lack of uniformity in reporting and interpretation.

Actual waste-reduction progress is best defined and monitored by the generator at the production-unit level. Progress in reduction is masked when the mass balance data from a smaller reporting unit, such as a production unit, are used to develop an industry-wide or national statistic. This masking of progress associated with a specific product also takes place when a production unit produces many products and generates multiple wastes that are accounted for in a combined fashion.

A production-normalized weighting statistic could be used to measure waste-reduction progress at the facility or industry level. However, the diversity of chemical products and manufactured goods that involve the use of toxic chemicals often makes it difficult to normalize waste data on a consistent and comparable basis. Specific data on production units must be used if meaningful waste-reduction statistics are desired at a national level; it would be difficult to assemble the data at this level. The use of chemical-specific data for normalization further increases calculational problems significantly and raises serious concerns about confidentiality because of the detailed data that must be supplied. Even such a normalized statistic must be interpreted with caution, because the relationship between waste generation and production might not be linearly correlated.

MA data, such as waste reports, production reports, and descriptions of waste-handling practices, coupled with descriptions of the results of implemented waste-reduction techniques, could in some cases contribute to forming a useful picture of waste-reduction progress and help provide information on reduction techniques. Such reporting could not, however, be meaningfully aggregated at the industry or national levels because too much information on individual production processes is lost, and waste-reduction progress would likely be obscured. There is no advantage in providing the raw material input information in reporting waste-reduction progress. The greater the number of listed and unlisted chemicals involved with this approach, the more intractable the problem of interpretation and comparison of progress within, between, or among industries.

Basing evaluation of waste-reduction progress data on the reduction of specific chemicals is not necessarily more effective than basing it on the reduction in total quantity of waste-chemical constituents or waste toxicity. The reduction of a listed chemical might not reduce the total waste stream and could increase the quantity through greater use of a nonregulated material of unknown hazard or toxicity. Expert analytic assistance as an adjunct to an MA data collection program would be helpful in addressing whether waste reduction has been accomplished by replacing a chemical of known health effects with a different chemical of unknown health effects. Normalized data by themselves might show a reduction in waste, but they would not indicate whether any change in potential health effects had occurred.

6

Evaluating Toxic Chemical Management Practices

INTRODUCTION

The third possible use of mass balance information listed in SARA Section 313(1) is for assessing "toxic chemical management practices" at facilities currently reporting to the TRI. These practices are considered to encompass transportation across and within facility boundaries, storage and handling, waste reduction, and on-site tracking and treatment of toxic chemicals. This chapter evaluates both EMB and MA practices for their adequacy in providing data on (a) the types and amounts of toxic chemicals managed by a facility; (b) the extent to which changes in amounts of toxic substances are attributable to changes in levels of manufacturing activity; (c) the comparability among facilities; (d) their usefulness to chemical managers for enhancing the safety of their management practices; and (e) their usefulness to the public and government in evaluating whether effective practices are being used to minimize the actual and potential releases of toxic chemicals into the environment. The use of mass balance information for evaluating waste reduction efficiency is discussed in Chapter 5.

CHEMICAL MANAGEMENT PRACTICES

Transportation

Assessing management of transportation of the chemicals outside of facilities is beyond the scope of the committee's charge. This section focuses on the movement of chemicals within and across boundaries of facilities. However, the methods used to transport chemicals outside of facilities might affect toxic chemical management practices at a facility. For example, materials brought to a facility by rail might be off loaded and stored differently from materials brought by trucks. Different transportation practices also have different potentials for routine and accidental releases.

The single and most relevant piece of information in evaluating toxic chemical management practices is the annual quantity of specific chemicals transported across facility boundaries. Although this information could be obtained through EMB, it would be much cheaper and simpler to obtain it from readily available records, such as invoices and shipping manifest records. In this case, information obtained through MA would be sufficient.

Information supplementing MA data could contribute to a community's ability to estimate risks for types and quantities of chemicals brought to and taken from a site. Descriptions of changes in physical-chemical properties (e.g., from a liquid to a solid material or from a more hazardous to a less hazardous form) or changes in transport methods could provide valuable information to the community in assessing the potential hazards associated with transport practices and for developing emergency response plans.

Storage and Handling of Chemicals

Storage and handling of chemicals at a facility can encompass a wide range of activities. Conceivably, these could include methods of shipping and transfer, quantities shipped and stored, high-pressure processing or storage of chemicals, form of storage, unloading systems, unloading procedures, safety systems, frequency of inspection, and other critical pieces of information necessary for the management and handling of chemicals.

The probability and severity of a sudden release of a toxic chemical at a facility relate to the maximum quantity stored at the facility. Community knowledge of quantities of hazardous materials stored is provided for by TRI reporting. This information, which is reported annually, is important in assessing a facility's progress in the reduction of the absolute quantity of chemicals stored on site and indicates to the public the facilities where large quantities of dangerous chemicals are stored.

However, the quantity of chemicals stored can fluctuate relative to a facility's level of production, which can make interfacility comparisons difficult, even among similar types. In these cases, on a conceptual basis, normalization of the maximum quantity of chemicals stored on site (by dividing this quantity by the level of production) could be useful. However, all proposed normalization factors lack consistency among various chemicals and processes (see Chapter 5).

The probability and severity of a release are also a function of a chemical's properties and reactivity; equipment design safeguards, operating procedures, operator training, quality of maintenance and monitoring; and the chemical's toxicity, transport characteristics, release location, and receptor locations. This type of information is not provided through TRI reporting requirements and also would not be provided through the additional reporting of any type of mass balance information.

The use of mass balance information collected within a facility can support chemical management practices that reduce the presence of toxic chemicals on site. For example, maintaining current information on the chemical quantities stored at a facility provides an owner or operator with greater certainty of chemical amounts available and allows for controlling inventory at a minimum level. A chemical inventory could be determined at any point from regularly recorded mass balance information on the amount of chemicals brought into a facility and the amounts shipped out of the same facility.

For users of chemicals in complex operations, such as motor vehicle manufacturing, a unit-specific control of inventory is necessary (Bowditch, 1988). In the case of facilities in which chemical conversions take place, calculating the usable volume of process vessels, piping, storage vessels, and containers associated with the chemicals might be needed in addition to mass balance information.

On-Site Treatment

Waste reduction via process modification should be the management strategy of choice before treatment is considered, since treatment always results in residuals and is prone to episodic chemical releases.

Treatment as a management process within a facility is used to render chemicals less toxic (e.g., conversion of hexavalent chromium to trivalent chromium or bioxidation of chlorinated organic compounds) or to render them less mobile (e.g., solidify heavy-metal wastes). Incinerators, wastewater treatment facilities, and air-pollution control devices are included in treatment processes. The efficiencies of such on-site treatment and the associated releases are requested as part of TRI reporting.

Loehr and Ward (1987) note that the

EMB approach can be effective in ensuring that a waste-management system does not unknowingly transfer pollutants from one medium to another in the process of meeting a particular regulation or effluent limit. They also indicate, however, that adequate data rarely are available to permit the development of meaningful mass balances. For waste-water treatment, mass balance information can demonstrate that some organic pollutants can undergo volatilization and accumulation in sludge as opposed to degradation through bioxidation.

A 3-week, multimedia sampling study was conducted using the EMB approach at a large petrochemical waste-water treatment facility to determine the fate of eight organic chemicals with various characteristics (Berglund and Whipple, 1986). This study illustrates the difficulty of using EMB on a facility of any complexity. Primarily because of wide variation in the chemical makeup and concentration in the influent waste water, and because of fluctuations in wind speed and direction (a factor in measuring volatilization losses), EMB did not provide sufficient closure to assess the efficacy of waste-water treatment. However, predictive models were developed, because data collected through EMB gave insight into the relationship of air release and sorption to biological process conditions and chemical properties. EMB data can also be useful in providing a maximum upper bound on possible atmospheric emissions from waste-water treatment (Noll and DePaul, 1987).

There are no obvious applications for MA in assessing treatment processes, because MA information typically is concerned with the flow of chemicals across facility boundaries. To assess treatment processes, detailed information is needed on the amounts of chemicals flowing through the facility before treatment, and thus within-facility information is required.

In summary, reporting of mass balance information, obtained through either EMB or MA, would not be appropriate in most cases, for assessing on-site treatment practices because of the within-facility complexity and variability of the waste streams flowing into the treatment systems. However, collecting EMB information on the treatment systems could be a useful management practice within a facility to indicate the release avenues that require more thorough investigation.

Gradual and sudden releases of toxic chemicals can occur as the result of the absence of management guidelines for prudent chemical-handling practices at a facility. Only limited public information is available concerning adequate chemical management practices at facilities and whether these practices are the most effective and are employed continuously. Useful information is provided to evaluate the management practices of a facility when release data reported to the TRI are combined with information on causes of the release (e.g., employee error, metal fatigue, inadequate detection and repair of equipment leaks, and equipment failures). However, as demonstrated through the New Jersey Industrial Survey, this additional information could be obtained only by evaluating the reported release data in conjunction with a site visit to the reporting facility (NJDEP, 1986).

CONCLUSIONS

EMB and MA are conceptually useful for assessing and sometimes improving management practices, including transportation of toxic chemicals into and out of a facility, storage, tracking toxic chemicals on site, waste reduction, and waste treatment. However, mass balance information obtained either through EMB or MA practice is generally inappropriate from a practical perspective. Because of large differences among the processes within facilities reporting TRI information, the practical usefulness of the EMB and MA data in making comparisons between facilities is severely limited, for assessing transportation, handling, and storage practices. Only EMB would be appropriate for assessing waste-treatment practices. However, the practical difficulty in achieving closure limits this application.

The maximum quantity of chemicals on site is one of the more important factors in estimating the likelihood and magnitude of a sudden release. The management practice of reducing stored quantities usually can be assessed by directly measuring on an absolute basis the maximum quantity of chemicals present. This information is currently reported to the TRI. When it is necessary either to assess inventory control practice at a facility with widely fluctuating production rates or to compare practices between facilities, normalization by dividing inventory by the amount used or produced at the facility is a means of accomplishing the objective. All normalization factors, however, fail to provide a consistent basis for comparisons among various chemicals and facilities.

Information currently reported to the TRI does not closely link release data to chemical-management practices except for on-site waste-treatment practices. Additional facility-specific information on other management practices, such as transportation and storage and handling, could assist the public in evaluating whether the most effective management practices are being used to control or prevent releases of TRI-listed chemicals.

Mass balance information collected within a facility can be used by that facility to support certain chemical-management practices that reduce the presence and release of TRI-listed chemicals. For example, mass balance information can provide the facility with current information on chemical quantities stored on site and facilitate controlling its inventory at a minimum level. Data obtained through EMB can be used to point out release routes from waste-treatment processes that need more complete and direct measurement. Because MA does not rely on chemical flow data from within a facility, this approach would not be useful in assessing waste-treatment practices.

7

Collection Of Mass Balance Information On A National Scale

INTRODUCTION

In evaluating the desirability of national collection of EMB and MA data, the committee was charged with considering relevant potential benefits to government and society, including the potential uses explicitly stated in SARA Section 313. The committee also considered (a) the costs of collection and analysis, (b) the complexity and interpretability of the data, (c) the way the data could enhance the public's and government's understanding of relationships between industrial manufacturing activities and the release of chemicals into the environment, and (d) potential burdens to facilities providing the data, including matters of confidentiality. Given the diversity of chemicals and manufacturing facilities to be considered, the committee relied on the limited empirical data available to it, the experience of the New Jersey Industrial Survey, and its professional judgment, experience, and reasoning to support its analysis. Because MA data do not provide information on exposure concentrations the committee did not make any specific recommendations concerning risk communication.

BACKGROUND

SARA Section 313 responded to demands for information that would inform communities about releases of toxic chemicals. The mechanism proposed was an annual national report of the quantities of toxic or otherwise hazardous chemicals released to the air, water, and land. Congress further suggested that it should be possible for the public to retrieve data on specific facilities as well as aggregate data organized, for example, by type of chemical and geographic location (Congressional Record, S 14908, October 3, 1986). SARA Section 313(h) states that information collected under the TRI "shall be available... to inform persons about releases of toxic chemicals to the environment; to assist government agencies, researchers, and other persons in the conduct of research and data gathering to aid in the development of appropriate regulations, guidelines, and standards; and for other similar purposes."

During its debate over SARA Section 313, Congress showed awareness of the potential difficulties of balancing the information requirements of a national mass balance program against the demands that such a data inventory might pose for business and industry. It directed the NAS to consider the collection of mass balance information, evaluating the value of the program to the public, regulators, and policymakers; the financial and other resources needed by governments and facilities to implement the program; and possible trade-secret concerns (Congressional Record, S 14908, October 3, 1986).

The information available to the committee regarding large-scale mass balance projects was not great. Mass balance information collection in federal programs has been sparse, primarily because agencies have traditionally dealt with specific parts of the environment. A survey of the 50 states undertaken by the NGA at the committee's behest discovered seven states reporting uses for mass balance data and five others that are planning to use such data. To date, only New Jersey and Maryland have undertaken extensive collection activities; five other states have collected mass balance information for more restricted applications, such as regulatory compliance.

USEFULNESS AND LIMITATIONS OF MASS BALANCE INFORMATION

The committee has evaluated mass balance information obtained for assessing release estimates, progress in waste reduction, and chemical management practices. Although EMB potentially is more useful than MA in several applications, the accuracy, precision, and expense of EMB are not necessary for achieving most of the three goals. MA appears to be more promising than EMB for the uses of mass balance data identified in this report, when the data are supplemented with expert technical assistance. MA also could target applications where EMB data are potentially useful. EMB could be useful in calculating the size of a release by difference when all data but that of the release are available. It also could serve as a check on the accuracy of other methods of estimating chemical releases, but when all quantities are of comparable magnitudes. The EMB approach can also be useful in identifying and characterizing sources of waste in a facility and in pointing out release routes from waste-treatment processes that need more complete and direct measurement. EMB might be useful in identifying points of chemical release into the workplace and thus might indicate where mitigation measures could reduce occupational exposures. Although the benefits and limitations of EMB data collection do not justify further consideration of a national EMB data collection program, the usefulness of EMB in special cases should not be overlooked.

Neither the implementation nor the use of MA would be simple or straightforward. The utility of MA information—especially on a national scale—must be examined in the light of how such information will be useful in tracking hazardous substances at manufacturing facilities: How useful will MA information be, compared with information already collected? How should these annually reported data be used with frequently reported data? Can these data replace others?

Proponents of mass balance information collection emphasize the need for MA data (e.g., inventories and amounts of chemicals shipped into and out of a facility) to put release data (e.g., TRI data) into a proper perspective. Claims are also made that mass balance information is useful, for example, in determining the waste-reduction efficiency of facilities or categories of facilities with respect to TRI-listed chemicals. Although some benefits might be realized from the use of MA data by themselves, a program supported by technical experts would have greater benefits.

Evaluating Chemical Release Estimates

MA is generally not useful for assessing the accuracy of data on releases, because of the limits inherent in measurement error and the assumptions or judgments necessary to implement the analysis. The amount of uncertainty in MA data would often exceed the quantities of environmental releases. However, MA information might be helpful for assessing the nature of reported releases, provided that MA data collection is supplemented by expert technical knowledge, data validation, and analysis.

A program with MA data could help community residents who are unfamiliar with the specifics of manufacturing proces ses determine why the releases are relatively high for a particular facility or industry.

MA data can also be used in a more qualitative way than for assessing accuracy. It can be used to assess whether releases are relatively high or low because of the chemical quantities handled or because the same quantity of a chemical is handled less efficiently by one facility than by another similar facility. For many chemicals, releases that do not occur at the time of manufacturing or of incorporation into a product will eventually occur after the chemical-containing product is purchased and used. It is therefore important to understand the release pathways of hazardous chemicals—for example, 1,1,1-trichloroethane (TCA) in adhesives—after they leave production facilities, as well as the releases reported by the facilities.

Validation of collected MA data is essential to their useful application to release estimates. Recognizing the complexity of the information requested and the substantial potential for inaccurate reporting, New Jersey in its Industrial Survey made a major commitment to provide expert assistance to respondents and to conduct routine field audits. Engineering staff reviewed all responses and worked with the respondents to improve response quality. As a result of this extensive validation program, it was found necessary to revise 75% of the original release estimates; approximately one-third of the revisions were due to inadequate estimates of release. New Jersey officials have stressed that it was impossible to ensure the validity of reported release information without additional MA information, or follow-up field audits or monitoring data. For example, knowing the quantities of the raw materials used and the products manufactured by a facility could be helpful in recognizing overestimation of discharges from a facility that mistakenly includes in its report the *total* mass discharged *plus* the water that contains it, instead of the mass of a specific chemical contained in the water. MA data are, however, of limited utility for the assessment of *underestimates* of releases because of the uncertainty inherent in MA data. Furthermore, mass balance information can be used to estimate releases by difference only when all the components are of comparable magnitudes. In this case, it is likely that each component is within a similar range of uncertainty. MA data together with technical knowledge of the manufacturing process can be useful in assessing releases from facilities where all of a TRI-listed chemical consumed at a facility is also released to the environment. This technique has been used successfully in estimating the release of gaseous fluorides from aluminum smelting facilities because the cryolite and aluminum fluoride consumed by the aluminum industry are used exclusively to replace fluorine losses (NAE, 1989).

MA information could be used by federal and state regulators and policymakers to set regulatory priorities for investigating chemicals of concern, to clarify their likely exposure pathways, and to disclose where they are. As the New Jersey Industrial Survey showed, MA data can provide insights into important, previously undocumented release pathways. Virginia and Vermont also have refined their environmental permitting processes through the use of mass balance information collected case by case, which allowed them to improve their assessments of releases and to apply more relevant conditions for the issuance of permits.

Evaluating Waste-Reduction Progress

MA data, accompanied by information that sets the data in a realistic engineering context, could in some cases contribute to forming a useful picture of waste-reduction progress at individual facilities and could help provide information on reduction techniques. Although neither EMB nor MA practice is generally applicable to determine waste-reduction efficiency, MA could be useful in qualitative applications such as identifying waste-reduction priorities among industries and facilities. Reporting of waste-reduction progress on a chemical-specific basis is most feasible if a normalizing factor is used to account for changes in waste amounts that are due to changes in the level of manufacturing activity.

Production data used to normalize quantities of generated waste can help account for changes in manufacturing activity, but the limitations of such data should be emphasized. The diversity of products sometimes makes it difficult to normalize waste data consistently and comparably among processes and facilities. Furthermore, waste and production are not always linearly related even if waste reduction is ignored. Nor is there any advantage in normalizing on the basis of raw-material input, especially if chemical conversions occur. The greater the number of chemicals involved in a waste-reduction assessment, the more difficult the problem of interpretation and comparison of progress.

MA data could be used to aid the setting of national priorities for chemical waste reduction, as New Jersey is attempting to do. If, for example, releases of a toxic chemical from a manufacturing facility are low, but the same chemical is released later in large amounts in its end-use product formulation, the only effective way to reduce environmental releases substantially is to identify safer substitutes for the chemical or to reformulate the product. For chemicals used in large volumes, a national priority might need to be established for research and development on alternative product formulations.

Waste reduction can be accomplished in many different ways, but some of them could worsen toxic releases to the environment or be undetectable through the use of raw MA data. The following example illustrates how a chemical user could reduce waste by replacing a chemical of known health effects with a chemical of unknown health effects. This example is not intended to hinder waste-reduction efforts, but is intended to indicate one potentially undesirable result of a specific waste-reduction effort. Suppose a lock manufacturer converts an operation to use a terpene hydrocarbon solvent that is not on the TRI list. The solvent only recently was introduced into the market, and not all of its properties are known. It is combustible, but no fire regulations govern its use. It forms precursors that, when released to the atmosphere, contribute to photochemical smog. Although air quality regulations in the region are stringent, the manufacturer can meet the regulations with this solvent. The solvent is so new that no workplace exposure levels have been set. The sanitation department has not set limits on the solvent's release into water, and so it can be poured into the sewer when it becomes contaminated. Although there has been an apparent waste reduction, the result could be the trading of one problem for a similar or worse problem.

MA practice by itself does not acknowledge past implementation of process modification or recycling and reuse, and facilities that have already achieved substantial waste-reduction successes would be at a disadvantage if little opportunity remained for further reduction at a reasonable cost. Technical assistance and data interpretation in the reporting of waste reduction could be important as they help to put complex data into a context of past waste-reduction progress and technically feasible future options. The following discussion illustrates the complex design decisions that facility managers must make when they attempt waste reduction, and it sheds light on the sort of perspective on economic and technologic factors that expert technical assistance and data analysis could provide. Suppose that the lock manufacturer's facility has been pressed by the community to reduce its emissions, and the facility is anxious to develop a positive image in the community. Carbon adsorption could be used to capture the TCA that the manufacturer uses before it is emitted from the facility. The TCA could be desorbed from the carbon with steam and then reused, but the facility does not have steam installed. It is expensive to adsorb TCA on carbon, because the TCA is unstable in the presence of water. It forms an acid that readily corrodes equipment, which must therefore be corrosion-resistant. If the facility purchases a carbon-adsorption unit without steam, the carbon with adsorbed TCA would constitute a solid hazardous waste that would require further off-site treatment or disposal. This would reduce the air emission problem but increase the hazardous waste problem commensurately; the waste would now consist of the original TCA plus the carbon adsorbent. If the facility decided to install steam to desorb the TCA for reuse, the capital cost would be extremely high. The TCA would have to be re-stabilized on site; some of the chemical stabilizers are very toxic, and facility personnel could be endangered. This option of carbon adsorption with steam for desorbing TCA, if the facility could afford it, would reduce the amount of TCA emitted into the atmosphere without increasing the amount of waste generated. Its drawbacks are that it is costly and the risk to the work force would be increased. Alternative methods for desorbing TCA could be considered that are potentially less costly and of lower worker risk (e.g., desorption with inert gas and electric heat).

Recycling is included in the term "waste reduction" as used in this report. The following example illustrates the complexity of waste reduction vis-a-vis recycling and the usefulness of additional technically informed analysis to augment raw MA data. Suppose that the lock manufacturer decides to sell the contaminated solvent to a recycling firm, instead of sending it for incineration as in the past or buying back the recycled solvent. The recycled solvent is eventually sold to another solvent user and is used in a cleaning operation. The amount of solvent sent off site remains the same for the lock manufacturer, although the reuse of the solvent results in a net reduction of virgin solvent production in the nation. If the spent solvent is considered a waste, it appears in the reported data that waste reduction has not occurred, but it has.

The lock manufacturer could further reduce waste by purchasing recycled solvent in place of virgin solvent. The reported MA numbers would not change, and reports of purchases and waste sent off site would be the same. Although there would be a net reduction in waste through reduction of total solvent production, the MA data would not show it.

Chemical Management Practice

MA information could be useful in providing to the public and the government information on the relationship among chemical management practices, releases that occur, and potential releases. MA data on changes in physical and chemical properties (e.g., from a liquid to a solid material and from a more hazardous to a less hazardous form) or changes in transport methods would provide valuable information to the community for assessing the potential hazards associated with transport practices and for developing emergency response plans. The most relevant datum for evaluating toxic chemical management practices is the annual quantity of specific chemicals transported across facility boundaries. Readily available records, such as invoices and shipping manifest records, would be used with the MA approach. The practical usefulness of the MA approach is small for assessing transportation and storage practices, however, because large differences among processes within a manufacturing facility limit comparability.

Chemical properties and reactivity, equipment design and safeguards, operating procedures, operator training, and quality of maintenance and monitoring all affect the likelihood of accidental releases, and the hazard associated with a release is influenced by the chemical's toxicity, transport characteristics, release location, and receptor locations. Such detailed information would not likely be collected through a national MA reporting program. At least some of it could be provided to the public, however, by supplementing reported data with information about chemical management practices at specific facilities.

Application to Health Surveillance and Assessments

The New Jersey Industrial Survey information has been put to a number of health-related uses. The data facilitated an occupational health surveillance that defined the number of workplaces in which toxic substances are used and the number of workers who were potentially exposed. Over 80% of the workplaces with potential exposures to mercury would not have been identified without MA data (New Jersey Department of Health, 1988). A statewide investigation used MA information from the Industrial Survey to find several previously undetected sites of workplace and environmental contamination with 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (NJDEP, 1985).

New Jersey Industrial Survey data were used with other information to assess potential human exposure to industrial releases in a community in Elizabeth, N.J. Facilities that were major sources of vinyl chloride monomer were identified, and initial site inspections resulted in one facility's being referred for enforcement actions for chemical spills and discharges (NJDEP, 1984).

Maryland has linked the Toxic Substances Registry System with the Statewide Cancer and Birth Defects Registry and the Occupational Disease Reporting System (Khoury et al., 1986). When geographic clusters of birth defects or occupational diseases are observed, these will be compared with the toxic substances database in a search for correlations.

Regulatory Support and Development

New Jersey reports that MA data helped provide a focus for the development of the state's Environmental Cleanup and Responsibility Act, Toxic Catastrophe Prevention Act, and Pollution Discharge Elimination System. The state is using survey information to assist in the development of the Air Toxics Strategy to revise regulations concerning the emission of toxic chemicals into the environment.

Maryland indicates that the Toxic Substances Registry System has provided it with a multimedia database that has been a building block for control and regulation of toxic substances. Data from the registry system were used to establish priorities for Maryland air toxics regulation and to establish a list of toxic air pollutants whose environmental releases facilities will be responsible for reporting. For both states, MA has been used mainly for qualitative purposes.

Environmental Economic Models

MA data could be used as input data to environmental economic models that address the government policy objective of striking a balance among competing uses of the environment. Industry relies on the environment as a receptor for chemical releases, and the public expects minimal environmental degradation. The models are designed to analyze industrial activities, waste generation, and environmental releases; the effects of releases on environmental quality; and the actions that can be taken to manage environmental quality at the regional level. James (1985) provides a review of the relevant literature.

NATIONAL ECONOMIC IMPACTS

The collection of MA information on a national scale could result in the expenditure of substantial resources by facilities required to report data and by agencies charged with processing, storing, and distributing the information. Furthermore, for information collected by state agencies to be useful to the EPA (and vice versa), data coding and management systems must be compatible. Considerable resources likely would be required to check the data submitted to ensure their accuracy and compliance. The pilot study described later in this chapter would provide valuable information on the economic impacts of a national, technically supported MA information collection program.

To minimize industry's financial and technical burden of TRI reporting, SARA Section 313 also provided that data collected in compliance with other regulations may be used for reporting purposes. The generation of valid and reliable MA information requires knowledge of materials and material contaminants, processes, and product and byproduct uses, as well as mathematical and engineering skills. Such expertise is most common among large companies that have available staff and resource flexibility. Small businesses with limited staff and expertise (e.g., a paint-stripper formulator with fewer than 25 employees) could be at a disadvantage in providing MA information, because many have not previously been required to report under any national environmental statutes and would need to acquire reporting expertise. Facilities are required to report to the TRI if they use a listed chemical on an average of approximately 30 lb/day throughout the year.

Many data collected under the mandates of various state and federal regulatory programs might be unusable for a MA program in their current forms, because their storage and retrieval systems are dissimilar. States planning to initiate mass balance information collection programs should be encouraged to coordinate with EPA to ensure consistency of nomenclature and data formats. Attention to data definition and collection consistency could reduce the costs of a national data collection program and improve access to a more extensive database.

CONFIDENTIALITY

A major concern of industry is that requirements to report the TRI-listed chemicals in individual waste streams could make public the information collected on raw materials or synthesis routes used to make products. This disclosure can involve a fairly complete description of operations, yields, and sales, all of which could be useful to competitors.

The experiences of the New Jersey Industrial Survey and the first collection cycle of the New Jersey Worker and Community Right-to-Know Act showed that less than 1% of the data submitted in each collection was claimed to be confidential (Alan Bookman, NJDEP, personal communication, March 1989). Nonetheless, the collection and use of confidential information remain an issue of great concern in the national collection of MA data. A prudent next step would be to assess, through the proposed pilot study of a national MA information collection program, whether industry's concerns regarding sensitive or proprietary information can be accommodated in ways that allow collection of useful data on a national scale. Experience gained through the Comprehensive Assessment Information Rule (Federal Register, 1988c) data collection program would also be helpful in addressing the issue of reporting information that is considered confidential business information.

NATIONAL MATERIALS ACCOUNTING DATA COLLECTION

A national MA data collection program can be useful if it is supplemented by additional information provided by technical experts. In such a program, MA data collection, verification, and analyses would be directed and performed by technically knowledgeable and experienced persons who could supplement the data with information relevant to chemical releases, waste-reduction progress, and chemical management practices. MA data would be the fundamental information provided by the facilities. Other readily available information might be requested initially or after a preliminary analysis of the initial information to better explain the relationship between industrial activities and environmental releases and waste reduction. General knowledge of the way toxic chemicals are produced or used at a facility is necessary information and might be requested in addition to MA data, if unknown to the experts. For example, the committee envisions that the experts might ask facilities manufacturing a certain type of product to describe the ways that a solvent is used to better explain why the solvent releases are relatively high compared to other manufacturing activities.

These experts should be independent of regulatory agencies and in a position to provide interpretative assistance as raw data are reported to the public. For example, mass release data do not necessarily enable accurate assessment of exposures; release concentrations, as well as other information (e.g., release height), would be necessary for accurate exposure assessments. Such augmentation of MA data might reduce the potential for misdirected interpretations of release data, and would assist risk communication programs.

A technically supported MA program could be a useful application of MA data that would enhance the public and government understanding of relationships between manufacturing and the environmental release of chemicals, which in turn might lead to reductions in the releases of toxic substances into the environment.

PILOT STUDY RECOMMENDATION

The committee recommends that a pilot study be conducted to test the feasibility of the national collection of MA information and that the study include a technical support group. This recommendation grows out of the original plan for this study as suggested by the NRC, which led to the present committee's deliberative process and review. This plan envisioned a two-phase investigation that would begin with a review of existing information to evaluate mass balance options. The present report completes the first phase. The second phase, as recommended by the committee, should involve a pilot study involving a national MA data collection program; it should be performed by a contractor or through a cooperative agreement with one or several engineering schools or research groups, with appropriately qualified, independent oversight of the study design and evaluation of results.

The pilot study is suggested as a prudent step in further considering a national MA data collection for all TRI-listed chemicals from thousands of facilities. The pilot study would obtain information to weigh the benefits and costs of MA information, and thus enable a reasoned decision on a national MA program. It also would indicate the following:

- The general feasibility of a nationwide collection and public dissemination of MA data designed, analyzed, and interpreted by technical experts.
- The utility of such nationwide MA information (beyond the value of TRI data) for the applications discussed in this report.
- The potential cost of such a program.
- The feasibility of conducting a national program that involves the collection of possibly sensitive or proprietary data for eventual public use.

Any collection of MA information, even at the level of a pilot study, will be time-consuming and expensive. The data selection should be a rigorous test of the complexity and interpretability of MA data. To maximize the information yield relative to resources expended, the pilot study should focus on just two or three chemicals from the TRI list. (Pilot study investigators could consider studying more chemicals if resources are available to support a larger study; however, adding more chemicals to the pilot study would not necessarily provide a more complete answer.) It might be specified that the selected chemicals have important known adverse health or environmental effects. Or it might be better to select chemicals used in large volumes, for two reasons: chemicals used in large volumes theoretically have a greater potential for significant amounts of releases, and the collection of MA information on chemicals used in large volumes would provide a rigorous test of information collection. Additional chemical-specific questions might be designed to focus on particular risks or chemical use patterns or to address metropolitan or regional issues. Comparisons might be made within a single industrial category or between industrial categories.

Data collected by the New Jersey Industrial Survey would be useful to a national pilot study but, by themselves, would not provide all of the information necessary to decide if a national program should be put in place. First, the New Jersey Industrial Survey did not have as one of its goals to provide information that has been supplemented by expert analysis in order to make it fully useful to the public. Therefore, it would be difficult to estimate the resource requirements for a national program as discussed in this report by relying solely on the New Jersey Industrial Survey. Second, as mentioned in Chapter 3, in many cases, field audits revealed that erroneous information was reported, and audits were not conducted at every facility. Third, the Industrial Survey response rate was 43% and may underrepresent releases from all relevant facilities in New Jersey.

The pilot study should build on the experience of the New Jersey Industrial Survey by evaluating a national-scale testing of all the characteristics of a MA program, assisted by a technical support group. It should consider all possible important releases of the few chemicals selected (i.e., from chemical uses by consumers and nonmanufacturing industries, in addition to those currently reporting to the TRI).

The pilot study should include an experimental public dissemination program designed to maximize the accessibility of an MA database supplemented with technical support. In evaluating the potential utility of such an MA program, pilot study investigators should solicit public comments on the disseminated information.

The pilot study should be designed to test ways to achieve the potential benefits of MA with technical support as cost-effectively as possible. Reliance on data that are likely to be routinely collected is another aspect to be evaluated. The pilot study should address the utility of MA data aggregated at the national or regional level, for example, as inputs to environmental economic models used to develop strategies for managing environmental quality.

Existing, nonconfidential data include all release-related data currently available to EPA, such as permit data, TRI data, and facility management data (e.g., production and sales information, purchase records, and waste manifest records). They also include monitoring data that are already being obtained by federal or state programs, emission inventories conducted under the Clean Air Act, water quality information obtained under the Clean Water Act, information on The Resource Conservation and Recovery Act hazardous waste manifests, population densities, and information from trade associations (e.g., production volumes and intermediate commercial uses). MA data collected on a regular basis under the New Jersey Worker and Community Right-to-Know Act of 1983 should also be considered. Validation checks are likely to be required for some of the data. Such checks would probably include visits to facilities and interviews of their personnel.

In summary, mass balance information, and in particular MA supplemented by expert technical assistance, has potential utility for addressing the information needs specified in SARA Section 313. However, the potential usefulness of a national program cannot be clearly established without conducting the recommended second phase of the study. It is the committee's consensus that a nationwide pilot data collection performed for a few chemicals would be the appropriate next step in pursuing the environmental protection and public-information goals of Title III of SARA.

Glossary

Chemical management practice.	For the purpose of this report, activities consisting of transportation across and within facility boundaries, waste reduction, storage and handling, and on-site tracking and treatment of toxic chemicals.
Closure.	In a mass balance application, closure is achieved when all inputs to a manufacturing facility, outputs from it, and accumulations within have been identified and the masses measured. The mass of inputs should equal the mass of outputs plus accumulations, within the accuracy of the measurements. The masses used may be total mass, masses of individual, nonreacting chemicals, or masses of individual chemical elements or combinations of elements.
EMB (engineering mass balance).	An application of the principle of mass balance to a production unit or facility. For each unit and for the whole facility, the mass of inputs, outputs, and accumulations are determined by measurement. The masses used may be the total mass, mass of a nonreacting chemical, or the masses of individual chemical elements or combinations of elements.
Facility.	All buildings, equipment, structures, and other stationary items that are located on a single site or on contiguous or adjacent sites and that are owned and operated by the same person (or by any person who controls, is controlled by, or shares control with such person).
Manufacture.	For the purpose of this report, to produce, prepare, import, or compound a chemical.
MA (materials accounting).	An approach to obtaining mass balance data that relies on information likely to be collected routinely at a facility for various purposes. Such information usually describes only material flows across facility boundaries; closure is not the goal. Examples of information used in MA are shipment records of raw materials into a facility and production records indicating the specific amounts of chemicals contained in products shipped from the facility. More exacting measurements made for an EMB could also be included as MA data.
Mass balance.	The principle that the sum of the mass of chemical inputs equals the sum of the outputs after all chemical changes and accumulation within a facility have been accounted for.
Mass balance data (or information).	An accumulation of the quantities of chemicals transported to a facility, produced at a

	facility, consumed at a facility, used at a facility, accumulated at a facility, released from a facility, and transported from a facility as a waste or as a commercial product or byproduct or component of a commercial product or byproduct.
New Jersey Industrial Survey.	A project conducted by the New Jersey Department of Environmental Protection between 1979 and 1982 to establish a MA database about the manufacture, use, storage, processing, formation, release, disposal, and repackaging of a group of chemical substances selected on the basis of their carcinogenicity or other toxic effects.
NGA (National Governors' Association).	Under agreement with the National Research Council, NGA conducted a survey to obtain information from the states about their past or current collection of mass balance-oriented data.
Normalization.	A procedure for adjusting the reported amount of waste by dividing it by such mass balance data as amount of input (e.g., raw material) or output (e.g., product).
Precision.	A measure of the agreement among individual measurements made of the same property of a sample.
Process.	To prepare a chemical, after its manufacture, for distribution in commerce: (1) in the same form or physical state in which or in a different form or physical state from which it was received by the person so preparing such chemical, or (2) as part of an article containing the chemical.
Production unit.	An assemblage of equipment used to produce one or more chemicals or other manufactured goods.
Release.	Release of a toxic chemical is the discharge into the environment of the chemical through such actions as spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment (including the abandonment or discarding of barrels, containers, and other closed receptacles).
SARA.	The Superfund Amendments and Reauthorization Act of 1986. P.L. 99-499.
Toxic chemicals.	The 308 specific chemicals and 20 chemical categories listed by the EPA for the first cycle of reporting to the TRI.
TRI (Toxics Release Inventory).	The database resulting from the information reported to EPA as specified in the Toxic Chemical Release Reporting Final Rule (53 Federal Register 4525, February 16, 1988) and required under SARA Section 313.
TRI-listed chemical.	The same as toxic chemical.
Use of a toxic chemical.	Any use, including those covered by the terms to "manufacture" or to "process" and including use of a toxic chemical contained in a mixture or trade-name product. The definition of "use" presented in 40 CFR 372.3 of the Community Right-to-Know Final Rule (see Chapter 1) is more narrow than the definition used in this report.
Waste minimization.	Same as waste reduction.
Waste reduction.	Any of the following activities performed on wastes generated within a facility: recycling and/or reuse on site; recycling and/or reuse off site; modifying equipment and/or technology; modifying production and/or processing procedures; redesigning and/or reformulating a product; substituting raw materials; improving housekeeping, training, and inventory control; and any other technique that results in the reduction or elimination of waste released to any environmental medium.
Waste-reduction efficiency.	A quantitative measure of progress in waste reduction, normalized for changes in the production rate of the facility generating the waste.

Appendix A

TRI (Toxic Release Inventory) Chemicals Subject To the Reporting Requirements of SARA Section 313[*]

The chemicals that have been delisted or added to the initial list of TRI chemicals are presented on the next page. The remainder of this appendix presents three lists of the initial TRI chemicals: (a) an alphabetical list of the TRI chemicals that have an associated chemical Abstracts Service (CAS) registry number, (b) a list by CAS number of the same chemicals, and (c) the chemical categories for which reporting is required (no CAS numbers are associated with those categories).

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[*] These chemicals were presented in the Toxic Chemical Release Reporting Final Rule 53 Fed. Reg. 4525 February 16, 1988.

EPA through several rule makings has delisted seven chemicals from the TRI list as follows:

CAS REGISTRY NO.	CHEMICAL NAME	DELISTING NOTICE
13463-67-7	Titanium dioxide	53 Fed. Reg. 23108 June 20, 1988
2650-18-2	C.I. Acid blue 9, diammonium salt	53 Fed. Reg. 39474 October 7, 1988
3844-45-9	C.I. Acid Blue 9, disodium salt	53 Fed. Reg. 39474 October 7, 1988
108-78-1	Melamine	54 Fed. Reg. 12912 March 29, 1989
7757-82-6	Sodium sulfate (solution)	54 Fed. Reg. 25850 June 20, 1989
1310-73-2	Sodium hydroxide (solution)	54 Fed. Reg. 51298 Dec. 14, 1989
1344-28-1	Aluminum oxide (non-fibrous forms)	55 Fed. Reg. 5220 February 14, 1989

On December 1, 1989 (54 Fed. Reg. 49948), EPA added the following nine chemicals to the TRI list:

CAS REGISTRY NO.	CHEMICAL NAME
107-18-6	Allyl alcohol
8001-58-9	Creosote
78-88-6	2,3-Dichloropropene
99-65-0	m-Dinitrobenzene
528-29-0	*o*-Dinitrobenzene
100-25-4	*p*-Dinitrobenzene
25321-14-6	Dinitrotoluene (mixed isomers)
120-58-1	Isosafrole
26471-62-5	Toluenedisocyanate (mixed isomers)

TABLE III

SECTION 313 TOXIC CHEMICAL LIST
(Including Chemical Categories)

[Note: Chemicals may be added or deleted to the list. The Emergency Planning and Community Right-to-Know Hotline, (800) 535-0202 or (202) 479-2449 in Washington, D.C. or Alaska, will provide up-to-date information on the status of these changes.]

a. Alphabetical List (Effective Date January 1, 1987)

CAS Number	Chemical Name
75-07-0	Acetaldehyde
60-35-5	Acetamide
67-64-1	Acetone
75-05-8	Acetonitrile
53-96-3	2-Acetylaminofluorene
107-02-8	Acrolein
79-06-1	Acrylamide
79-10-7	Acrylic acid
107-13-1	Acrylonitrile
309-00-2	Aldrin [1,4:5,8-Dimethanonaphthalene, 1,2,3,4,10,10-hexachloro-1,4,4a, 5,8,8a-hexahydro-(1.alpha., 4.alpha.,4a.beta.,5.alpha., 8.alpha.,8a.beta.)-]
107-05-1	Allyl chloride
7429-90-5	Aluminum (fume or dust)
1344-28-1	Aluminum oxide
117-79-3	2-Aminoanthraquinone
60-09-3	4-Aminoazobenzene
92-67-1	4-Aminobiphenyl
82-28-0	1-Amino-2-methylanthraquinone
7664-41-7	Ammonia
6484-52-2	Ammonium nitrate (solution)
7783-20-2	Ammonium sulfate (solution)
62-53-3	Aniline
90-04-0	o-Anisidine
104-94-9	p-Anisidine
134-29-2	o-Anisidine hydrochloride
120-12-7	Anthracene
7440-36-0	Antimony
7440-38-2	Arsenic
1332-21-4	Asbestos (friable)
7440-39-3	Barium
98-87-3	Benzal chloride
55-21-0	Benzamide
71-43-2	Benzene
92-87-5	Benzidine
98-07-7	Benzoic trichloride (Benzotrichloride)
98-88-4	Benzoyl chloride
94-36-0	Benzoyl peroxide
100-44-7	Benzyl chloride
7440-41-7	Beryllium
92-52-4	Biphenyl
111-44-4	Bis(2-chloroethyl) ether
542-88-1	Bis(chloromethyl) ether
108-60-1	Bis(2-chloro-1-methylethyl) ether
103-23-1	Bis(2-ethylhexyl) adipate
75-25-2	Bromoform (Tribromomethane)
74-83-9	Bromomethane (Methyl bromide)
106-99-0	1,3-Butadiene
141-32-2	Butyl acrylate
71-36-3	n-Butyl alcohol
78-92-2	sec-Butyl alcohol
75-65-0	tert-Butyl alcohol
85-68-7	Butyl benzyl phthalate
106-88-7	1,2-Butylene oxide
123-72-8	Butyraldehyde
2650-18-2	C.I. Acid Blue 9, diammonium salt
3844-45-9	C.I. Acid Blue 9, disodium salt
4680-78-8	C.I. Acid Green 3
569-64-2	C.I. Basic Green 4
989-38-8	C.I. Basic Red 1
1937-37-7	C.I. Direct Black 38
2602-46-2	C.I. Direct Blue 6
16071-86-6	C.I. Direct Brown 95
2832-40-8	C.I. Disperse Yellow 3
3761-53-3	C.I. Food Red 5
81-88-9	C.I. Food Red 15
3118-97-6	C.I. Solvent Orange 7
97-56-3	C.I. Solvent Yellow 3
842-07-9	C.I. Solvent Yellow 14
492-80-8	C.I. Solvent Yellow 34 (Auramine)
128-66-5	C.I. Vat Yellow 4
7440-43-9	Cadmium
156-62-7	Calcium cyanamide
133-06-2	Captan [1H-Isoindole-1,3(2H)-dione, 3a,4,7,7a-tetrahydro-2-[(trichloromethyl)thio]-]
63-25-2	Carbaryl [1-Naphthalenol, methylcarbamate]
75-15-0	Carbon disulfide
56-23-5	Carbon tetrachloride
463-58-1	Carbonyl sulfide
120-80-9	Catechol
133-90-4	Chloramben [Benzoic acid, 3-amino-2,5-dichloro-]
57-74-9	Chlordane [4,7-Methanoindan, 1,2,4,5,6,7,8,8- octachloro-2,3,3a,4,7,7a-hexahydro-]
7782-50-5	Chlorine
10049-04-4	Chlorine dioxide
79-11-8	Chloroacetic acid
532-27-4	2-Chloroacetophenone
108-90-7	Chlorobenzene
510-15-6	Chlorobenzilate [Benzeneacetic acid, 4-chloro-.alpha.-(4-chlorophenyl)-.alpha.-hydroxy-, ethyl ester]
75-00-3	Chloroethane (Ethyl chloride)
67-66-3	Chloroform
74-87-3	Chloromethane (Methyl chloride)
107-30-2	Chloromethyl methyl ether
126-99-8	Chloroprene
1897-45-6	Chlorothalonil [1,3-Benzenedicarbonitrile, 2,4,5,6-tetrachloro-]
7440-47-3	Chromium
7440-48-4	Cobalt
7440-50-8	Copper
120-71-8	p-Cresidine
1319-77-3	Cresol (mixed isomers)
108-39-4	m-Cresol
95-48-7	o-Cresol
106-44-5	p-Cresol
98-82-8	Cumene
80-15-9	Cumene hydroperoxide
135-20-6	Cupferron [Benzeneamine, N-hydroxy-N-nitroso, ammonium salt]

110-82-7	Cyclohexane
94-75-7	2,4-D [Acetic acid, (2,4-dichloro-phenoxy)-]
1163-19-5	Decabromodiphenyl oxide
2303-16-4	Diallate [Carbamothioic acid,bis (1-methylethyl)-, S-(2,3-dichloro-2-propenyl) ester]
615-05-4	2,4-Diaminoanisole
39156-41-7	2,4-Diaminoanisole sulfate
101-80-4	4,4'-Diaminodiphenyl ether
25376-45-8	Diaminotoluene (mixed isomers)
95-80-7	2,4-Diaminotoluene
334-88-3	Diazomethane
132-64-9	Dibenzofuran
96-12-8	1,2-Dibromo-3-chloropropane (DBCP)
106-93-4	1,2-Dibromoethane (Ethylene dibromide)
84-74-2	Dibutyl phthalate
25321-22-6	Dichlorobenzene (mixed isomers)
95-50-1	1,2-Dichlorobenzene
541-73-1	1,3-Dichlorobenzene
106-46-7	1,4-Dichlorobenzene
91-94-1	3,3'-Dichlorobenzidine
75-27-4	Dichlorobromomethane
107-06-2	1,2-Dichloroethane (Ethylene dichloride)
540-59-0	1,2-Dichloroethylene
75-09-2	Dichloromethane (Methylene chloride)
120-83-2	2,4-Dichlorophenol
78-87-5	1,2-Dichloropropane
542-75-6	1,3-Dichloropropylene
62-73-7	Dichlorvos [Phosphoric acid, 2 dichloroethenyl dimethyl ester]
115-32-2	Dicofol [Benzenemethanol, 4-chloro-.alpha.- 4-chlorophenyl)-.alpha.- (trichloromethyl)-]
1464-53-5	Diepoxybutane
111-42-2	Diethanolamine
117-81-7	Di-(2-ethylhexyl) phthalate (DEHP)
84-66-2	Diethyl phthalate
64-67-5	Diethyl sulfate
119-90-4	3,3'-Dimethoxybenzidine
60-11-7	4-Dimethylaminoazobenzene
119-93-7	3,3'-Dimethylbenzidine (o-Tolidine)
79-44-7	Dimethylcarbamyl chloride
57-14-7	1,1-Dimethyl hydrazine
105-67-9	2,4-Dimethylphenol
131-11-3	Dimethyl phthalate
77-78-1	Dimethyl sulfate
534-52-1	4,6-Dinitro-o-cresol
51-28-5	2,4-Dinitrophenol
121-14-2	2,4-Dinitrotoluene
606-20-2	2,6-Dinitrotoluene
117-84-0	n-Dioctyl phthalate
123-91-1	1,4-Dioxane
122-66-7	1,2-Diphenylhydrazine (Hydrazobenzene)
106-89-8	Epichlorohydrin
110-80-5	2-Ethoxyethanol
140-88-5	Ethyl acrylate
100-41-4	Ethylbenzene
541-41-3	Ethyl chloroformate
74-85-1	Ethylene
107-21-1	Ethylene glycol
151-56-4	Ethyleneimine (Aziridine)
75-21-8	Ethylene oxide
96-45-7	Ethylene thiourea
2164-17-2	Fluometuron [Urea, N,N-dimethyl-N'-[3-(trifluoromethyl)phenyl]-]
50-00-0	Formaldehyde
76-13-1	Freon 113 [Ethane, 1,1,2-trichloro-1,2, 2-trifluoro-]
76-44-8	Heptachlor [1,4,5,6,7,8,8-Heptachloro-3a,4,7,7a-tetrahydro-4,7-methano-1H-indene]
118-74-1	Hexachlorobenzene
87-68-3	Hexachloro-1,3-butadiene
77-47-4	Hexachlorocyclopentadiene
67-72-1	Hexachloroethane
1335-87-1	Hexachloronaphthalene
680-31-9	Hexamethylphosphoramide
302-01-2	Hydrazine
10034-93-2	Hydrazine sulfate
7647-01-0	Hydrochloric acid
74-90-8	Hydrogen cyanide
7664-39-3	Hydrogen fluoride
123-31-9	Hydroquinone
78-84-2	Isobutyraldehyde
67-63-0	Isopropyl alcohol (manufacturing-strong acid process, no supplier notification)
80-05-7	4,4'-Isopropylidenediphenol
7439-92-1	Lead
58-89-9	Lindane[Cyclohexane, 1,2,3,4,5,6-hexachloro-,(1.alpha.,2.alpha.,3.beta.,4.alpha.,5.alpha.,6.beta.)-]
108-31-6	Maleic anhydride
12427-38-2	Maneb [Carbamodithioic acid, 1,2-ethanediylbis-, manganese complex]
7439-96-5	Manganese
108-78-1	Melamine
7439-97-6	Mercury
67-56-1	Methanol
72-43-5	Methoxychlor [Benzene, 1,1'-(2,2,2-trichloroethylidene)bis [4-methoxy-]
109-86-4	2-Methoxyethanol
96-33-3	Methyl acrylate
1634-04-4	Methyl tert-butyl ether
101-14-4	4,4'-Methylenebis(2-chloro aniline) (MBOCA)
101-61-1	4,4'-Methylenebis(N,N-dimethyl) benzenamine
101-68-8	Methylenebis(phenylisocyanate) (MBI)
74-95-3	Methylene bromide
101-77-9	4,4'-Methylenedianiline
78-93-3	Methyl ethyl ketone
60-34-4	Methyl hydrazine
74-88-4	Methyl iodide
108-10-1	Methyl isobutyl ketone
624-83-9	Methyl isocyanate
80-62-6	Methyl methacrylate
90-94-8	Michler's ketone
1313-27-5	Molybdenum trioxide
505-60-2	Mustard gas [Ethane, 1,1'-tahiobis [2-chloro-]
91-20-3	Naphthalene
134-32-7	alpha-Naphthylamine
91-59-8	beta-Naphthylamine
7440-02-0	Nickel
7697-37-2	Nitric acid
139-13-9	Nitrilotriacetic acid
99-59-2	5-Nitro-o-anisidine
98-95-3	Nitrobenzene
92-93-3	4-Nitrobiphenyl
1836-75-5	Nitrofen [Benzene, 2,4-dichloro-1-(4-nitrophenoxy)-]
51-75-2	Nitrogen mustard [2-Chloro-N-(2-chloroethyl) -N-methylethanamine]
55-63-0	Nitroglycerin
88-75-5	2-Nitrophenol
100-02-7	4-Nitrophenol

79-46-9	2-Nitropropane
156-10-5	p-Nitrosodiphenylamine
121-69-7	N,N-Dimethylaniline
924-16-3	N-Nitrosodi-n-butylamine
55-18-5	N-Nitrosodiethylamine
62-75-9	N-Nitrosodimethylamine
86-30-6	N-Nitrosodiphenylamine
621-64-7	N-Nitrosodi-n-propylamine
4549-40-0	N-Nitrosomethylvinylamine
59-89-2	N-Nitrosomorpholine
759-73-9	N-Nitroso-N-ethylurea
684-93-5	N-Nitroso-N-methylurea
16543-55-8	N-Nitrosonornicotine
100-75-4	N-Nitrosopiperidine
2234-13-1	Octachloronaphthalene
20816-12-0	Osmium tetroxide
56-38-2	Parathion [Phosphorothioic acid, 0, 0-diethyl-0-(4-nitrophenyl) ester]
87-86-5	Pentachlorophenol (PCP)
79-21-0	Peracetic acid
108-95-2	Phenol
106-50-3	p-Phenylenediamine
90-43-7	2-Phenylphenol
75-44-5	Phosgene
7664-38-2	Phosphoric acid
7723-14-0	Phosphorus (yellow or white)
85-44-9	Phthalic anhydride
88-89-1	Picric acid
1336-36-3	Polychlorinated biphenyls (PCBs)
1120-71-4	Propane sultone
57-57-8	beta-Propiolactone
123-38-6	Propionaldehyde
114-26-1	Propoxur [Phenol, 2-(1-methylethoxy)-, methylcarbamate]
115-07-1	Propylene (Propene)
75-55-8	Propyleneimine
75-56-9	Propylene oxide
110-86-1	Pyridine
91-22-5	Quinoline
106-51-4	Quinone
82-68-8	Quintozene [Pentachloronitrobenzene]
81-07-2	Saccharin (manufacturing, no supplier notification) [1,2-Benzisothiazol -3(2H)-one, 1,1-dioxide]
94-59-7	Safrole
7782-49-2	Selenium
7440-22-4	Silver
1310-73-2	Sodium hydroxide (solution)
7757-82-6	Sodium sulfate (solution)
100-42-5	Styrene
96-09-3	Styrene oxide
7664-93-9	Sulfuric acid
100-21-0	Terephthalic acid
79-34-5	1,1,2,2-Tetrachlroethane
127-18-4	Tetrachloroethylene (Perchloroethylene)
961-11-5	Tetrachlorvinphos [Phosphoric acid, 2-chloro-1- (2,3,5-trichlorophenyl)ethenyl dimethyl ester]
7440-28-0	Thallium
62-55-5	Thioacetamide
139-65-1	4,4'-Thiodianiline
62-56-6	Thiourea
1314-20-1	Thorium dioxide
13463-67-7	Titanium dioxide
7550-45-0	Titanium tetrachloride
108-88-3	Toluene
584-84-9	Toluene-2,4-diisocyanate
91-08-7	Toluene-2,6-diisocyanate
95-53-4	o-Toluidine
636-21-5	o-Toluidine hydrochloride
8001-35-2	Toxaphene
68-76-8	Triaziquone [2,5-Cyclohexadiene-1,4-dione, 2,3,5-tris(1-aziridinyl)-]
52-68-6	Trichlorfon [Phosphonic acid, (2,2,2-trichloro-1-hydroxyethyl)-, dimethyl ester]
120-82-1	1,2,4-Trichlorobenzene
71-55-6	1,1,1-Trichloroethane (Methyl chloroform)
79-00-5	1,1,2-Trichloroethane
79-01-6	Trichloroethylene
95-95-4	2,4,5-Trichlorophenol
88-06-2	2,4,6-Trichlorophenol
1582-09-8	Trifluralin [Benzeneamine, 2,6-dinitro-N,N-dipropyl-4-(trifluoromethyl)-]
95-63-6	1,2,4-Trimethylbenzene
126-72-7	Tris(2,3-dibromopropyl) phosphate
51-79-6	Urethane (Ethyl carbamate)
7440-62-2	Vanadium (fume or dust)
108-05-4	Vinyl acetate
593-60-2	Vinyl bromide
75-01-4	Vinyl chloride
75-35-4	Vinylidene chloride
1330-20-7	Xylene (mixed isomers)
108-38-3	m-Xylene
95-47-6	o-Xylene
106-42-3	p-Xylene
87-62-7	2,6-Xylidine
7440-66-6	Zinc (fume or dust)
12122-67-7	Zineb [Carbamodithioic acid, 1,2-ethanediylbis-, zinc complex]

b. List By CAS Number (Effective Date January 1, 1987)

CAS Number	Chemical Name
50-00-0	Formaldehyde
51-28-5	2,4-Dinitrophenol
51-75-2	Nitrogen mustard [2-Chloro-N-(2-chloroethyl)-N-methylanamine]
51-79-6	Urethane (Ethyl carbamate)
52-68-6	Trichlorfon [Phosphonic acid, (2,2,2-trichloro-1-hydroxyethyl)-dimethyl ester]
53-96-3	2-Acetylaminofluorene
55-18-5	N-Nitrosodiethylamine
55-21-0	Benzamide
55-63-0	Nitroglycerin
56-23-5	Carbon tetrachloride
56-38-2	Parathion [Phosphorothioic acid, O,O-diethyl-O-(4-nitrophenyl)ester]
57-14-7	1,1-Dimethyl hydrazine
57-57-8	beta-Propiolactone
57-74-9	Chlordane [4,7-Methanoindan, 1,2,4,5,6,7,8,8- octachloro-2,3,3a,4,7,7a-hexahydro-]
58-89-9	Lindane [Cyclohexane, 1,2,3,4,5,6-hexachloro-,(1.alpha., 2.alpha.,3.beta., 4.alpha.,5.alpha.,6.beta.)-]
59-89-2	N-Nitrosomorpholine
60-09-3	4-Aminoazobenzene
60-11-7	4-Dimethylaminoazobenzene
60-34-4	Methyl hydrazine
60-35-5	Acetamide
62-53-3	Aniline
62-55-5	Thioacetamide
62-56-6	Thiourea
62-73-7	Dichlorvos [Phosphoric acid, 2,2-dichloroethenyl dimethyl ester]

62-75-9	N-Nitrosodimethylamine
63-25-2	Carbaryl [1-Naphthalenol, methylcarbamate]
64-67-5	Diethyl sulfate
67-56-1	Methanol
67-63-0	Isopropyl alcohol(manufacturing-strong acid process, no supplier notification)
67-64-1	Acetone
67-66-3	Chloroform
67-72-1	Hexachloroethane
68-76-8	Triaziquone [2,5-Cyclohexadiene-1,4-dione, 2,3,5-tris(1-aziridinyl)-]
71-36-3	n-Butyl alcohol
71-43-2	Benzene
71-55-6	1,1,1-Trichloroethane (Methyl chloroform)
72-43-5	Methoxychlor [Benzene, 1,1'-(2,2,2-trichloroethylidene)bis [4-methoxy-]
74-83-9	Bromomethane (Methyl bromide)
74-85-1	Ethylene
74-87-3	Chloromethane (Methyl chloride)
74-88-4	Methyl iodide
74-90-8	Hydrogen cyanide
74-95-3	Methylene bromide
75-00-3	Chloroethane (Ethyl chloride)
75-01-4	Vinyl chloride
75-05-8	Acetonitrile
75-07-0	Acetaldehyde
75-09-2	Dichloromethane (Methylene chloride)
75-15-0	Carbon disulfide
75-21-8	Ethylene oxide
75-25-2	Bromoform (Tribromomethane)
75-27-4	Dichlorobromomethane
75-35-4	Vinylidene chloride
75-44-5	Phosgene
75-55-8	Propyleneimine
75-56-9	Propylene oxide
75-65-0	tert-Butyl alcohol
76-13-1	Freon 113 [Ethane, 1,1,2-trichloro-1,2,2-trifluoro-]
76-44-8	Heptachlor [1,4,5,6,7,8,8-Heptachloro-3a,4,7,7a-tetrahydro-4,7-methano-1H-indene]
77-47-4	Hexachlorocyclopentadiene
77-78-1	Dimethyl sulfate
78-84-2	Isobutyraldehyde
78-87-5	1,2-Dichloropropane
78-92-2	sec-Butyl alcohol
78-93-3	Methyl ethyl ketone
79-00-5	1,1,2-Trichloroethane
79-01-6	Trichloroethylene
79-06-1	Acrylamide
79-10-7	Acrylic acid
79-11-8	Chloroacetic acid
79-21-0	Peracetic acid
79-34-5	1,1,2,2-Tetrachloroethane
79-44-7	Dimethylcarbamyl chloride
79-46-9	2-Nitropropane
80-05-7	4,4'-Isopropylidenediphenol
80-15-9	Cumene hydroperoxide
80-62-6	Methyl methacrylate
81-07-2	Saccharin (manufacturing, no supplier notification) [1,2-Benzisothiazol-3(2H)-one, 1,1-dioxide]
81-88-9	C.I. Food Red 15
82-28-0	1-Amino-2-methylanthraquinone
82-68-8	Quintozene [Pentachloronitrobenzene]
84-66-2	Diethyl phthalate
84-74-2	Dibutyl phthalate
85-44-9	Phthalic anhydride
85-68-7	Butyl benzyl phthalate
86-30-6	N-Nitrosodiphenylamine
87-62-7	2,6-Xylidine
87-68-3	Hexachloro-1,3-butadiene
87-86-5	Pentachlorophenol (PCP)
88-06-2	2,4,6-Trichlorophenol
88-75-5	2-Nitrophenol
88-89-1	Picric acid
90-04-0	o-Anisidine
90-43-7	2-Phenylphenol
90-94-8	Michler's ketone
91-08-7	Toluene-2,6-diisocyanate
91-20-3	Naphthalene
91-22-5	Quinoline
91-59-8	beta-Naphthylamine
91-94-1	3,3'-Dichlorobenzidine
92-52-4	Biphenyl
92-67-1	4-Aminobiphenyl
92-87-5	Benzidine
92-93-3	4-Nitrobiphenyl
94-36-0	Benzoyl peroxide
94-59-7	Safrole
94-75-7	2,4-D [Acetic acid, (2,4-dichlorophenoxy)-]
95-47-6	o-Xylene
95-48-7	o-Cresol
95-50-1	1,2-Dichlorobenzene
95-53-4	o-Toluidine
95-63-6	1,2,4-Trimethylbenzene
95-80-7	2,4-Diaminotoluene
95-95-4	2,4,5-Trichlorophenol
96-09-3	Styrene oxide
96-12-8	1,2-Dibromo-3-chloropropane (DBCP)
96-33-3	Methyl acrylate
96-45-7	Ethylene thiourea
97-56-3	C.I. Solvent Yellow 3
98-07-7	Benzoic trichloride (Benzotrichloride)
98-82-8	Cumene
98-87-3	Benzal chloride
98-88-4	Benzoyl chloride
98-95-3	Nitrobenzene
99-59-2	5-Nitro-o-anisidine
100-02-7	4-Nitrophenol
100-21-0	Terephthalic acid
100-41-4	Ethylbenzene
100-42-5	Styrene
100-44-7	Benzyl chloride
100-75-4	N-Nitrosopiperidine
101-14-4	4,4'-Methylenebis(2-chloroaniline) (MBOCA)
101-61-1	4,4'-Methylenebis(N,N-dimethyl) benzenamine
101-68-8	Methylenebis(phenylisocyanate) (MBI)
101-77-9	4,4'-Methylenedianiline
101-80-4	4,4'-Diaminodiphenyl ether
103-23-1	Bis(2-ethylhexyl) adipate
104-94-9	p-Anisidine
105-67-9	2,4-Dimethylphenol
106-42-3	p-Xylene
106-44-5	p-Cresol
106-46-7	1,4-Dichlorobenzene
106-50-3	p-Phenylenediamine
106-51-4	Quinone
106-88-7	1,2-Butylene oxide
106-89-8	Epichlorohydrin
106-93-4	1,2-Dibromoethane (Ethylene dibromide)
106-99-0	1,3-Butadiene
107-02-8	Acrolein
107-05-1	Allyl chloride
107-06-2	1,2-Dichloroethane (Ethylene dichloride)
107-13-1	Acrylonitrile
107-21-1	Ethylene glycol
107-30-2	Chloromethyl methyl ether
108-05-4	Vinyl acetate

108-10-1	Methyl isobutyl ketone
108-31-6	Maleic anhydride
108-38-3	m-Xylene
108-39-4	m-Cresol
108-60-1	Bis(2-chloro-1-methylethyl) ether
108-78-1	Melamine
108-88-3	Toluene
108-90-7	Chlorobenzene
108-95-2	Phenol
109-86-4	2-Methoxyethanol
110-80-5	2-Ethoxyethanol
110-82-7	Cyclohexane
110-86-1	Pyridine
111-42-2	Diethanolamine
111-44-4	Bis(2-chloroethyl) ether
114-26-1	Propoxur [Phenol, 2-(1-methylethoxy)-, methylcarbamate]
115-07-1	Propylene (Propene)
115-32-2	Dicofol [Benzenemethanol, 4-chloro-.alpha.-(4-chlorophenyl)-.alpha.-(trichloromethyl)-]
117-79-3	2-Aminoanthraquinone
117-81-7	Di(2-ethylhexyl) phthalate (DEHP)
117-84-0	n-Dioctyl phthalate
118-74-1	Hexachlorobenzene
119-90-4	3,3'-Dimethoxybenzidine
119-93-7	3,3'-Dimethylbenzidine (o-Tolidine)
120-12-7	Anthracene
120-71-8	p-Cresidine
120-80-9	Catechol
120-82-1	1,2,4-Trichlorobenzene
120-83-2	2,4-Dichlorophenol
121-14-2	2,4-Dinitrotoluene
121-69-7	N,N-Dimethylaniline
122-66-7	1,2-Diphenylhydrazine (Hydrazobenzene)
123-31-9	Hydroquinone
123-38-6	Propionaldehyde
123-72-8	Butyraldehyde
123-91-1	1,4-Dioxane
126-72-7	Tris(2,3-dibromopropyl) phosphate
126-99-8	Chloroprene
127-18-4	Tetrachloroethylene (Perchloroethylene)
128-66-5	C.I. Vat Yellow 4
131-11-3	Dimethyl phthalate
132-64-9	Dibenzofuran
133-06-2	Captan [1H-Isoindole-1,3(2H)-dione, 3a,4,7,7a-tetrahydro-2-[(trichloromethyl)thio]-]
133-90-4	Chloramben [Benzoic acid, 3-amino-2,5-dichloro-]
134-29-2	o-Anisidine hydrochloride
134-32-7	alpha-Naphthylamine
135-20-6	Cupferron [Benzeneamine, N-hydroxy-N-nitroso, ammonium salt]
139-13-9	Nitrilotriacetic acid
139-65-1	4,4'-Thiodianiline
140-88-5	Ethyl acrylate
141-32-2	Butyl acrylate
151-56-4	Ethyleneimine (Aziridine)
156-10-5	p-Nitrosodiphenylamine
156-62-7	Calcium cyanamide
302-01-2	Hydrazine
309-00-2	Aldrin [1,4:5,8-Dimethanonaphthalene, 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-(1.alpha.,4.alpha.,4a.beta.,5.alpha.,8.alpha.,8a.beta.)-]
334-88-3	Diazomethane
463-58-1	Carbonyl sulfide
492-80-8	C.I. Solvent Yellow 34 (Auramine)
505-60-2	Mustard gas [Ethane,1,1'-thiobis[2-chloro-]
510-15-6	Chlorobenzilate [Benzeneacetic acid, 4-chloro-.alpha.-(4-chlorophenyl)-.alpha.-hydroxy-,ehtyl ester]
532-27-4	2-Chloroacetophenone
534-52-1	4,6-Dinitro-o-cresol
540-59-0	1,2-Dichloroethylene
541-41-3	Ethyl chloroformate
541-73-1	1,3-Dichlorobenzene
542-75-6	1,3-Dichloropropylene
542-88-1	Bis(chloromethyl) ether
569-64-2	C.I. Basic Green 4
584-84-9	Toluene-2,4-diisocyanate
593-60-2	Vinyl bromide
606-20-2	2,6-Dinitrotoluene
615-05-4	2,4-Diaminoanisole
621-64-7	N-Nitrosodi-n-propylamine
624-83-9	Methyl isocyanate
636-21-5	o-Toluidine hydrochloride
680-31-9	Hexamethylphosphoramide
684-93-5	N-Nitroso-N-methylurea
759-73-9	N-Nitroso-N-ethylurea
842-07-9	C.I. Solvent Yellow 14
924-16-3	N-Nitrosodi-n-butylamine
961-11-5	Tetrachlorvinphos [Phosphoric acid, 2-chloro-1- (2,3,5-trichlorophenyl)ethenyl dimethyl ester]
989-38-8	C.I. Basic Red 1
1120-71-4	Propane sultone
1163-19-5	Decabromodiphenyl oxide
1310-73-2	Sodium hydroxide (solution)
1313-27-5	Molybdenum trioxide
1314-20-1	Thorium dioxide
1319-77-3	Cresol (mixed isomers)
1330-20-7	Xylene (mixed isomers)
1332-21-4	Asbestos (friable)
1335-87-1	Hexachloronaphthalene
1336-36-3	Polychlorinated biphenyls (PCBs)
1344-28-1	Aluminum oxide
1464-53-5	Diepoxybutane
1582-09-8	Trifluralin [Benzeneamine, 2,6-dinitro-N,N-dipropyl-4-(trifluoromethyl)-]
1634-04-4	Methyl tert-butyl ether
1836-75-5	Nitrofen [Benzene, 2,4-dichloro-1-(4-nitrophenoxy)-]
1897-45-6	Chlorothalonil [1,3-Benzenedicarbonitrile, 2,4,5,6-tetrachloro-]
1937-37-7	C.I. Direct Black 38
2164-17-2	Fluometuron [Urea, N,N-dimethyl-N'-[3-(trifluoromethyl)phenyl]-]
2234-13-1	Octachloronaphthalene
2303-16-4	Diallate [Carbamothioc acid, bis (1-methylethyl)-, S-(2,3-dichloro-2-propenyl) ester]
2602-46-2	C.I. Direct Blue 6
2650-18-2	C.I. Acid Blue 9, diammonium salt
2832-40-8	C.I. Disperse Yellow 3
3118-97-6	C.I. Solvent Orange 7
3761-53-3	C.I. Food Red 5
3844-45-9	C.I. Acid Blue 9, disodium salt
4549-40-0	N-Nitrosomethylvinylamine
4680-78-8	C.I. Acid Green 3
6484-52-2	Ammonium nitrate (solution)
7429-90-5	Aluminum (fume or dust)
7439-92-1	Lead
7439-96-5	Manganese
7439-97-6	Mercury
7440-02-0	Nickel
7440-22-4	Silver
7440-28-0	Thallium
7440-36-0	Antimony
7440-38-2	Arsenic

7440-39-3	Barium
7440-41-7	Beryllium
7440-43-9	Cadmium
7440-47-3	Chromium
7440-48-4	Cobalt
7440-50-8	Copper
7440-62-2	Vanadium (fume or dust)
7440-66-6	Zinc (fume or dust)
7550-45-0	Titanium tetrachloride
7647-01-0	Hydrochloric acid
7664-38-2	Phosphoric acid
7664-39-3	Hydrogen fluoride
7664-41-7	Ammonia
7664-93-9	Sulfuric acid
7697-37-2	Nitric acid
7723-14-0	Phosphorus (yellow or white)
7757-82-6	Sodium sulfate (solution)
7782-49-2	Selenium
7782-50-5	Chlorine
7783-20-2	Ammonium sulfate (solution)
8001-35-2	Toxaphene
10034-93-2	Hydrazine sulfate
10049-04-4	Chlorine dioxide
12122-67-7	Zineb [Carbamodithioic acid, 1,2-ethanediylbis-, zinc complex]
12427-38-2	Maneb [Carbamodithioic acid, 1,2-ethanediylbis-, manganese complex]
13463-67-7	Titanium dioxide
16071-86-6	C.I Direct Brown 95
16543-55-8	N-Nitrosonornicotine
20816-12-0	Osmium tetroxide
25321-22-6	Dichlorobenzene (mixed isomers)
25376-45-8	Diaminotoluene (mixed isomers)
39156-41-7	2,4-Diaminoanisole sulfate

c. Chemical Categories (Effective Date January 1, 1987)

Antimony Compounds - Includes any unique chemical substance that contains antimony as part of that chemical's infrastructure.

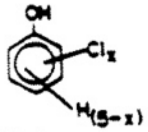
Arsenic Compounds - Includes any unique chemical substance that contains arsenic as part of that chemical's infrastructure.

Barium Compounds - Includes any unique chemical substance that contains bariumas part of that chemical's infrastructure.

Beryllium Compounds - Includes any unique chemical substance that contains beryllium as part of that chemical's infrastructure.

Cadmium Compounds - Includes any unique chemical substance that contains cadmium as part of that chemical's infrastructure.

Chlorophenols -



where x = 1 to 5

Chromium Compounds - Includes any unique chemical substance that contains chromium as part of that chemical's infrastructure.

Cobalt Compounds - Includes any unique chemical substance that contains cobalt as part of that chemical's infrastructure.

Copper Compounds - Includes any unique chemical substance that contains copper as part of that chemical's infrastructure.

Cyanide Compounds - $X^+ CN^-$ where $X = H^+$ or any other group where a formal dissociation can be made. For example KCN or $Ca(CN)_2$.

Glycol Ethers - Includes mono- and di- ethers of ethylene glycol, diethylene glycol, and triethylene glycol.

R-$(OCH_2CH_2)_n$-OR'
Where n = 1,2,or 3
R = alkyl or aryl groups
R'= R, H, or groups which, when removed, yield glycol ethers with the structure:
R-$(OCH_2CH_2)_n$-OH

Polymers are excluded from this category.

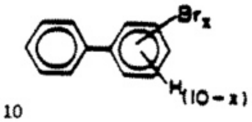
Lead Compounds - Includes any unique chemical substance that contains lead as part of that chemical's infrastructure.

Manganese Compounds - Includes any unique chemical substance that contains manganese as part of that chemical's infrastructure.

Mercury Compounds - Includes any unique chemical substance that contains mercury as part of that chemical's infrastructure.

Nickel Compounds - Includes any unique chemical substance that contains nickel as part of that chemical's infrastructure.

Polybrominated Biphenyls (PBBs)



where x = 1 to 10

Selenium Compounds - Includes any unique chemical substance that contains selenium as part of that chemical's infrastructure.

Silver Compounds - Includes any unique chemical substance that contains silver as part of that chemical's infrastructure.

Thallium Compounds - Includes any unique chemical substance that contains thallium as part of that chemical's infrastructure.

Zinc Compounds - Includes any unique chemical substance that contains zinc as part of that chemical's infrastructure.

APPENDIX A HOW TO DETERMINE LATITUDE AND LONGITUDE FROM TOPOGRAPHIC MAPS

Latitude is the distance north or south of the equator. Longitude is the distance east or west of the prime meridian (Greenwich, England). Latitude and longitude are measured in seconds, minutes and degrees.

$$60'' \text{ (seconds)} = 1' \text{ (minute)}$$

$$60' \text{ (minutes)} = 1^{\circ} \text{ (degree)}$$

To determine the latitude and longitude of your facility you will need the following:

- topographic map from United States Geological Survey (USGS)
- ruler graduated in decimal units (cm or inches)
- pencil
- small calculator (optional).

How to Obtain USGS Maps -

USGS maps used for determining latitude and longitude may be obtained from one of two distribution centers. These maps are available in both the 7.5 minute and 15 minute series. For areas east of the Mississippi River, including Minnesota, Puerto Rico, and the U.S. Virgin Islands, contact:

Branch of Distribution
U.S. Geological Survey
Reston, VA 22092

or areas west of the Mississippi, including Alaska, Hawaii, Louisiana, American Samoa and Guam, contact:

Branch of Distribution
U.S. Geological Survey
Box 25286 Federal Center
Denver, CO 80225

If you are not sure of the map on which your site is located, USGS will provide a free index to topographic maps for your state. USGS maps cost about $3.00 and are often available in local libraries and at commercial dealers such as surveyors or outdoor recreation equipment dealers. The index for your state will list these alternative sources for obtaining maps.

Determining Your Facility's Latitude and Longitude (See diagram next page.)

Once you have obtained the correct map for your facility you should follow these steps:

1. Mark the location of your facility on the map with a point. If your facility is large, choose a point central to the production activities of the facility. If certain structures in your facility are represented on the map, mark one of the structures with a point.
2. Construct a small quadrangle (a four sided figure) around the point with fine pencil lines connecting the nearest 2 1/2' or 5' graticules. Graticules are intersections of latitude and longitude lines that are marked on the map edge, and appear as black crosses at four points in the interior of the map.
3. Read and record the latitude and longitude for the southeast corner of the small quadrangle drawn in step two. The latitude and longitude are written at the edges of the map.
4. To determine the increment of latitude above the latitude line recorded in step 3,

- position the map so that you face its west edge;
- place the ruler in approximately a north-south alignment with the "0" on the latitude line recorded in step 3 and the edge intersecting the point.

Without moving the ruler, read and record:

- the measurement from the latitude line to the desired point (the point distance);
- the measurement from the latitude line to the north line of the small quadrangle (the total distance).

Determine the number of seconds to be added to the latitude recorded in step 3 by using the ratio:

$$\frac{\text{Point distance}}{\text{Total distance between lines}} \times 150'' = \text{increment of latitude}$$

(Note: 150" is the number of seconds of arc for the side of the small quadrangle on a 7.5' map. If you are using a 15' map then the multiplication factor is 300" instead of 150" since each graticule is 5' of latitude or longitude.)

For example:

$$\text{Point distance} = 99.5$$

$$\text{Total distance} = 192.0$$

$$\frac{99.5}{192.0} \times 150'' = 77.7'' = 01'\ 17.7''$$

$$(60'' = 1';\ 77.7'' - 60'' = 01'\ 17.7'')$$

Latitude in step 3:	32°17'30"
Increment:	+ 01'17.7"
Latitude of point:	32°18'47.7"

$$\text{to the nearest second} = 32^{\circ}18'48''$$

5. To determine the increment of longitude west of the longitude line recorded in step 3,

- position the map so that you face its south edge;
- place the ruler in approximately an east-west alignment with the "0" on the longitude line recorded in step S and the edge intersecting the point.

Without moving the ruler, read and record:

- the measurement from the longitude line to the desired point (the point distance);
- the measurement from the longitude line to the west line of the small quadrangle (the total distance).

Determine the number of seconds to be added to the longitude recorded in step S by using the ratio:

Appendix B

Standard Industrial Classification Codes Within the Manufacturing Division[*]

As indicated in Chapter 1, any industrial facility may be required to report its annual releases of any TRI-listed chemical it handles if the facility has a Standard Industrial Classification (SIC) Code with the first two digits in the range from 20 through 39.

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[*] SOURCE: Executive Office of the President, Office of Management and Budget, 1987. Standard Industrial Classification Manual, 1987. Washington, DC: Government Printing Office. Available from NTIS as PB 87-100012.

STANDARD INDUSTRIAL CLASSIFICATION NUMERICAL LIST OF SHORT TITLES (PARTIAL LISTING)

D. Manufacturing

Code	Short Title
20	FOOD AND KINDRED PRODUCTS
201	Meat Products
202	Dairy Products
203	Preserved Fruits and Vegetables
204	Grain Mill Products
205	Bakery Products
206	Sugar and Confectionery Products
207	Fats and Oils
208	Beverages
209	Misc. Food and Kindred Products
21	TOBACCO PRODUCTS
211	Cigarettes
212	Cigars
213	Chewing and Smoking Tobacco
214	Tobacco Stemming and Redrying
22	TEXTILE MILL PRODUCTS
221	Broadwoven Fabric Mills, Cotton
222	Broadwoven Fabric Mills, Man-made
223	Broadwoven Fabric Mills, Wool
224	Narrow Fabric Mills
225	Knitting Mills
226	Textile Finishing, Except Wool
227	Carpets and Rugs
228	Yarn and Thread Mills
229	Miscellaneous Textile Goods
23	APPAREL AND OTHER TEXTILE PRODUCTS
231	Men's and Boys' Suits and Coats
232	Men's and Boys' Furnishings
233	Women's and Misses' Outerwear
234	Women's and Children's Undergarments
235	Hats, Caps, and Millinery
236	Girls' and Children's Outerwear
237	Fur Goods
238	Miscellaneous Apparel and Accessories
239	Misc. Fabricated Textile Products
24	LUMBER AND WOOD PRODUCTS
241	Logging
242	Sawmills and Planing Mills
243	Millwork, Plywood & Structural Members
244	Wood Containers
245	Wood Buildings and Mobile Homes
249	Miscellaneous Wood Products
25	FURNITURE AND FIXTURES
251	Household Furniture
252	Office Furniture
253	Public Building & Related Furniture
254	Partitions and Fixtures
259	Miscellaneous Furniture and Fixtures
26	PAPER AND ALLIED PRODUCTS
261	Pulp Mills
262	Paper Mills
263	Paperboard Mills
265	Paperboard Containers and Boxes
267	Misc. Converted Paper Products
27	PRINTING AND PUBLISHING
271	Newspapers
272	Periodicals
273	Books
274	Miscellaneous Publishing
275	Commercial Printing
276	Manifold Business Forms
277	Greeting Cards
278	Blankbooks and Bookbinding
279	Printing Trade Services
28	CHEMICALS AND ALLIED PRODUCTS
281	Industrial Inorganic Chemicals
282	Plastics Materials and Synthetics
283	Drugs

Code	Short Title
284	Soap, Cleaners, and Toilet Goods
285	Paints and Allied Products
286	Industrial Organic Chemicals
287	Agricultural Chemicals
289	Miscellaneous Chemical Products
29	PETROLEUM AND COAL PRODUCTS
291	Petroleum Refining
295	Asphalt Paving and Roofing Materials
299	Misc. Petroleum and Coal Products
30	RUBBER AND MISC. PLASTICS PRODUCTS
301	Tires and Inner Tubes
302	Rubber and Plastics Footwear
305	Hose & Belting & Gaskets & Packing
306	Fabricated Rubber Products, nec (not elsewhere classified)
308	Miscellaneous Plastics Products, nec
31	LEATHER AND LEATHER PRODUCTS
311	Leather Tanning and Finishing
313	Footwear Cut Stock
314	Footwear, Except Rubber
315	Leather Gloves and Mittens
316	Luggage
317	Handbags and Personal Leather Goods
319	Leather Goods, nec
32	STONE, CLAY, AND GLASS PRODUCTS
321	Flat Glass
322	Glass and Glassware, Pressed or Blown
323	Products of Purchased Glass
324	Cement, Hydraulic
325	Structural Clay Products
326	Pottery and Related Products
327	Concrete, Gypsum, and Plaster Products
328	Cut Stone and Stone Products
329	Misc. Nonmetallic Mineral Products
33	PRIMARY METAL INDUSTRIES
331	Blast Furnace and Basic Steel Products
332	Iron and Steel Foundries
333	Primary Nonferrous Metals
334	Secondary Nonferrous Metals
335	Nonferrous Rolling and Drawing
336	Nonferrous Foundries (Castings)
339	Miscellaneous Primary Metal Products
340	FABRICATED METAL PRODUCTS
341	Metal Cans and Shipping Containers
342	Cutlery, Handtools, and Hardware
343	Plumbing and Heating, Except Electric
344	Fabricated Structural Metal Products
345	Screw Machine Products, Bolts, Etc.
346	Metal Forgings and Stampings
347	Metal Services, nec
348	Ordnance and Accessories, nec
349	Misc. Fabricated Metal Products
35	INDUSTRIAL MACHINERY AND EQUIPMENT
351	Engines and Turbines
352	Farm and Garden Machinery
353	Construction and Related Machinery
354	Metalworking Machinery
355	Special Industry Machinery
356	General Industrial Machinery
357	Computer and Office Equipment
358	Refrigeration and Service Machinery
359	Industrial Machinery, nec
36	ELECTRONIC & OTHER ELECTRIC EQUIPMENT
361	Electric Distribution Equipment
362	Electrical Industrial Apparatus
363	Household Appliances
364	Electric Lighting and Wiring Equipment
365	Household Audio and Video Equipment
366	Communications Equipment
367	Electronic Components and Accessories
369	Misc. Electrical Equipment & Supplies
37	TRANSPORTATION EQUIPMENT
371	Motor Vehicles and Equipment
372	Aircraft and Parts
373	Ship and Boat Building and Repairing
374	Railroad Equipment
375	Motorcycles, Bicycles, and Parts
376	Guided Missiles, Space Vehicles, Parts
379	Miscellaneous Transportation Equipment
38	INSTRUMENTS AND RELATED PRODUCTS
381	Search and Navigation Equipment
382	Measuring and Controlling Devices
384	Medical Instruments and Supplies
385	Ophthalmic Goods
386	Photographic Equipment and Supplies
387	Watches, Clocks, Watchcases & Parts

Code	Short Title
39	MISCELLANEOUS MANUFACTURING INDUSTRIES
391	Jewelry, Silverware, and Plated Ware
393	Musical Instruments
394	Toys and Sporting Goods
395	Pens, Pencils, Office, & Art Supplies
396	Costume Jewelry and Notions
399	Miscellaneous Manufactures

Appendix C

U.S. EPA Form R: Toxic Chemical Release Inventory Reporting Form

Submission of Form R is required for manufacturing facilities affected by SARA Section 313. Section 313(h) of SARA indicates the intended purposes of the Toxic Chemical Release Inventory Reporting Form:

> "(h)Use of Release Form.-The release forms required under this section are intended to provide information to the Federal, State, and local governments and the public, including citizens of communities surrounding covered facilities. The release form shall be available, consistent with section 324(a), to inform persons about releases of toxic chemicals to the environment; to assist governmental agencies, researchers, and other persons in the conduct of research and data gathering; to aid in the development of appropriate regulations, guidelines, and standards; and for other similar purposes."

INSTRUCTIONS FOR COMPLETING SPECIFIC SECTIONS OF EPA FORM R

The following are specific instructions for completing each part of EPA Form R. The number designations of the parts and sections of these instructions correspond to those in Form R unless otherwise indicated.

A sample, completed Form R for a hypothetical facility reporting under Title III, section 313, is included as Appendix A (page 47). You may want to refer to this sample as you read through these instructions.

Instructions for Completing All Parts of Form R:

1. Type or print information on the form in the units and format requested.
2. Longitudinal and latitudinal data were optional for the 1987 reports but are required for 1988 and subsequent reporting years. All information on Form R is required except Part III, Section 8.
3. Do not leave items on Form R blank unless specifically directed to do so; if an item does not apply to you, enter "NA," not applicable, in the space provided. If your information does not fill all the spaces provided for a type of information, enter NA, in the next blank space in the sequence.
4. Do not submit an incomplete form. The certification statement (Part I) specifies that the report is complete as submitted. See page 1 of these instructions for the definition of a complete submission.
5. When completing Part IV, supplemental information, or additional pages for Part II of the form, number the additional information sequentially from the prior sections of the form.
6. The box labelled "This space for your optional use" on each page may be used to differentiate one chemical-specific submission from another. You are not required to enter any information in this space. See page 2 for use of this box relating to a voluntary revision of a previous submission.

Part I. Facility Identification Information

1.1 Are You Claiming the Chemical Identity on Page 3 Trade Secret?

Answer this question only after you have completed the rest of the report. The specific identity of the toxic chemical being reported in Part III, Sections 1.2 and 1.3, may be designated as trade secret. If you are making a trade secret claim, mark "yes" and proceed to Section 1.2. Only check "Yes" if it is your manufacturing, processing, or use of the chemical that is a trade secret. (See page 1 of these instructions for specific information on trade secrecy claims.) If you checked "no," proceed to Section 1.3; do not answer Section 1.2.

1.2 If "Yes" in 1.1. is This Copy Sanitized or Unsanitized?

Answer this question only after you have completed the rest of the report. Check "sanitized" if this copy of the report is the public version and you have claimed the chemical identity trade secret in Part III, Section 1.1. Otherwise, check "unsanitized."

1.3 Reporting Year

Enter the last two digits of the calendar year to which the reported information applies, not the year in which you are submitting the report. Information for the 1988 reporting year must be submitted on or before July 1, 1989.

2. Certification

The certification statement must be signed by the owner or operator or a senior official with management responsibility for the person (or persons) completing the form. The owner, operator, or official must certify the accuracy and completeness of the information reported on the form by signing and dating the certification statement. Each report must contain an original signature. Print or type in the space provided the name and title of the person who signs the statement. This certification statement applies to all the information supplied on the form and should be signed only after the form has been completed.

3. Facility Identification

3.1 Facility Name and Location

Enter the name of your facility (plant site name or appropriate facility designation), street address, city, county, state, and zip code in the space provided. Do not use a post office box number as the address. The address provided should be the location where the chemicals are manufactured, processed, or otherwise used.

3.2 Full or Partial Facility Indication

A covered facility must report all releases of a listed chemical if it meets a reporting threshold for that chemical, However, if the facility is composed of several distinct establishments, EPA allows these establishments to submit separate reports for the chemical as long as all releases of the chemical from the entire facility are accounted for. Indicate in Section 3.2 whether your report is for the entire covered facility as a whole or for part of a covered facility. Check box a. if the chemical information applies to the entire covered facility. Check box b. if the chemical information applies only to part of a covered facility.

Section 313 requires reports by "facilities," which are defined as "all buildings, equipment, structures, and other stationary items which are located on a single site or on contiguous or adjacent sites and which are owned or operated by the same person."

The SIC code system defines business "establishments" as "distinct and separate economic activities [that] are performed at a single physical location." Under section 372.30(c) of the reporting rule, you may submit a separate Form R for each establishment, or for groups of establishments, in your covered facility, provided that all releases of the toxic chemicals from the entire covered facility are reported. This allows you the option of reporting separately on the activities involving a toxic chemical at each establishment, or group of establishments (e.g., part of a covered facility), rather than submitting a single Form R for that chemical for the entire facility. However, if an establishment or group of establishments does not manufacture, process, or otherwise use or release a toxic chemical, you do not have to submit a report for that establishment or group of establishments.

3.3 Technical Contact

Enter the name and telephone number (including area code) of a technical representative whom EPA or State officials may contact for clarification of the information reported on Form R. This contact person does not have to be the same person who prepares the report or signs the certification statement and does not necessarily need to be someone at the location of the reporting facility; however, this person must be familiar with the details of the report so that he or she can answer questions about the information provided.

3.4 Public Contact

Enter the name and telephone number (including area code) of a person who can respond to questions from the public about the report. If you choose to designate the same person as both the technical and the public contact, you may enter "Same as Section 3.3" in this space. This contact person does not have to be the same person who prepares the report or signs the certification statement and does not necessarily need to be someone at the location of the reporting facility.

3.5 Standard Industrial Classification (Sic) Code

Enter the appropriate 4-digit primary Standard Industrial Classification (SIC) code for your facility (Table I, page 30, lists the SIC codes within the 20-39 range). If the report covers more than one establishment, enter the primary 4-digit SIC code for each establishment. You are required to enter SIC codes only for those establishments within the facility that fall within SIC codes 20 to 39.

3.6 Latitude and Longitude

Enter the latitudinal and longitudinal coordinates of your facility. Sources of these data include EPA permits (e.g., NPDES permits), county property records, facility blueprints, and site plans. Instructions on how to develop these coordinates can be found in Appendix B (page 52). Enter only numerical data. Do not preface numbers with letters such as N or W to denote the hemisphere.

3.7 Facility Dun And Bradstreet Number

Enter the 9-digit number assigned by Dun and Bradstreet (D&B) for your facility or each establishment within your facility. These numbers code the facility for financial purposes. This number may be available from your facility's treasurer or financial officer. You can also obtain the numbers from your local Dun and Bradstreet office (check the White Pages). If none of your establishments has been assigned a D & B number, enter not applicable, NA, in box a. If only some of your establishments have been assigned Dun and Bradstreet numbers, enter those numbers in Section 3.7.

3.8 EPA Identification Number

The EPA I.D. Number is a 12-digit number assigned to facilities covered by hazardous waste regulations under the Resource Conservation and Recovery Act (RCRA). Facilities not covered by RCRA are not likely to have an assigned I.D. Number. If your facility is not required to have an I.D. Number, enter not applicable, NA, in box a. If your facility has been assigned EPA Identification Numbers, you must enter those numbers in the spaces provided in Section 3.8.

3.9 NPDES Permit Number

Enter the numbers of any permits your facility holds under the National Pollutant Discharge Elimination System (NPDES). This 9-digit permit number is assigned to your facility by EPA or the State under the authority of the Clean Water Act. If your facility does not have a permit, enter not applicable, NA, in box a.

3.10 Receiving Streams or Water Bodies

In Section 3.10 you are to enter the name(s) of the stream(s) or water body(ies) to which your facility directly discharges the chemicals you are reporting. A total of six spaces are provided, lettered a through f. The information you provide relates directly to the discharge quantity information required in Part III, Section 5.3. You can complete Section 3.10 in one of two ways. You can enter only those stream names that relate to the specific chemical that is the subject of the report or, you can enter all stream names that relate to all covered chemicals being reported by the facility. Enter the name of the first receiving stream or surface water body to which the chemical being reported is directly discharged. Report the name of the receiving stream or water body as it appears on the NPDES permit for the facility. If you do not have a permit, enter the name of the off-site stream or water body by which it is publicly known. Be sure to include the receiving stream(s) or water body(ies) that receive stormwater runoff from your facility. Do not enter names of streams to which off-site treatment plants discharge. Also do not list a series of streams through which the chemical flows. Enter not applicable, NA, in 3.10a. if you do not discharge any listed toxic chemicals to surface water bodies.

3.11 Underground Injection Well Code (UIC) Identification Number

If your facility has a permit to inject a chemical-containing waste that includes the toxic chemicals into Class 1 deep wells, enter the 12-digit Underground Injection Well Code (UIC) identification number assigned by EPA or by the State under the authority of the Safe Drinking Water Act. If your facility does not hold such a permit(s), enter not applicable, NA, in 3.11a.

4. Parent Company Information

You must provide information on your parent company. For purposes of Form R, a parent company is defined as the highest holder located in the United States that directly owns at least 50 percent of the voting stock of your company. If your facility is owned by a foreign entity, enter not applicable, NA, in this space. Corporate names should be treated as parent company names for companies with multiple sites. For example, the Bestchem Corporation is not owned or controlled by any other corporation. It has several sites throughout the country whose names begin with Bestchem. In this case, Bestchem Corporation would be listed as the "parent" company.

4.1 Name of Parent Company

Enter the name of the corporation or other business entity that is your parent company. If your facility has no parent company, enter not applicable, NA.

4.2 Parent Company's Dun & Bradstreet Number

Enter the Dun and Bradstreet Number for your parent company, if applicable. The number may be obtained from the treasurer or financial officer of the company. If your parent company does not have a Dun and Bradstreet number, enter not applicable, NA.

Part II. Off-Site Locations to Which Toxic Chemicals Are Transferred In Wastes

In this part of the form you are required to list all off-site locations to which you transfer wastes containing toxic chemicals. Do not list locations to which products containing toxic chemicals are shipped for sale or distribution in commerce or for further use. Also, do not list locations to which wastes containing chemicals are sold or sent for recovery, recycling, or reuse of the toxic chemicals. The information that you enter in this section relates to data you will report in Part III, Section 6. You may complete Part II for only the off-site locations that apply to the specific chemical cited in a particular report or you can list all off-site locations that apply to all chemicals being reported and include a photostatic copy of Part II with each individual report. List only publicly owned treatment works (POTWs) and off-site treatment or disposal facilities.

1. Publicly Owned Treatment Works (POTWs)

Enter the name and address of each POTW to which your facility discharges wastewater containing toxic chemicals for which you are reporting. If you do not discharge wastewater containing the reported toxic chemicals to a POTW, enter not applicable, NA in the facility name line of 1.1.

If you discharge such wastewater to more than two POTWs, use additional copies of Part II. Cross through the printed numbers and write in numbers for these locations in ascending order (e.g., 1.3, 1.4). Check the box at the bottom of the page and indicate the number of additional pages of Part II that are attached.

2. Other Off-Site Locations

Enter in the spaces provided, the name and address of each location (other than POTWs) to which you ship or transfer wastes containing toxic chemicals. If you do not ship or transfer wastes containing toxic chemicals to off-site locations, enter not applicable, NA in the Off-site location name line of 2.1. Also enter the EPA Identification Number (RCRA I.D. Number) for each such location if known to you. This number may be found on the Uniform Hazardous Waste Manifest, which is required by RCRA regulations. Also indicate in the space provided whether the location is owned or controlled by your facility or your parent company. If the facility does not have a RCRA I.D. number, enter not applicable, NA, in this space.

If your facility transfers toxic chemicals to more than six off-site locations, use additional copies of Part II. Cross through the printed numbers and write in numbers for these locations in ascending order (i.e., 2.7, 2.8). Check the box at the bottom of the page and indicate the number of additional pages of Part II that are attached.

EXAMPLE

Your facility is involved in chrome plating of metal parts, which are shipped to an off-site warehouse not owned by your company for distribution. Your facility produces an aqueous plating waste that is treated on-site to recover chromium sludge. The effluent from the on-site treatment plant, which contains chromium compounds (a listed toxic chemical), is piped to a POTW. The chromium sludge is transferred to an off-site, privately owned recovery firm. Chromium is recovered from the sludge by an ion exchange process. Your facility also produces a solid waste containing chromium, which is sent to an off-site permitted landfill owned by your facility.

You must report the locations of the POTW and the permitted landfill in Sections 1 and 2 of Part II of Form R. Do not report the location of the warehouse or give any information about the on-site treatment plant in this section. Indicate that the landfill is under the control of your facility. You are not required to report the location of the off-site, privately owned recovery firm or provide any information concerning off-site recovery.

Part III. Chemical-Specific Information

In Part III, you are to identify the toxic chemical being reported. You are to indicate some general uses and activities related to the chemical at your facility. Also in Part III you will enter quantitative data relating to releases of the chemical directly from the facility to air, water, and land. Quantities of the chemical transferred to off-site locations, identified in Part II, are also reported in this part. The final required section provides for reporting of waste treatment information. An additional optional section is included in this part that allows you to report waste minimization information associated with the chemical.

1.1 [Reserved]

1.2 CAS Number

Enter the Chemical Abstracts Service (CAS) registry number in Section 1.2 exactly as it appears in Table II, page 36, for the chemical being reported. CAS numbers are cross-referenced with an alphabetical list of chemical names in Table II of these instructions. If you are reporting one of the chemical categories in Table II (e.g., copper compounds), enter not applicable, NA, in the CAS number space.

If you are making a trade secret claim, you must report the CAS number on your unsanitized Form R and unsanitized substantiation form. Do not report it on your sanitized Form R and sanitized substantiation form.

1.3 Chemical or Chemical Category Name

Enter the name of the chemical or chemical category exactly as it appears in Table II. If the chemical name is followed by a synonym in parentheses, report the chemical by the name that directly follows the CAS number (i.e., not the synonym). If the listed chemical identity is actually a product tradename (e.g., dicofol), the 9th Collective Index name is listed below it in brackets. You may report either name in this case. Do not list the name of a chemical that does not appear in Table II, including individual members of a reportable category. For example, if you use silver nitrate, do not report silver nitrate with its CAS number. Report this chemical as "silver compounds" with no CAS number.

If you are making a trade secret claim, you must report the specific chemical identity on your unsanitized Form R and unsanitized substantiation form. Do not report the chemical name on your sanitized Form R and sanitized substantiation form; report a generic name in Section 1.4 below.

1.4 Generic Chemical Name

Complete Section 1.4 only if you are claiming the specific chemical identity of the toxic chemical as a trade secret and have marked the trade secret block in Part I, Section 1.1 on page 1 of Form R. Enter a generic chemical name that is descriptive of the chemical structure. You must limit the generic name to seventy characters (e.g., numbers, letters, spaces, punctuation) or less. Do not enter mixture names in Section 1.4; see Section 2 below.

In-house plant codes and other substitute names that are not structurally descriptive of the chemical identity being withheld as a trade secret are not acceptable as a generic name. The generic name must appear on both sanitized and unsanitized Form R's, and the name must be the same as that used on your substantiation forms. The Emergency Planning and Community Right-to-Know Information Hotline can provide you with assistance in selecting an appropriate generic name.

2. Mixture Component Identity

Do not complete this section if you have completed Section 1 of Part III. Report the generic name provided to you by your supplier in the section if your supplier is claiming the chemical identity proprietary or trade secret. Do not answer "yes" in Part I, Section 1.1 on page I of the form if you complete this section. You do not need to supply substantiation forms.

Enter the generic chemical name in this section only if the following four conditions apply:

1. The amount of the particular mixture or trade name product you "use" exceeds 10,000 pounds or the amount you "process" exceeds the applicable process threshold for the year (i.e., 50,000 lbs. in 1988);
2. You determine that the mixture contains a listed toxic chemical but the only identity you have for that chemical is a generic name;
3. You know either the specific concentration of that toxic chemical component or a maximum concentration figure; and
4. You determine by multiplying the concentration figure by the total annual amount of the whole mixture used (or processed) that you exceed the use or process threshold for that single, generically identified mixture component.

EXAMPLE

Your facility uses 20,000 pounds of a solvent that your supplier has told you contains 80 percent "chlorinated aromatic," their generic name for a chemical subject to reporting under section 313. You therefore know that you have used 16,000 pounds of some listed toxic chemical which exceeds the use threshold. You would file a Form R and enter the name "chlorinated aromatic" in the space provided in Part III, Section 2.

3. Activities and Uses of the Chemical at the Facility

Indicate in this section whether the chemical is manufactured (including imported), processed, or otherwise used at the facility and the general nature of such activities and uses at the facility during the calendar year. Report activities that take place only at your facility, not activities that take place at other facilities involving your products. You must check all the blocks in this section that apply. If you are a manufacturer of the chemical, you must check a and/or b, and at least one of c, d, e, or f. Refer to the definitions of "manufacture," "process," and "otherwise use" in the general information section of these instructions or section 372.3 of the rule for explanations supplementing those provided below.

3.1 Manufacture the Chemical

Check at least one:

a. *Produce*-A chemical included in this category is produced at the facility.
b. *Import*-A chemical included in this category is imported by the facility into the Customs Territory of the United States.

Check at least one:

c. *For on-site use/processing*-A chemical included in this category is produced or imported and then further processed or otherwise used at the same facility. If you check this block you must also check at least one item in 3.2 or 3.3.
d. *For sale/distribution*-A chemical in this category is produced or imported specifically for sale or distribution outside the manufacturing facility.
e. *As a byproduct*-A chemical in this category is produced coincidentally during the production, processing, use, or disposal of another chemical substance or mixture and, following its production, is separated from that other chemical substance or mixture. Chemicals produced and released as a result of waste treatment or disposal are also considered byproducts.
f. *As an impurity*-A chemical in this category is produced coincidentally as a result of the manufacture, processing or use of another chemical but remains primarily in the mixture or product with that other chemical.

3.2 Process The Chemical (incorporative-type activities)

a. *As a reactant*-A natural or synthetic chemical used in chemical reactions for the manufacture of another chemical substance or of a product. Includes, but is not limited to, feedstocks, raw materials, intermediates, and initiators.

b. *As a formulation component*-A chemical added to a product or product mixture prior to further distribution of the product that acts as a performance enhancer during use of the product. Examples of chemicals used in this capacity include, but are not limited to, additives, dyes, reaction diluents, initiators, solvents, inhibitors, emulsifiers, surfactants, lubricants, flame retardants, and rheological modifiers.
c. *As an article component*-A chemical substance that becomes an integral component of an article distributed for industrial, trade, or consumer use. One example is the pigment components of paint applied to a chair that is sold.
d. *Repackaging only*-Processing or preparation of a chemical or product mixture for distribution in commerce in a different form, state, or quantity. This includes, but is not limited to, the transfer of material from a bulk container, such as a tank truck to smaller cans or bottles.

3.3 Otherwise Use the Chemical (non-incorporative-type Activities)

a. *As a chemical processing aid*- A chemical that is added to a reaction mixture to aid in the manufacture or synthesis of another chemical substance but is not intended to remain in or become part of the product or product mixture. Examples of such chemicals include, but are not limited to, process solvents, catalysts, inhibitors, initiators, reaction terminators, and solution buffers.
b. *As a manufacturing aid*- A chemical that aids the manufacturing process but does not become part of the resulting product and is not added to the reaction mixture during the manufacture or synthesis of another chemical substance. Examples include, but are not limited to, lubricants, metalworking fluids, coolants, refrigerants, and hydraulic fluids.
c. *Ancillary or other use*- A chemical in this category is used at a facility for purposes other than as a chemical processing aid or manufacturing aid as described above. Includes, but is not limited to, cleaners, degreasers, lubricants, and fuels.

EXAMPLE

In the example below, it is assumed that the threshold quantities for manufacture, process, or otherwise use (50,000 pounds, 50,000 pounds, and 10,000 pounds, respectively, for 1988) have been exceeded and the reporting of listed chemicals is therefore required.

1. Your facility receives toluene and naphthalene (both listed toxic chemicals) from an off-site location. You react the toluene with air to form benzoic acid and react the naphthalene with sulfuric acid, which forms phthalic acid and also produces sulfur dioxide fumes. Your facility processes toluene and naphthalene. Both are used as reactants to produce benzoic acid and phthalic acid, chemicals not on the section 313 list.

   The phthalic acid and benzoic acid are reacted to form a reaction intermediate. The reaction intermediate is dissolved in sulfuric acid, which precipitates terephthalic acid (TPA). Fifty percent of the TPA is sold as a product and 50 percent is further processed at your facility into polyester fiber. The TPA is treated with ethylene glycol to form an intermediate product, which is condensed to polyester.

   Your company manufactures terephthalic acid, a listed chemical, both for sale/distribution as a commercial product and for on-site use/processing as a feedstock in the polyester process. Because it is a reactant , it is also processed.

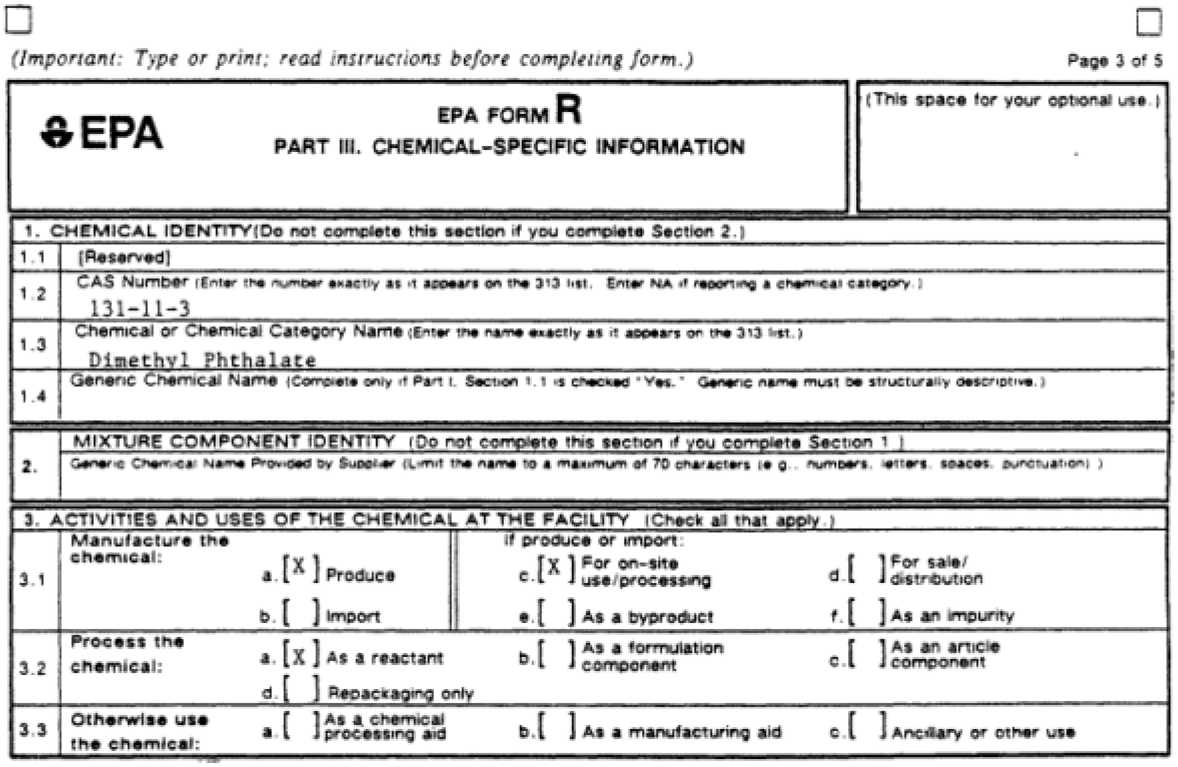
   Your facility also uses. as well as processes. sulfuric acid, a listed substance, as it serves as a process solvent to precipitate terephthalic acid.
2. The intermediate product, from which the polyester is prepared, contains dimethylphthalate, a listed substance. The method of reporting this substance depends on its eventual disposition in the polyester production process:

(a) If the dimethyl phthalate is removed from the intermediate product before it is reacted to form polyester fiber, then dimethyl phthalate is manufactured at your facility as a byproduct.
(b) If it is incorporated into the polyester fiber in an un-reacted form, then it is manufactured at your facility as an impurity.
(c) If the dimethyl phthalate participates in the reaction to form polyester fiber without leaving the process, then it is processed as a reactant (intermediate), as are the ethylene glycol and terephthalic acid in the process.

Sections of Part III that have been completed for scenario 2(c), are illustrated on the following page.

3. Your facility operates a fume scrubber that uses sodium hydroxide solution and recovers the sulfur dioxide fumes from the phthalic acid production process as sodium sulfate solution. Both sodium solutions are listed chemicals. Your facility manufactures sodium sulfate as a byproduct and otherwise uses sodium hydroxide.

4. Your facility applies C.I. disperse yellow 3, a listed chemical, to the finished polyester fiber as a dye, which is incorporated into the polyester fiber product and remains in the product after it is sold. Your facility processes the C.I disperse yellow 3 as an article component.



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(Important: Type or print; read instructions before completing form.)

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EPA

EPA FORM R

PART III. CHEMICAL-SPECIFIC INFORMATION

(This space for your optional use.)

1. CHEMICAL IDENTITY (Do not complete this section if you complete Section 2.)

1.1 [Reserved]

1.2 CAS Number (Enter the number exactly as it appears on the 313 list. Enter NA if reporting a chemical category.) 131-11-3

1.3 Chemical or Chemical Category Name (Enter the name exactly as it appears on the 313 list.) Dimethyl Phthalate

1.4 Generic Chemical Name (Complete only if Part I, Section 1.1 is checked "Yes." Generic name must be structurally descriptive.)

2. MIXTURE COMPONENT IDENTITY (Do not complete this section if you complete Section 1.)

Generic Chemical Name Provided by Supplier (Limit the name to a maximum of 70 characters (e.g., numbers, letters, spaces, punctuation).)

3. ACTIVITIES AND USES OF THE CHEMICAL AT THE FACILITY (Check all that apply.)

3.1	Manufacture the chemical:	a. [X] Produce b. [ ] Import	If produce or import: c. [X] For on-site use/processing e. [ ] As a byproduct	d. [ ] For sale/distribution f. [ ] As an impurity
3.2	Process the chemical:	a. [X] As a reactant d. [ ] Repackaging only	b. [ ] As a formulation component	c. [ ] As an article component
3.3	Otherwise use the chemical:	a. [ ] As a chemical processing aid	b. [ ] As a manufacturing aid	c. [ ] Ancillary or other use

4. Maximum Amount of the Chemical On-Site at Any Time During the Calendar Year

Insert the appropriate code (see below) that indicates the maximum quantity of the chemical (e.g., in storage tanks, process vessels, on-site shipping containers) at your facility at any time during the calendar year. If the chemical was present at several locations within your facility, use the maximum total amount present at the entire facility at any one time.

	Weight Range in Pounds	
Range Code	From...	To....
01	0	99
02	100	999
03	1,000	9,999
04	10,000	99,999
05	100,000	999,999
06	1,000,000	9,999,999
07	10,000,000	49,999,999
08	50,000,000	99,999,999
09	100,000,000	499,999,999
10	500,000,000	999,999,999
11	1 billion	more than 1 billion

If the toxic chemical present at your facility was part of a mixture or trade name product, determine the maximum quantity of the chemical present at the facility by calculating the weight of the toxic chemical only. Do not include the weight of the entire mixture or trade name product. See section 372.30(b) of the reporting rule for further information on how to calculate the weight of the chemical in the mixture or trade name product. For chemical categories (e.g., copper compounds), include all chemicals in the category when calculating the weight of the toxic chemical.

5. Releases of The Chemical to the Environment On-Site

In Section 5, you must account for the total aggregate releases of the toxic chemical to the environment on-site from your facility for the calendar year. Releases to the environment include emissions to the air, discharges to surface waters, and releases to land and underground injection wells. If you have no releases to a particular media (e.g., stack air), enter not applicable, NA; do not leave blank. Check the box on the last line of this section if you use Part IV, the supplemental information sheet.

You are not required to count as a release quantities of a toxic chemical that are lost due to natural weathering or corrosion, normal/natural degradation of a product, or normal migration of a chemical from a product. For example, amounts of a covered toxic chemical that migrate from plastic products in storage do not have to be counted in estimates of releases of that chemical from the facility. Also, amounts of listed metal compounds (e.g., copper compounds) that are lost due to normal corrosion of process equipment do not have to be considered as releases of copper compounds from the facility.

All air releases of the chemical from the facility must be accounted for. Do not enter information on individual emission points or releases. Enter only the total release. If there is doubt about whether an air release is a point or non-point release, you must identify the release as one or the other rather than leave items 5.1 and 5.2 blank. Instructions for columns A, B, and C follow the discussions of Sections 5.1 through 5.5.

5.1 Fugitive or Non-Point Air Emissions

These are releases to the air that are not released through stacks, vents, ducts, pipes, or any other confined air stream. You must include (1) fugitive equipment leaks from valves, pump seals, flanges, compressors, sampling connections, open-ended lines, etc.; (2) evaporative losses from surface impoundments; (3) releases from building ventilation systems; and (4) any other fugitive or non-point air emissions.

5.2 Stack or Point Air Emissions

These are releases to the air that occur through stacks, vents, ducts, pipes, or other confined air streams. You must include storage tank emissions. Air releases from air pollution control equipment would generally fall in this category.

5.3 Discharges to Receiving Streams or Water Bodies

Enter the applicable letter code for the receiving stream or water body from Section 3.10 of Part I of the form. Also, enter the total annual amount of the chemical released from all discharge points at the facility to each receiving stream or water body. Include process outfalls such as pipes and open trenches, releases from on-site wastewater treatment systems, and the contribution from stormwater runoff, if applicable (see instructions for column C below). Do not include discharges to a POTW or other off-site wastewater treatment facilities in this section. These off-site transfers must be reported in Part III, Section 6 of the form.

5.4 Underground Injection

Enter the total annual amount of the chemical that was injected into all wells, including Class I wells, at the facility.

5.5 Releases to Land

Report quantities of the chemical that were landfilled, treated or applied in farming, impounded, or otherwise disposed of at the facility. Do not report land disposal at off-site locations in this section.

For the purpose of this form, a surface impoundment is considered "final disposal." Quantities of the chemical released to surface impoundments that are used merely as part of a wastewater treatment process generally must not be reported in this section of the form. However, if the impoundment accumulates sludges containing the chemical, you must include an estimate in this section unless the sludges are removed and otherwise disposed of (in which case they should be reported under the appropriate section of the form). For the purposes of This reporting, storage tanks are not considered to be a type of disposal and are not to be reported in this section of the form.

A. Total Release

Only on-site releases of the toxic chemical to the environment for the calendar year are to be reported in this section of the form. The total releases from your facility do not include transfers or shipments of the chemical from your facility for sale or distribution in commerce or of wastes to other facilities for treatment or disposal (see Part III, Section 6). Both routine releases, such as fugitive air emissions, and accidental or nonroutine releases, such as chemical spills, must be included in your estimate of the quantity released.

Total annual releases or off-site transfers of a toxic chemical from the facility of less than 1 pound may be reported in one of several ways. The fractional figure may be entered in column A.2. However, EPA encourages rounding to the nearest pound. For example, if the estimate is 0.5 pounds or greater, you should either check the range bracket of "1-499" in column A.1 or enter "1" in column A.2. Do not use both columns A.1 and A.2. If the release is less than 0.5 pounds, you may round to zero and check the "0" bracket in A.1. Note that releases of less than 0.5 pounds from the processing or use of an article does not negate the article status of that item. Thus, if the only releases you have are from an article and such releases are less than 0.5 pounds per year, you are not required to submit a report for that chemical.

For reports submitted for calendar years 1987, 1988 and 1989 only, you may take advantage of range reporting for releases to an environmental medium that are less than 1,000 pounds for the year. If you choose this option, mark one of the three boxes, 0, 1-499, or 500-999, that corresponds to releases of the chemical to the appropriate environmental medium (i.e., any line item). You are not required, however, to use these range check boxes; you have the option of providing a specific figure in column A.2, as described below. However, do not mark a range and also enter a specific estimate in A.2.

For releases to any medium that amount to 1,000 pounds or more for the year, you must provide an estimate in pounds per year in column A.2. Any estimate provided in column A.2 is required to be accurate to no more than two significant digits.

If you do not use the range reporting option, provide your estimates of releases in pounds for the year in column A.2. This estimate is required to be rounded to no more than two significant digits.

Calculating Releases-To provide the release information required in both columns A.1 and A.2 in this section of the form, you must use all readily available data (including relevant monitoring data and emissions measurements) collected at your facility pursuant to other provisions of law or as part of routine plant operations, to the extent you have such data for the toxic chemical.

When relevant monitoring data or emission measurements ate not readily available, reasonable estimates of the amounts released must be made using published emission factors, material balance calculations, or engineering calculations. You may not use emission factors or calculations to estimate releases if more accurate data are available.

No additional monitoring or measurement of the quantities or concentrations of any toxic chemical released into the environment, or of the frequency of such releases, is required for the purpose of completing this form, beyond that which is required under other provisions of law or regulation or as part of routine plant operations.

You must estimate as accurately as possible the quantity in pounds of the chemical or chemical category that is released annually to each environmental medium. Include only the quantity of the toxic chemical component of the waste stream in this estimate. If the toxic chemical present at your facility was part of a mixture or trade name product, calculate only the releases of the chemical. Do not report releases of the other components of the mixture or trade name product. If you are only able to estimate the releases of the mixture or trade name product as a whole, you must assume that the release of the toxic chemical is proportional to its concentration in the mixture or trade name product. See section 372.30(b) of the reporting rule (Appendix G) for further information on how to calculate the concentration and weight in the mixture or trade name product.

If you are reporting a chemical category listed in Table II of these instructions, rather than a specific chemical, you must combine the release data for all chemicals in the listed chemical category (e.g., all glycol ethers or all chlorophenols) and report the aggregate amount for that chemical category. Do not report releases of each individual chemical in that category separately. For example, if your facility releases 3,000 pounds per year of 2-chlorophenol, 4,000 pounds per year of 3-chlorophenol, and 4,000 pounds per year of 4-chlorophenol, you should report that your facility releases 11,000 pounds per year of chlorophenols.

For listed chemicals with the qualifier "solution," such as sodium sulfate, at concentrations of 1 percent (or 0.1 percent in the case of a carcinogen) or greater, the chemical concentrations must be factored into threshold and release calculations because threshold and release amounts relate to the amount of chemical in solution, not the amount of solution.

For metal compound categories (e.g., chromium compounds), report releases of only the parent metal. For example, a user of various inorganic chromium salts would report the total chromium released in each waste type regardless of the chemical form (e.g., as the original salts, chromium ion, oxide) and exclude any contribution to mass made by other species in the molecule.

EXAMPLE

Your facility disposes of 14.000 pounds of lead chromate ($PbCrO_4$ PbO) and 15,000 pounds of zinc dichromate ($ZnCr_2O_73H_2O$) in an on-site landfill and transfers 16,000 pounds of lead selenate ($PbSeO_4$) to an off-site land disposal facility. You would therefore be submitting four separate reports on the following: lead compounds. zinc compounds, selenium compounds, and chromium compounds. However, the quantities you would be reporting would be the pounds of "parent" metal being released or transferred off-site. All quantities are based on mass balance calculations (See Section 5.B for information on Basis of Estimate and Section 6.C for treatment/disposal codes and information on transfers of chemical wastes). You would calculate releases of lead, zinc, chromium. and selenium by first determining the percentage by weight of these metals in the materials you use as follows:

Lead Chromate ($PbCrO_4$. PbO)

Molecular weight = 546.37

Lead 2 Pb

Molecular weight = 207.2 x 2 = 414.4

Chromate 1 Cr

Molecular weight = 51.996

Lead chromate is therefore (% by weight)

(414.4/546.37) = 75.85% lead and (51.996/546.37) = 9.52% chromium

You can then calculate the total amount of the metals that you must report.

14,000 pounds of lead chromate contains:

14,000 x 0.7585 = 10,619 lbs of lead

14,000 x 0.0952 = 1,332.8 lbs of chromium

Similarly, zinc dichromate is (65.38/335.4) = 19.49% zinc and (51.996 x 2/335.4) = 31.01% chromium, and lead selenate is (207.2/350.17) = 59.17% lead and (78.96/350.17) = 22.55% selenium.

The total pounds of lead, chromium, zinc, and selenium released or transferred from your facility are as follows:

Lead

Release:

0.7585 x 14,000 = 10,619.0 lbs from lead chromate (round to 11,000 lbs)

Transfer:.

0.5917 x 16,000 = 9,467.2 lbs from lead selenate (round to 9,500 lbs)

As an example, the releases and transfers of lead should be reported as illustrated on the next page.

Chromium

Release:

0.0952 x 14,000 = 1,332.8 lbs from lead chromate (round to 1,300 lbs)

Release:

0.3101 x 15,000 = 4,651.5 lbs from zinc dichromate (round to 4,700 lbs)

Zinc

Release:

0.1949 x 15,000 = 2,923.5 lbs from zinc dichromate (round to 2,900 lbs)

Selenium
Transfer:

0.2255 x 16,000 = 3,608.0 lbs of selenium from lead selenate (round to 3,600 lbs)

For each release estimate, you are required to indicate the principal method by which the quantity was derived. Enter a letter code from below that identifies the method that applies to the largest portion of the total estimated quantity. EPA requires that decimal fractions be rounded to no more than two significant digits when reporting releases.

For example, if 40 percent of stack emissions of the reported substance were derived using monitoring data, 30 percent by mass balance, and 30 percent by emission factors, you would enter the code letter "M" for monitoring. The codes are as follows:

M-Estimate is based on monitoring data or measurements for the toxic chemical as released to the environment and/ or off-site facility.

C-Estimate is based on mass balance calculations, such as calculation of the amount of the toxic chemical in streams entering and leaving process equipment.

E-Estimate is based on published emission factors, such as those relating release quantity to through-put or equipment type (e.g., air emission factors).

O-Estimate is based on other approaches such as engineering calculations (e.g., estimating volatilization using published mathematical formulas) or best engineering judgment. This would include applying an estimated removal efficiency to a waste stream, even if the composition of the stream before treatment was fully characterized by monitoring data.

If the monitoring data, mass balance, or emission factor used to estimate the release is not specific to the toxic chemical being reported, the form should identify the estimate as based on engineering calculations or judgment.

If a mass balance calculation yields the flow rate of a waste stream, but the quantity of reported chemical in the waste stream is based on solubility data, report "O" because "engineering calculations" were used as the basis of estimate of the quantity of the chemical in the waste stream.

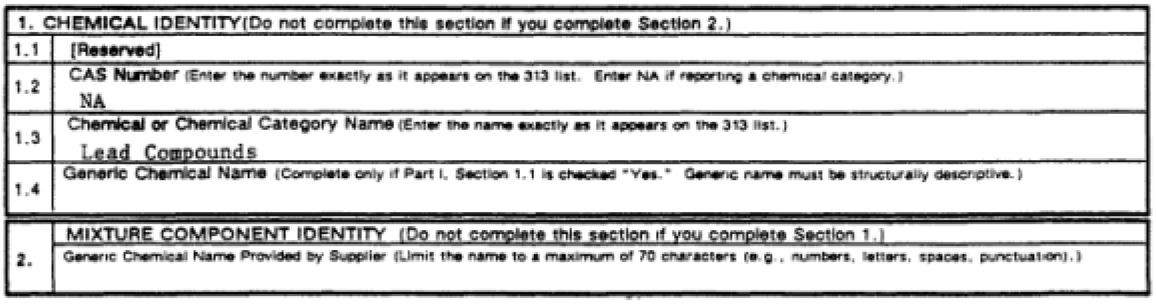
If the concentration of the chemical in the waste stream was measured by monitoring equipment and the flow rate of the waste stream was determined by mass balance, then the primary basis of estimate is "monitoring" (M) even though a mass balance calculation also contributed to the estimate. "Monitoring" should be indicated because monitoring data was used to estimate the concentration of the waste stream.

Mass balance (C) should only be indicated if it is directly used to calculate the mass (weight) of chemical released. Monitoring data should be indicated as the basis of estimate only if the chemical concentration is measured in the waste stream being released into the environment as opposed to measured in other process streams containing the chemical.

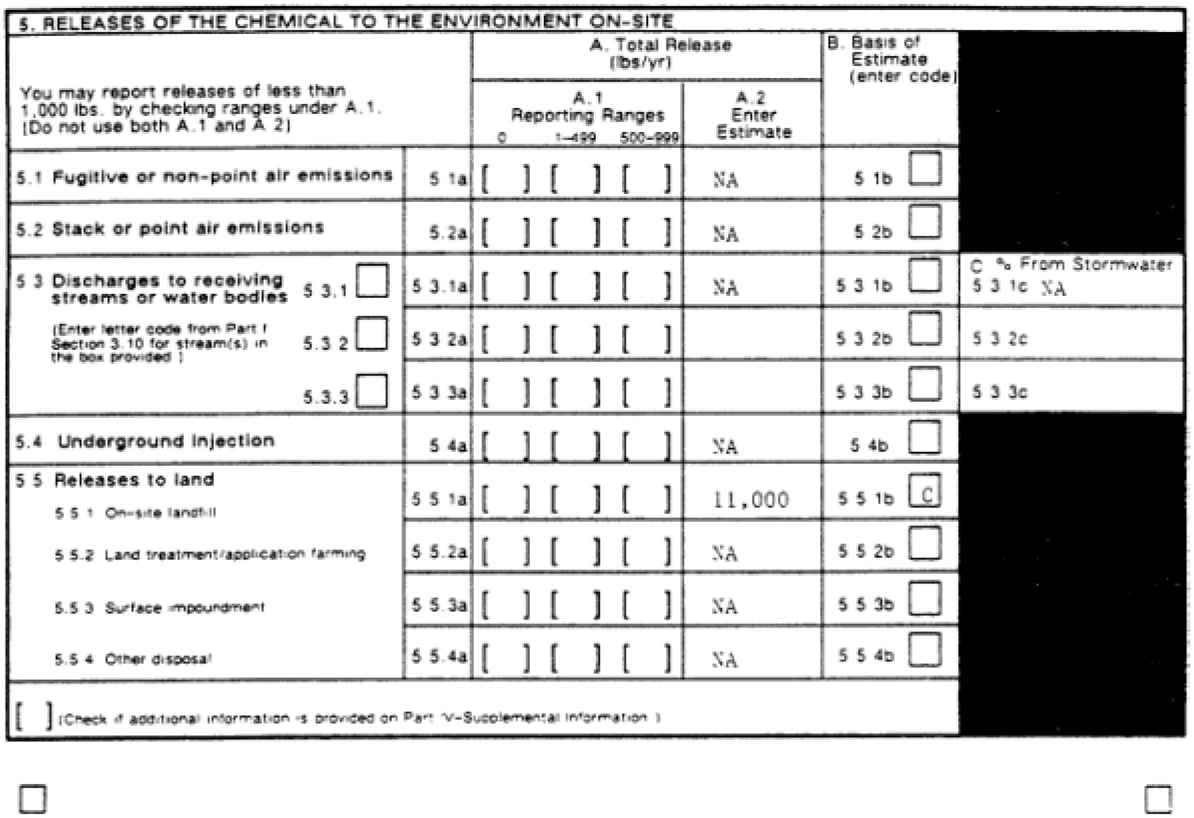
This column relates only to Section 5.3-Discharges to receiving streams or water bodies. If your facility has monitoring data on the amount of the chemical in stormwater runoff (including unchanneled runoff), you must include that quantity of the chemical in your water release in column A and indicate the Percentage of the total quantity (by weight) of the chemical contributed by stormwater in column C (5.3c).

If your facility has monitoring data on the chemical and an estimate of flow rate, you must use this data to determine the Percent stormwater.

If you have monitored stormwater but did not detect the chemical, enter zero (0) in column C. If your facility has no stormwater monitoring data for the chemical, enter not applicable, NA, in this space on the form.



1. CHEMICAL IDENTITY (Do not complete this section if you complete Section 2.)	
1.1	[Reserved]
1.2	**CAS Number** (Enter the number exactly as it appears on the 313 list. Enter NA if reporting a chemical category.) NA
1.3	**Chemical or Chemical Category Name** (Enter the name exactly as it appears on the 313 list.) Lead Compounds
1.4	**Generic Chemical Name** (Complete only if Part I, Section 1.1 is checked "Yes." Generic name must be structurally descriptive.)
2.	**MIXTURE COMPONENT IDENTITY** (Do not complete this section if you complete Section 1.) Generic Chemical Name Provided by Supplier (Limit the name to a maximum of 70 characters (e.g., numbers, letters, spaces, punctuation).)

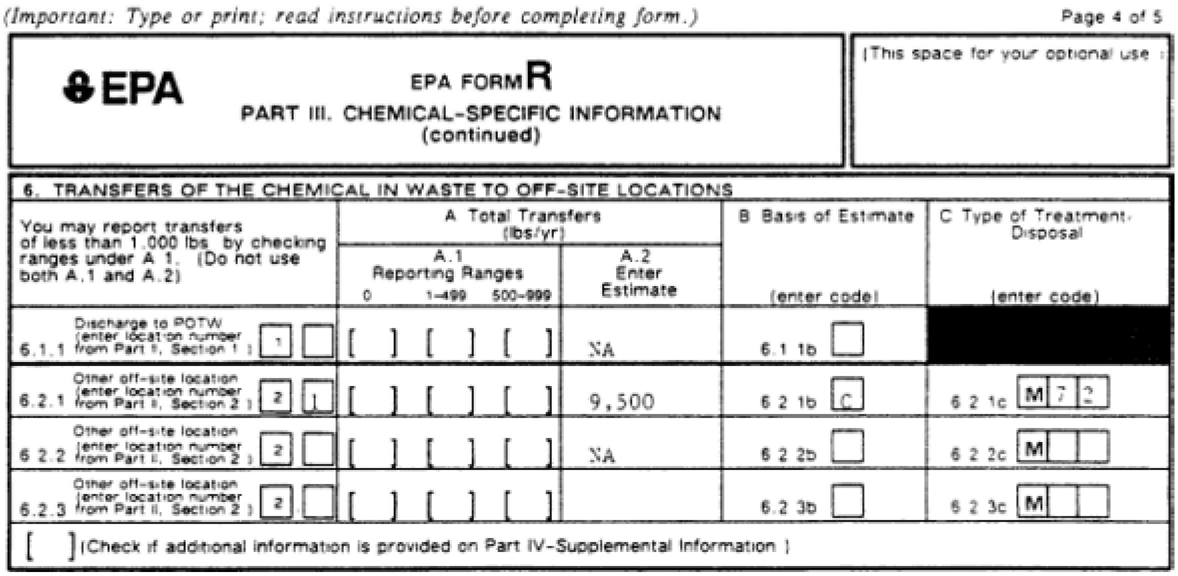


5. RELEASES OF THE CHEMICAL TO THE ENVIRONMENT ON-SITE

You may report releases of less than 1,000 lbs. by checking ranges under A.1. (Do not use both A.1 and A.2)		A. Total Release (lbs/yr) A.1 Reporting Ranges 0 / 1–499 / 500–999	A. Total Release (lbs/yr) A.2 Enter Estimate	B. Basis of Estimate (enter code)	
5.1 Fugitive or non-point air emissions	5.1a	[ ] [ ] [ ]	NA	5.1b ☐	
5.2 Stack or point air emissions	5.2a	[ ] [ ] [ ]	NA	5.2b ☐	
5.3 Discharges to receiving streams or water bodies 5.3.1 ☐	5.3.1a	[ ] [ ] [ ]	NA	5.3.1b ☐	C. % From Stormwater 5.3.1c NA
(Enter letter code from Part I Section 3.10 for stream(s) in the box provided.) 5.3.2 ☐	5.3.2a	[ ] [ ] [ ]		5.3.2b ☐	5.3.2c
5.3.3 ☐	5.3.3a	[ ] [ ] [ ]		5.3.3b ☐	5.3.3c
5.4 Underground injection	5.4a	[ ] [ ] [ ]	NA	5.4b ☐	
5.5 Releases to land 5.5.1 On-site landfill	5.5.1a	[ ] [ ] [ ]	11,000	5.5.1b C	
5.5.2 Land treatment/application farming	5.5.2a	[ ] [ ] [ ]	NA	5.5.2b ☐	
5.5.3 Surface impoundment	5.5.3a	[ ] [ ] [ ]	NA	5.5.3b ☐	
5.5.4 Other disposal	5.5.4a	[ ] [ ] [ ]	NA	5.5.4b ☐	

[ ] (Check if additional information is provided on Part IV-Supplemental Information.)

☐ ☐



(Important: Type or print; read instructions before completing form.) Page 4 of 5

EPA

EPA FORM **R**

PART III. CHEMICAL-SPECIFIC INFORMATION (continued)

(This space for your optional use.)

6. TRANSFERS OF THE CHEMICAL IN WASTE TO OFF-SITE LOCATIONS

You may report transfers of less than 1,000 lbs. by checking ranges under A.1. (Do not use both A.1 and A.2)	A. Total Transfers (lbs/yr) A.1 Reporting Ranges 0 / 1–499 / 500–999	A. Total Transfers (lbs/yr) A.2 Enter Estimate	B. Basis of Estimate (enter code)	C. Type of Treatment/Disposal (enter code)
6.1.1 Discharge to POTW (enter location number from Part II, Section 1.) 1 ☐	[ ] [ ] [ ]	NA	6.1.1b ☐	
6.2.1 Other off-site location (enter location number from Part II, Section 2.) 2 1	[ ] [ ] [ ]	9,500	6.2.1b C	6.2.1c M 7 2
6.2.2 Other off-site location (enter location number from Part II, Section 2.) 2 ☐	[ ] [ ] [ ]	NA	6.2.2b ☐	6.2.2c M ☐ ☐
6.2.3 Other off-site location (enter location number from Part II, Section 2.) 2 ☐	[ ] [ ] [ ]		6.2.3b ☐	6.2.3c M ☐ ☐

[ ] (Check if additional information is provided on Part IV-Supplemental Information.)

EXAMPLE

Bi-monthly stormwater monitoring data shows that the average concentration of zinc in the stormwater runoff from your facility from a biocide containing a zinc compound is 1.4 milligrams per liter, and the total annual stormwater discharge from the facility is 7.527 million gallons. The total amount of zinc discharged to surface water through the plant wastewater discharge (non-stormwater) is 250 pounds per year. The total amount of zinc discharged with stormwater is:

(7,527,000 gallons stormwater) x (3.785 liters/gallon)
= 28,489,695 liters stormwater

(28,489,695 liters stormwater) x (1.4 mg. zinc/liter)
= 39,885.6 g zinc
= 87.9 lbs zinc

The total amount of zinc discharged from all sources of your facility is:

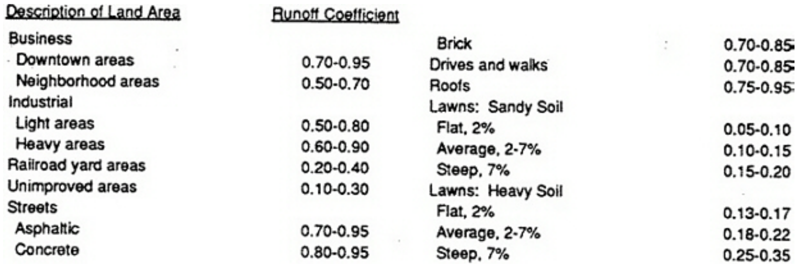
250	lbs zinc from wastewater discharge
+ 87.9	lbs zinc from stormwater runoff
337.9	lbs zinc total water discharge

Round to 340 lbs. of zinc for report.

The percentage of zinc discharged through stormwater is:

87.9/337.9 x 100 = 26%

If your facility does not have periodic measurements of stormwater releases of the chemical, but has submitted chemical-specific monitoring data in permit applications, then these data must be used to calculate the percent contribution from stormwater. Rates of flow can be estimated by multiplying the annual amount of rainfall by the land area of the facility and then multiplying that figure by the runoff coefficient. The runoff coefficient represents the fraction of rainfall that does not infiltrate into the ground but runs off as stormwater. The runoff coefficient is directly related to how the land in the drainage area is used. (See table below.)



Description of Land Area	Runoff Coefficient		
Business		Brick	0.70-0.85
Downtown areas	0.70-0.95	Drives and walks	0.70-0.85
Neighborhood areas	0.50-0.70	Roofs	0.75-0.95
Industrial		Lawns: Sandy Soil	
Light areas	0.50-0.80	Flat, 2%	0.05-0.10
Heavy areas	0.60-0.90	Average, 2-7%	0.10-0.15
Railroad yard areas	0.20-0.40	Steep, 7%	0.15-0.20
Unimproved areas	0.10-0.30	Lawns: Heavy Soil	
Streets		Flat, 2%	0.13-0.17
Asphaltic	0.70-0.95	Average, 2-7%	0.18-0.22
Concrete	0.80-0.95	Steep, 7%	0.25-0.35

Choose the most appropriate runoff coefficient for your site or calculate a weighted-average coefficient, which takes into account different types of land use at your facility:

$$\text{Weighted-average runoff coefficient} = \frac{\text{Area}_1 C_1 + \text{Area}_2 C_2 + \ldots\ldots\ldots\ A_1\ C_1}{\text{Total Site Area}}$$

where C_1 = runoff coefficient for a specific land use of Area.

EXAMPLE

Your facility is located in a semi-and region of the United States which has an annual precipitation (including snowfall) of 12 inches of rain. (Snowfall should be converted to the equivalent inches of rain; assume one foot of snow is equivalent to one inch of rain.) The area covered by your facility is 42 acres (about 170,000 square meters or 1,829,520 square feet). The area of your facility is 50 percent unimproved area, 10 percent asphaltic streets, and 40 percent concrete pavement.

The total stormwater runoff from your facility is therefore calculated as follows:

Land Use	% Area	Runoff Coefficient
Unimproved area	50	0.20
Asphaltic streets	10	0.85
Concrete pavement	40	0.90

$$\text{runoff coefficient} = \frac{+\ (40\%) \times (0.90)}{100\%\ \text{Area}}$$

Weighted-average (50%) × (0.20) + (10%) × (0.85)
= 0.545

(Rainfall) × (land area) × (conversion factor) × (runoff coefficient) = stormwater runoff

(1 foot) x (1,829,520 ft²) x (7.48 gal/ft³) x (0.545)
= 7,458,221 gallons/year

Total stormwater runoff = 7.45 million gallons/year

6. Transfers of The Chemical in Waste to Off-Site Locations

You must report in this section the total annual quantity of the chemical sent to any of the off-site disposal, treatment, or storage facilities for which you have provided an address in Part II. You are not required to report quantities of the chemical sent off-site for purposes of recycle or reuse.

On line 6.1.1, report the amount of the listed chemical transferred to a POTW listed in Part II, Section 1. In the block provided, enter the number from Part II, Section 1 corresponding to the POTW to which the discharge is sent. For example, if the discharge is sent to the location listed in Part II, Section 1.1, then enter "1" in the block provided (the first digit of this section number has been precoded). If you transfer waste containing the toxic chemical to more than one POTW, check the box at the bottom of Section 6 and use the Part IV, the supplemental information sheet to report these transfers.

On lines 6.2.1 through 6.2.3, report the amount of the chemical transferred to other off-site locations corresponding to those listed in Part II, Sections 2.1 through 2.6, including privately owned wastewater treatment facilities. In the block provided, enter the number from Part II, Section 2 corresponding to the off-site location to which the transfer is sent. For example, if the transfer is sent to the location listed in Part II, Section 2.3, enter "3" in the block provided (the first digit of this section number has been precoded). If you need additional space, check the box at the bottom of Section 6 and use the supplemental information sheet (Part IV, Section 6) to report these transfers.

A. Total Transfers

Follow the instructions for providing estimates as presented in the instructions for column A of Section 5 above. Enter the amount, in pounds, of the toxic chemical that is being transferred, including mixtures or trade name products containing the chemical. Do not enter the total poundage of wastes. See Section 5 for information on reporting off-site transfers of less than 1 pound. As in Section 5, if the total amount transferred is less than 1,000 pounds, you may report a range, but only for reporting years 1987, 1988, and 1989. Enter not applicable, NA, if you have no off-site transfers.

B. Basis of Estimate

You must identify the basis for your estimate. Enter the letter code that applies to the method by which the largest percentage of the estimate was derived. Use the same codes identified in the instructions for column B of Section 5.

C. Type of Treatment/Disposal

Enter one of the following codes to identify the type of treatment or disposal method used by the off-site location for the chemical being reported. You should use more than one line for a single location when the toxic chemical is subject to different disposal methods; the same location code may be used more than once. You may have this information in your copy of EPA Form SO, Item S of the Annual/Biennial Hazardous Waste Treatment, Storage, and Disposal Report (RCRA). Applicable codes for this Section 6(c) are as follows:

M10	Storage Only
M40	Solidification/Stabilization
M50	Incineration/Thermal Treatment
M61	Wastewater Treatment (Excluding POTW)
M69	Other Treatment
M71	Underground Injection
M72	Landfill/Disposal Surface Impoundment
M73	Land Treatment
M79	Other Land Disposal
M90	Other Off-Site Management
M91	Transfer to Waste Broker
M99	Unknown

7. Waste Treatment Methods and Efficiency

In Section 7, you must provide the following information related to the chemical for which releases are being reported: (A) the general waste stream types containing the chemical being reported; (B) the waste-treatment methods used on all waste streams containing the chemical; (c) the range of concentrations of the chemical in the influent to the treatment method; (D) whether sequential treatment is used; (E) the efficiency or effectiveness of each treatment method in removing the chemical; and (F) whether the treatment efficiency figure was based on actual operating data. Use a separate line in Section 7 for each treatment method used on a waste stream. Report in this section only information about treatment of waste streams at your facility. not about off-site treatment. If you do not perform on-site treatment of wastes, enter not applicable, NA, in 7.1b.

A. General Waste Stream

For each waste treatment method, indicate the type of waste stream containing the chemical that is treated. Enter the letter code that corresponds to the general waste stream type:

A = Gaseous (gases, vapors, airborne particulates)
W = Wastewater (aqueous waste)
L = Liquid waste (non-aqueous waste)
S = Solid waste (including sludges and slurries)

If a waste is a mixture of water and organic liquid, you must report it as wastewater unless the organic content exceeds 50 percent. Slurries and sludges containing water must be reported as solid waste if they contain appreciable amounts of dissolved solids, or solids that may settle, such that the viscosity or density of the waste is considerably different from that of process wastewater.

B. Treatment Method

Enter the appropriate code from one of the lists below for each treatment method used on a waste stream containing the toxic chemical, regardless of whether the treatment method actually removes the specific chemical being reported. Treatment methods must be reported for each type of waste being treated (i.e., gaseous wastes, aqueous wastes, liquid non-aqueous wastes, and solids).

Waste streams containing the chemical may have a single source or may be aggregates of many sources. For example, process water from several pieces of equipment at your facility may be combined prior to treatment. Report treatment methods that apply to the aggregate waste stream, as well as treatment methods that apply to individual waste streams. If your facility treats various wastewater streams containing the chemical in different ways, the different treatment methods must each be listed separately.

Your facility may have several pieces of equipment performing a similar service and for such equipment you may combine the reporting on a single line. It is not necessary to enter four lines of data to cover four scrubber units, for example, if all four are treating wastes of similar character (e.g., sulfuric acid mist emissions), have similar influent concentrations, and have similar removal efficiencies. If, however, any of these parameters differ from one unit to the next, each scrubber must be listed separately.

Air Emissions Treatment
A01 Flare
A02 Condenser
A03 Scrubber
A04 Absorber
A05 Electrostatic Precipitator
A06 Mechanical Separation
A07 Other Air Emission Treatment
Biological Treatment
B11 Biological Treatment — Aerobic
B21 Biological Treatment — Anaerobic
B31 Biological Treatment-Facultative
B99 Biological Treatment-Other
Chemical Treatment
C01 Chemical Precipitation — Lime or Sodium Hydroxide
C02 Chemical Precipitation — Sulfide
C09 Chemical Precipitation — Other
C11 Neutralization
C21 Chromium Reduction
C31 Complexed Metals Treatment (other than pH Adjustment)
C41 Cyanide Oxidation-Alkaline Chlorination
C42 Cyanide Oxidation — Electrochemical
C43 Cyanide Oxidation — Other
C44 General Oxidation (including Disinfection) —Chlorination
C45 General Oxidation (including Disinfection)—Ozonation
C46 General Oxidation (including Disinfection)— Other
C99 Other Chemical Treatment
Incineration/Thermal Treatment
F01 Liquid Injection
F11 Rotary Kiln with Liquid Injection Unit
F19 Other Rotary Kiln
F31 Two Stage
F41 Fixed Hearth
F42 Multiple Hearth
F51 Fluidized Bed
F61 Infra-Red
F71 Fume/Vapor
F81 Pyrolytic Destructor
F82 Wet Air Oxidation
F83 Thermal Drying/Dewatering
F99 Other Incineration/Thermal Treatment
Physical Treatment
P01 Equalization
P09 Other Blending
P11 Settling/Clarification
P12 Filtration
P13 Sludge Dewatering (non-thermal)
P14 Air Flotation
P15 Oil Skimming
P16 Emulsion Breaking — Thermal
P17 Emulsion Breaking — Chemical
P19 Other Liquid Phase Separation
P21 Adsorption — Carbon
P22 Adsorption — Ion Exchange (other than for recovery/reuse)
P23 Adsorption — Resin
P29 Adsorption — Other
P31 Reverse Osmosis (other than for recovery/reuse)
P41 Stripping — Air
P42 Stripping — Steam
P49 Stripping — Other
P51 Acid Leaching (other than for recovery/reuse)
P61 Solvent Extraction (other than recovery/reuse)
P99 Other Physical Treatment

Recovery/Reuse
R01 Reuse as Fuel— Industrial Kiln
R02 Reuse as Fuel— Industrial Furnace
R03 Reuse as Fuel — Boiler
R04 Reuse as Fuel— Fuel Blending
R09 Reuse as Fuel-Other
R11 Solvents/Organics Recovery— Batch Still Distillation
R12 Solvents/Organics Recovery — Thin-Film Evaporation
R13 Solvents/Organics Recovery — Fractionation
R14 Solvents/Organics Recovery— Solvent Extraction
R19 Solvents/Organics Recovery — Other
R21 Metals Recovery — Electrolytic
R22 Metals Recovery— Ion Exchange
R23 Metals Recovery — Acid Leaching
R24 Metals Recovery— Reverse Osmosis
R26 Metals Recovery — Solvent Extraction
R29 Metals Recovery— Other
R99 Other Reuse or Recovery
Solidification/Stabilization
G01 Cement Processes (including Silicates)
G09 Other Pozzolonic Processes (including Silicates)
G11 Asphaltic Processes
G21 Thermoplastic Techniques
G99 Other Solidification Processes

C. Range of Influent Concentration

The form requires an indication of the range of concentration of the toxic chemical in the waste stream (i.e., the influent) as it typically enters the treatment equipment. Enter in the space provided one of the following code numbers corresponding to the concentration of the chemical in the influent:

1 =Greater than 1 percent
2 =100 parts per million (0.01 percent) to 1 percent
(10,000 parts per million)
3 = 1 part per million to 100 parts per million 4 = 1 part per billion to I part per million 5 = Less than 1 part per billion

[Note: Parts per million (ppm) is milligrams/kilogram (mass/ mass) for solids and liquids; cubic centimeters/cubic meter (volume/volume) for gases; milligrams/liter for solutions or dispersions of the chemical in water; and milligrams of chemical/ kilogram of air for particulates in air. If you have particulate concentrations (at standard temperature and pressure) as grains/ cubic foot of air, multiply by 1766.6 to convert to parts per million; if in milligrams/cubic meter, multiply by 0.773 to obtain parts per million. Factors are for standard conditions of 0°C (32°F) and 760 mmHg atmospheric pressure.]

D. Sequential Treatment?

The blocks in this column may be used in the following case:

- Individual treatment steps are used in a series to treat the chemical, but
- You have no data on the individual efficiencies of each step, but you are able to estimate the overall efficiency of the treatment sequence.

If this is the case, then you may do the following:

- List the appropriate codes for the treatment steps in order (column B) and then put an "X" in the boxes in column D for all these sequential treatment steps.
- Enter the appropriate code for the influent concentration (column c) for only the first treatment step in the sequence. Leave this item blank for the rest of the treatment steps in the sequence only. Enter NA in column E for the efficiency of preceding steps in the sequence.
- Provide the treatment efficiency (column E) for the entire sequence by entering that value in connection with the last treatment step in the sequence only. Enter NA in column E for the efficiency of preceding steps in the sequence.

An example of how to use the sequential treatment option is provided in Appendix A (page 47).

E. Treatment Efficiency Estimate

In the space provided, enter the number indicating the Percentage of the toxic chemical removed from the waste stream through destruction, biological degradation, chemical conversion, or physical removal. The treatment efficiency (expressed as percent removal) represents the mass or weight percentage of chemical destroyed or removed, not merely changes in volume or concentration of the chemical or the waste stream. The efficiency refers only to the percent conversion or removal of the listed toxic chemical from the waste stream, not the percent conversion or removal of other waste stream constituents (alone or together with the listed chemical), and not the general efficiency of the method for any waste stream. For some treatments, the percent removal will represent removal by several mechanisms, as in secondary wastewater treatment, where a chemical may evaporate, be biodegraded, or be physically removed in the sludge.

Percent removal must be calculated as follows:

$$\frac{(I - E)}{I} \times 100$$

where I = mass of the chemical in the influent waste stream and E = mass of the chemical In the effluent waste stream.

- Mark yes or no in column F only in connection with the final step in the sequence. Do not mark in this column for proceeding steps in the sequence.

Calculate the mass or weight of chemical in the waste stream being treated by multiplying the concentration (by weight) of the chemical in the waste stream by the flow rate. In most cases, the percent removal compares the treated effluent to the influent for the particular type of waste stream. However, for some treatment methods, such as incineration or solidification of wastewater, the percent removal of the chemical from the influent waste stream would be reported as 100 percent because the waste stream does not exist in a comparable form after treatment. Some of the treatments (e.g., fuel blending and evaporation) do not destroy, chemically convert, or physically remove the chemical from its waste stream. For these treatment methods, an efficiency of zero must be reported.

For metal compounds, the calculation of the reportable concentration and treatment efficiency is based on the weight of the parent metal, not on the weight of the metal compounds. Metals are not destroyed, only physically removed or chemically converted from one form into another. The treatment efficiency reported represents only physical removal of the parent metal from the waste stream, not the percent chemical conversion of the metal compound. If a listed treatment method converts but does not remove a metal (e.g., chromium reduction), the method must be reported, but the treatment efficiency must be reported as zero.

All data available at your facility must be utilized to calculate treatment efficiency and influent chemical concentration. You are not required to collect any new data for the purposes of this reporting requirement. If data are lacking, estimates must be made using best engineering judgment or other methods.

F. Based on Operating Data?

This column requires you to indicate "Yes" or "No" to whether the treatment efficiency estimate is based on actual operating data. For example, you would check "Yes" if the estimate is based on monitoring of influent and effluent wastes under typical operating conditions. For sequential treatment, do not indicate "Yes" or "No" in column F for a treatment step unless you have provided a treatment estimate in column E.

If the efficiency estimate is based on published data for similar processes or on equipment supplier's literature, or if you otherwise estimated either the influent or effluent waste comparison or the flow rate, check "No."

EXAMPLE

Your facility produces several different waste streams treated on-site and transferred to off-site facilities. You have previously indicated, in Part II, Section 2.1, of Form R, the location of the off-site facilities and the quantity of each reported chemical transferred to off-site facilities in Part III, Section 6.2.1, of the form, using a separate form for each chemical. One waste stream generated by your facility is aqueous waste containing lead chromate, zinc dichromate, and lead selenate as discussed in a previous example in these instructions. In this example, the Waste is transferred to off-site facilities after on-site wastewater treatment. The on-site wastewater treatment plant precipitates metal sludges. The wastewater is first treated with sulfuric acid and sodium disulfate to reduce the hexavalent chromate to trivalent chromium and then treated with lime to raise the pH. This precipitates chromium hydroxide, zinc hydroxide, and lead hydroxide, but does not remove the selenium. The selenium is removed from the wastewater by an ionic exchange system. The chromium, zinc, and lead hydroxide sludge (solid) waste is transferred to an off-site land disposal facility and the selenium-containing ion exchange resin is transferred to an off-site facility for metal recovery (offsite recovery should not be reported). The treated wastewater is sent to a POTW after neutralization. You would indicate the following treatment methods for the on-site treatment of each of the lead, zinc, chromium, and selenium compounds:

C21	-	Chromium Reduction
C01	-	Chemical Precipitation — Lime or Sodium Hydroxide
R22	-	Metals Recovery— Ion Exchange
C11	-	Neutralization

All sequential treatment steps must be indicated for all the metal compound categories reported even if the treatment method does not affect the particular metal. For example, ionic exchange must be reported as a treatment method for lead, zinc, chromium, and selenium compounds, even though the method affects only the selenium compound.

You would calculate the percent removal of chromium, lead, zinc, and selenium, by subtracting the amount of each metal in the wastewater discharge from the amount of each metal in the wastewater before treatment, and then dividing by the amount of each metal in the wastewater before treatment.

You would indicate a discharge to a POTW in Part III, Section 6.1.1 and the location of the POTW in Part II, Section 1.1. You would also indicate the release of the metal sludge to an offsite land disposal facility in Part III, Section 6.2.1.

8. Optional Information on Waste Minimization

Information provided in Part III. Section 8. of Form R is optional. In this section, you may identify waste minimization efforts relating to the reported toxic chemical that may not have been reflected in your responses to previous sections of the form. Waste minimization reduces the amount of the chemical in wastes that are generated. Treatment or disposal does not minimize waste, but recycling or reuse of a waste should be counted as waste minimization. Waste minimization applies to air emissions and wastewater, as well as to liquid or solid materials that are released, disposed of, or treated. For example, a program to recycle material from reactor cleaning could reduce the amount of a listed chemical in wastewater prior to treatment. This reduction might not show up in annual reports of releases to receiving streams (due to effective treatment, for example) but would be captured in this section.

A. Type of Modification

Enter from the following list the one code that best describes the type of waste minimization activity:
M1 Recycling/Reuse On-Site
M2 Recycling/Reuse Off-Site
M3 Equipment/Technology Modifications
M4 Process Procedure Modifications
M5 Reformulation/Redesign of Product
M6 Substitution of Raw Materials
M7 Improved Housekeeping, Training, Inventory Control
M8 Other Waste Minimization Technique

B. Quantity of the Chemical in The Wastestream Prior to Treatment/Disposal

Enter the pounds of the toxic chemical contained in all wastes in the reporting year and the pounds contained in all wastes in the year prior to the reporting year. Alternatively, to protect confidential information, you may wish to enter only the percentage by which the weight of the chemical in the wastes has changed. This figure may be calculated using the following formula.

$$\frac{(\text{toxic chemical in wastes in reporting year} - \text{toxic chemical in wastes in prior year})}{\text{toxic chemical in wastes in prior year}} \times 100$$

The resulting figure may be either negative or positive (i.e., if the amount of waste generated has been reduced. a negative number should be reported).

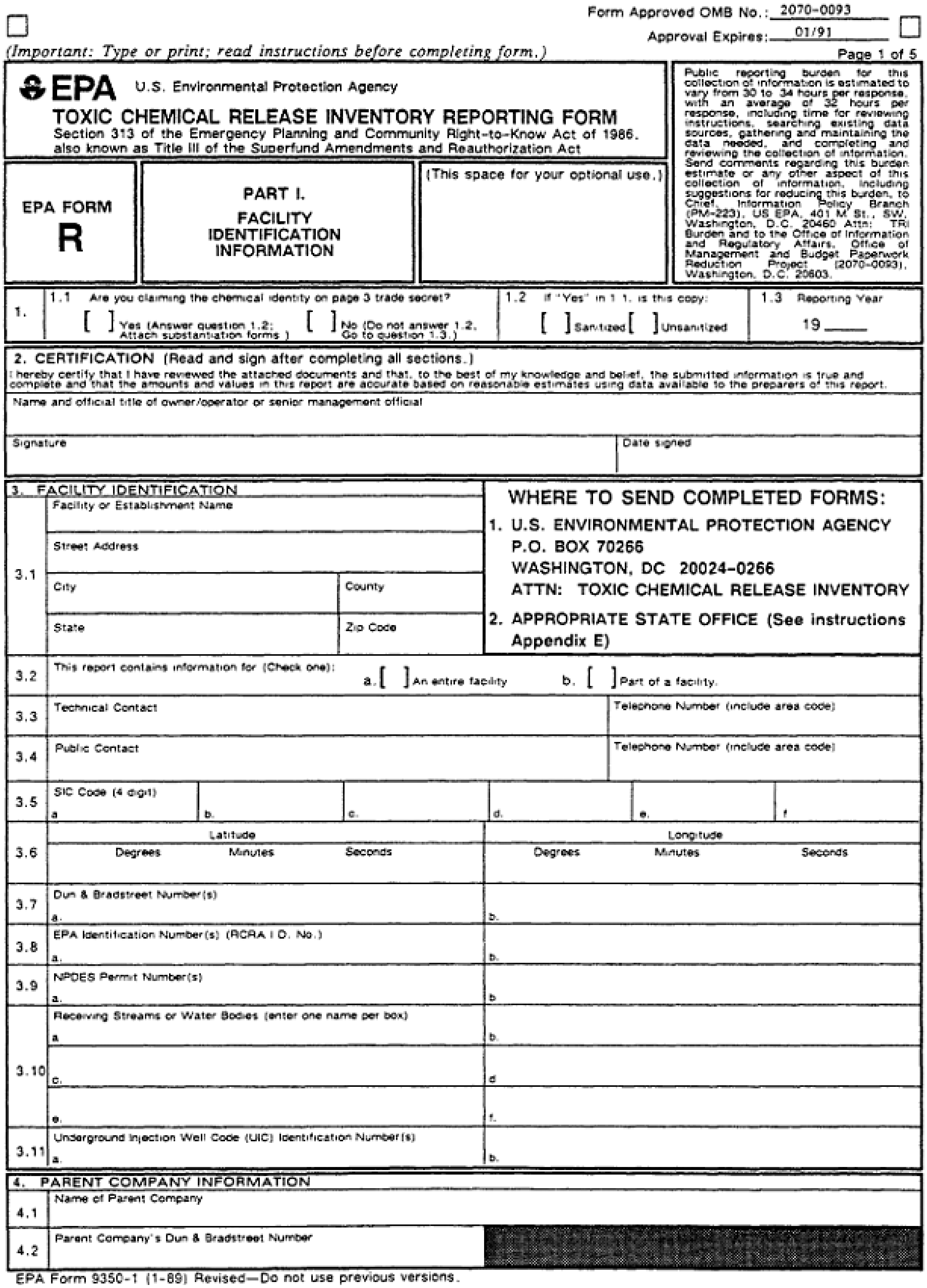
C. Index

Enter the ratio of reporting-year production to production in the year prior to the reporting year. This index should be calculated to most closely reflect activities involving the chemical. The index provides a means for users of the data to distinguish effects due to changes in business activity from the effects specifically due to waste minimization efforts. It is not necessary to indicate the units on which the index is based. Examples of acceptable indices include:

- Amount of chemical produced in 1988/amount of chemical produced in 1987. For example, a company manufactures 200,000 pounds of a chemical in 1987 and 250,000 pounds of the same chemical in 1988. The index figure to report would be 1.3 (1.25 rounded to two significant digits).
- Amount of paint produced in 1988/amount of paint produced in 1987.
- Number of appliances coated in 1988/number of appliances coated in 1987.
- Square feet of solar collector fabricated in 1988/square feet of solar collector fabricated in 1987.

D. Reason For Action

Finally, enter the codes from the following list that best describe the reason for initiating the waste minimization effort:
R1 Regulatory Requirement for the Waste
R2 Reduction of Treatment/Disposal Costs
R3 Other Process Cost Reduction
R4 Self-Initiated Review
R5 Other (e.g., discontinuation of product, occupational safety).



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Approval Expires: 01/91

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EPA U.S. Environmental Protection Agency

TOXIC CHEMICAL RELEASE INVENTORY REPORTING FORM

Section 313 of the Emergency Planning and Community Right-to-Know Act of 1986, also known as Title III of the Superfund Amendments and Reauthorization Act

Public reporting burden for this collection of information is estimated to vary from 30 to 34 hours per response, with an average of 32 hours per response, including time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Chief, Information Policy Branch (PM-223), US EPA, 401 M St., SW, Washington, D.C. 20460 Attn: TRI Burden and to the Office of Information and Regulatory Affairs, Office of Management and Budget Paperwork Reduction Project (2070-0093), Washington, D.C. 20603.

EPA FORM **R**	**PART I.** **FACILITY IDENTIFICATION INFORMATION**	(This space for your optional use.)

1.	1.1 Are you claiming the chemical identity on page 3 trade secret? [ ] Yes (Answer question 1.2; Attach substantiation forms.) [ ] No (Do not answer 1.2. Go to question 1.3.)	1.2 If "Yes" in 1.1, is this copy: [ ] Sanitized [ ] Unsanitized	1.3 Reporting Year 19 _____

2. CERTIFICATION (Read and sign after completing all sections.)

I hereby certify that I have reviewed the attached documents and that, to the best of my knowledge and belief, the submitted information is true and complete and that the amounts and values in this report are accurate based on reasonable estimates using data available to the preparers of this report.

Name and official title of owner/operator or senior management official

Signature	Date signed

3. FACILITY IDENTIFICATION

3.1	Facility or Establishment Name	
	Street Address	
	City	County
	State	Zip Code

WHERE TO SEND COMPLETED FORMS:

1. U.S. ENVIRONMENTAL PROTECTION AGENCY
P.O. BOX 70266
WASHINGTON, DC 20024-0266
ATTN: TOXIC CHEMICAL RELEASE INVENTORY
2. APPROPRIATE STATE OFFICE (See instructions Appendix E)

3.2	This report contains information for (Check one): a. [ ] An entire facility b. [ ] Part of a facility.					
3.3	Technical Contact			Telephone Number (include area code)		
3.4	Public Contact			Telephone Number (include area code)		
3.5	SIC Code (4 digit) a.	b.	c.	d.	e.	f.
3.6	Latitude: Degrees	Minutes	Seconds	Longitude: Degrees	Minutes	Seconds
3.7	Dun & Bradstreet Number(s) a.	b.				
3.8	EPA Identification Number(s) (RCRA I.D. No.) a.	b.				
3.9	NPDES Permit Number(s) a.	b.				
3.10	Receiving Streams or Water Bodies (enter one name per box) a.	b.				
	c.	d.				
	e.	f.				
3.11	Underground Injection Well Code (UIC) Identification Number(s) a.	b.				

4. PARENT COMPANY INFORMATION

4.1	Name of Parent Company	
4.2	Parent Company's Dun & Bradstreet Number	

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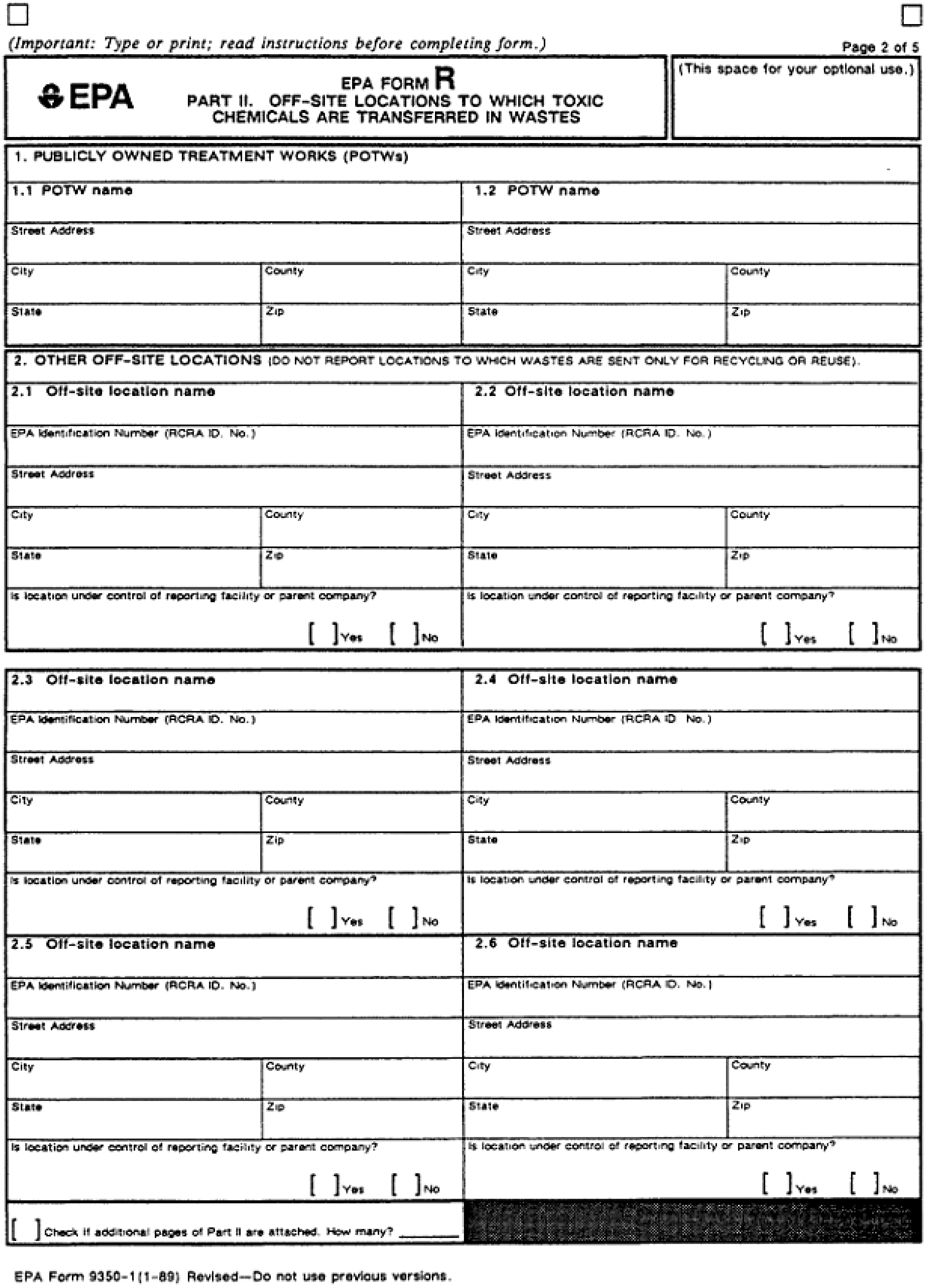

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EPA FORM R
PART II. OFF-SITE LOCATIONS TO WHICH TOXIC CHEMICALS ARE TRANSFERRED IN WASTES

(This space for your optional use.)

1. PUBLICLY OWNED TREATMENT WORKS (POTWs)

1.1 POTW name		**1.2 POTW name**	
Street Address		Street Address	
City	County	City	County
State	Zip	State	Zip

2. OTHER OFF-SITE LOCATIONS (DO NOT REPORT LOCATIONS TO WHICH WASTES ARE SENT ONLY FOR RECYCLING OR REUSE).

2.1 Off-site location name		**2.2 Off-site location name**	
EPA Identification Number (RCRA ID. No.)		EPA Identification Number (RCRA ID. No.)	
Street Address		Street Address	
City	County	City	County
State	Zip	State	Zip
Is location under control of reporting facility or parent company? [ ] Yes [ ] No		Is location under control of reporting facility or parent company? [ ] Yes [ ] No	

2.3 Off-site location name		**2.4 Off-site location name**	
EPA Identification Number (RCRA ID. No.)		EPA Identification Number (RCRA ID No.)	
Street Address		Street Address	
City	County	City	County
State	Zip	State	Zip
Is location under control of reporting facility or parent company? [ ] Yes [ ] No		Is location under control of reporting facility or parent company? [ ] Yes [ ] No	
2.5 Off-site location name		**2.6 Off-site location name**	
EPA Identification Number (RCRA ID. No.)		EPA Identification Number (RCRA ID. No.)	
Street Address		Street Address	
City	County	City	County
State	Zip	State	Zip
Is location under control of reporting facility or parent company? [ ] Yes [ ] No		Is location under control of reporting facility or parent company? [ ] Yes [ ] No	

[ ] Check if additional pages of Part II are attached. How many? ________

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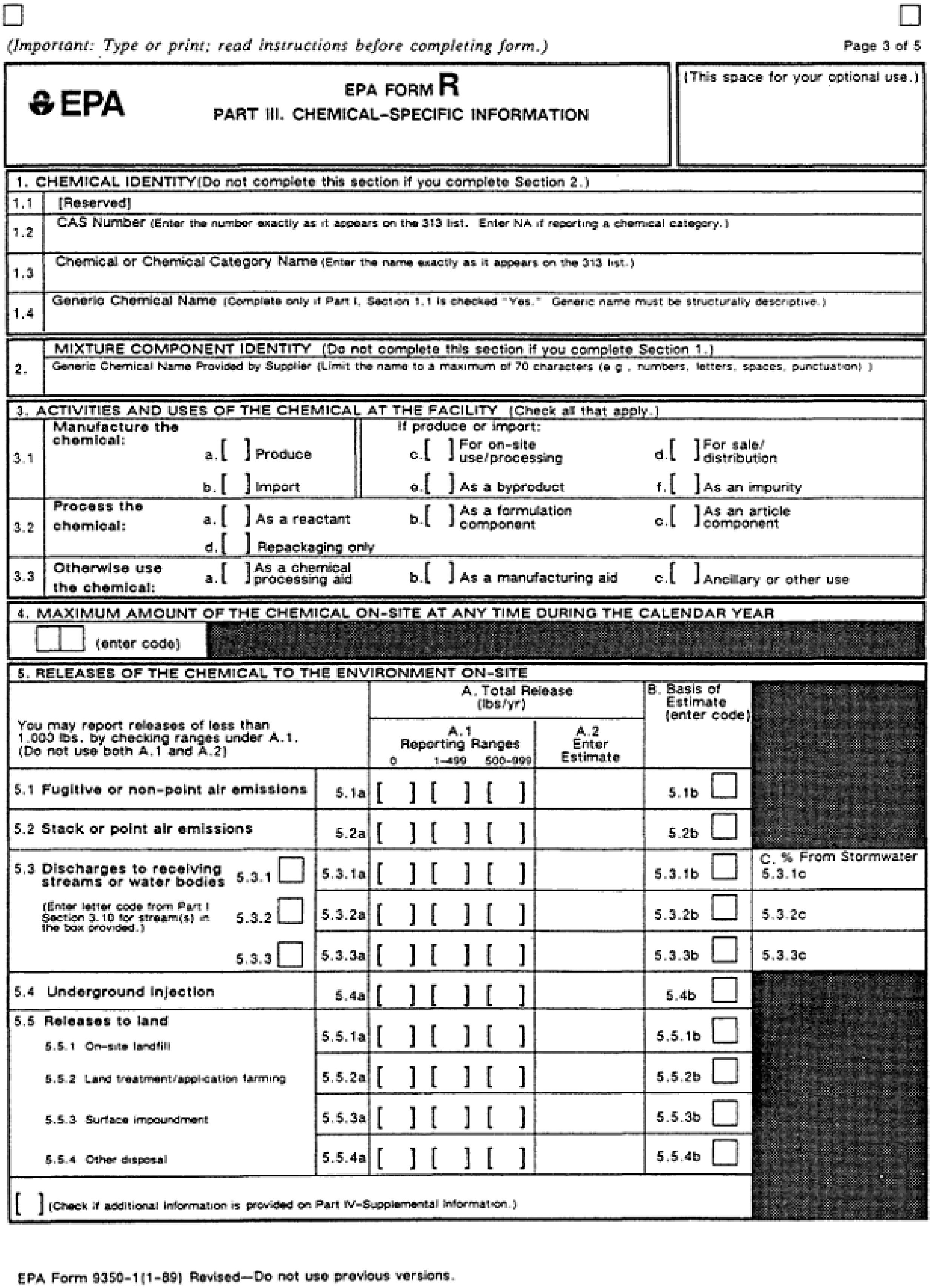

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EPA FORM R

PART III. CHEMICAL-SPECIFIC INFORMATION

(This space for your optional use.)

1. CHEMICAL IDENTITY (Do not complete this section if you complete Section 2.)

1.1	[Reserved]
1.2	CAS Number (Enter the number exactly as it appears on the 313 list. Enter NA if reporting a chemical category.)
1.3	Chemical or Chemical Category Name (Enter the name exactly as it appears on the 313 list.)
1.4	Generic Chemical Name (Complete only if Part I, Section 1.1 is checked "Yes." Generic name must be structurally descriptive.)

2.	**MIXTURE COMPONENT IDENTITY** (Do not complete this section if you complete Section 1.) Generic Chemical Name Provided by Supplier (Limit the name to a maximum of 70 characters (e g , numbers, letters, spaces, punctuation))

3. ACTIVITIES AND USES OF THE CHEMICAL AT THE FACILITY (Check all that apply.)

3.1	Manufacture the chemical:	a. [ ] Produce b. [ ] Import	If produce or import: c. [ ] For on-site use/processing e. [ ] As a byproduct	d. [ ] For sale/ distribution f. [ ] As an impurity
3.2	Process the chemical:	a. [ ] As a reactant d. [ ] Repackaging only	b. [ ] As a formulation component	c. [ ] As an article component
3.3	Otherwise use the chemical:	a. [ ] As a chemical processing aid	b. [ ] As a manufacturing aid	c. [ ] Ancillary or other use

4. MAXIMUM AMOUNT OF THE CHEMICAL ON-SITE AT ANY TIME DURING THE CALENDAR YEAR

☐☐ (enter code)

5. RELEASES OF THE CHEMICAL TO THE ENVIRONMENT ON-SITE

You may report releases of less than 1,000 lbs. by checking ranges under A.1. (Do not use both A.1 and A.2)		A. Total Release (lbs/yr)				B. Basis of Estimate (enter code)	
		A.1 Reporting Ranges			A.2 Enter Estimate		
		0	1–499	500–999			
5.1 Fugitive or non-point air emissions	5.1a	[ ]	[ ]	[ ]		5.1b ☐	
5.2 Stack or point air emissions	5.2a	[ ]	[ ]	[ ]		5.2b ☐	
5.3 Discharges to receiving streams or water bodies 5.3.1 ☐	5.3.1a	[ ]	[ ]	[ ]		5.3.1b ☐	C. % From Stormwater 5.3.1c
(Enter letter code from Part I Section 3.10 for stream(s) in the box provided.) 5.3.2 ☐	5.3.2a	[ ]	[ ]	[ ]		5.3.2b ☐	5.3.2c
5.3.3 ☐	5.3.3a	[ ]	[ ]	[ ]		5.3.3b ☐	5.3.3c
5.4 Underground Injection	5.4a	[ ]	[ ]	[ ]		5.4b ☐	
5.5 Releases to land 5.5.1 On-site landfill	5.5.1a	[ ]	[ ]	[ ]		5.5.1b ☐	
5.5.2 Land treatment/application farming	5.5.2a	[ ]	[ ]	[ ]		5.5.2b ☐	
5.5.3 Surface impoundment	5.5.3a	[ ]	[ ]	[ ]		5.5.3b ☐	
5.5.4 Other disposal	5.5.4a	[ ]	[ ]	[ ]		5.5.4b ☐	

[ ] (Check if additional information is provided on Part IV–Supplemental Information.)

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EPA FORM R

PART III. CHEMICAL-SPECIFIC INFORMATION (continued)

(This space for your optional use.)

6. TRANSFERS OF THE CHEMICAL IN WASTE TO OFF-SITE LOCATIONS

You may report transfers of less than 1,000 lbs. by checking ranges under A.1. (Do not use both A.1 and A.2)	A. Total Transfers (lbs/yr) A.1 Reporting Ranges 0	1-499	500-999	A.2 Enter Estimate	B. Basis of Estimate (enter code)	C. Type of Treatment/ Disposal (enter code)
6.1.1 Discharge to POTW (enter location number from Part II, Section 1.) 1.☐	[ ]	[ ]	[ ]		6.1.1b ☐	▨
6.2.1 Other off-site location (enter location number from Part II, Section 2.) 2.☐	[ ]	[ ]	[ ]		6.2.1b ☐	6.2.1c M☐☐
6.2.2 Other off-site location (enter location number from Part II, Section 2.) 2.☐	[ ]	[ ]	[ ]		6.2.2b ☐	6.2.2c M☐☐
6.2.3 Other off-site location (enter location number from Part II, Section 2.) 2.☐	[ ]	[ ]	[ ]		6.2.3b ☐	6.2.3c M☐☐

[ ] (Check if additional information is provided on Part IV-Supplemental Information.)

7. WASTE TREATMENT METHODS AND EFFICIENCY

A. General Wastestream (enter code)	B. Treatment Method (enter code)	C. Range of Influent Concentration (enter code)	D. Sequential Treatment? (check if applicable)	E. Treatment Efficiency Estimate	F. Based on Operating Data? Yes	No
7.1a ☐	7.1b ☐☐☐	7.1c ☐	7.1d [ ]	7.1e %	7.1f [ ]	[ ]
7.2a ☐	7.2b ☐☐☐	7.2c ☐	7.2d [ ]	7.2e %	7.2f [ ]	[ ]
7.3a ☐	7.3b ☐☐☐	7.3c ☐	7.3d [ ]	7.3e %	7.3f [ ]	[ ]
7.4a ☐	7.4b ☐☐☐	7.4c ☐	7.4d [ ]	7.4e %	7.4f [ ]	[ ]
7.5a ☐	7.5b ☐☐☐	7.5c ☐	7.5d [ ]	7.5e %	7.5f [ ]	[ ]
7.6a ☐	7.6b ☐☐☐	7.6c ☐	7.6d [ ]	7.6e %	7.6f [ ]	[ ]
7.7a ☐	7.7b ☐☐☐	7.7c ☐	7.7d [ ]	7.7e %	7.7f [ ]	[ ]
7.8a ☐	7.8b ☐☐☐	7.8c ☐	7.8d [ ]	7.8e %	7.8f [ ]	[ ]
7.9a ☐	7.9b ☐☐☐	7.9c ☐	7.9d [ ]	7.9e %	7.9f [ ]	[ ]
7.10a ☐	7.10b ☐☐☐	7.10c ☐	7.10d [ ]	7.10e %	7.10f [ ]	[ ]

[ ] (Check if additional information is provided on Part IV-Supplemental Information.)

8. OPTIONAL INFORMATION ON WASTE MINIMIZATION
(Indicate actions taken to reduce the amount of the chemical being released from the facility. See the instructions for coded items and an explanation of what information to include.)

A. Type of Modification (enter code)	B. Quantity of the Chemical in Wastes Prior to Treatment or Disposal Current reporting year (lbs/yr)	Prior year (lbs/yr)	Or percent change	C. Index	D. Reason for Action (enter code)
M☐	________	________	________ %	☐.☐	R☐

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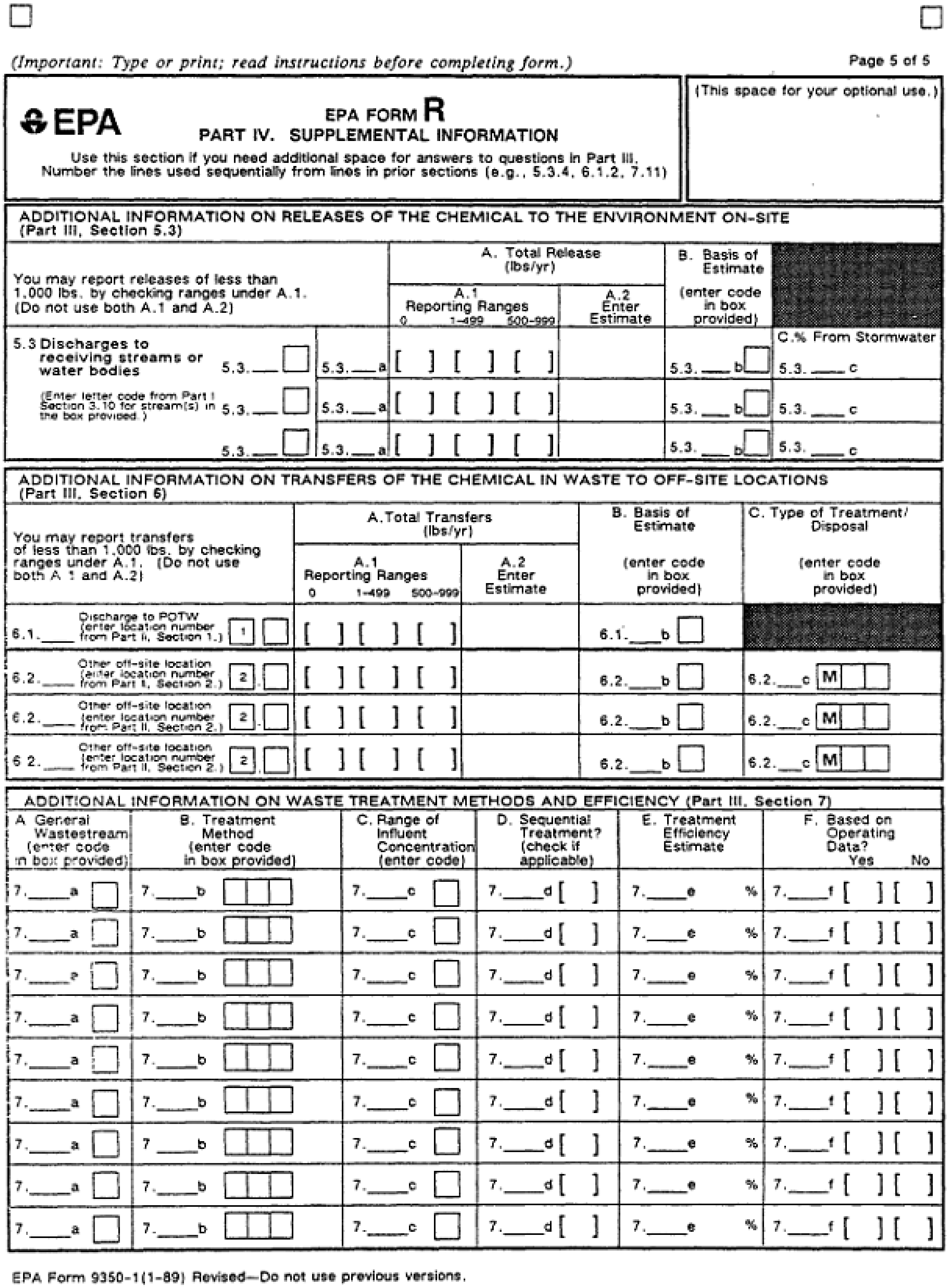

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EPA EPA FORM **R**

PART IV. SUPPLEMENTAL INFORMATION

Use this section if you need additional space for answers to questions in Part III. Number the lines used sequentially from lines in prior sections (e.g., 5.3.4, 6.1.2, 7.11)

(This space for your optional use.)

ADDITIONAL INFORMATION ON RELEASES OF THE CHEMICAL TO THE ENVIRONMENT ON-SITE (Part III, Section 5.3)

You may report releases of less than 1,000 lbs. by checking ranges under A.1. (Do not use both A.1 and A.2)		A. Total Release (lbs/yr) A.1 Reporting Ranges 0 1-499 500-999	A.2 Enter Estimate	B. Basis of Estimate (enter code in box provided)	C.% From Stormwater
5.3 Discharges to receiving streams or water bodies 5.3.___ ☐	5.3.___a	[ ] [ ] [ ]		5.3.___b ☐	5.3.____c
(Enter letter code from Part I Section 3.10 for stream(s) in the box provided.) 5.3.___ ☐	5.3.___a	[ ] [ ] [ ]		5.3.___b ☐	5.3.____c
5.3.___ ☐	5.3.___a	[ ] [ ] [ ]		5.3.___b ☐	5.3.____c

ADDITIONAL INFORMATION ON TRANSFERS OF THE CHEMICAL IN WASTE TO OFF-SITE LOCATIONS (Part III, Section 6)

You may report transfers of less than 1,000 lbs. by checking ranges under A.1. (Do not use both A.1 and A.2)	A.Total Transfers (lbs/yr) A.1 Reporting Ranges 0 1-499 500-999	A.2 Enter Estimate	B. Basis of Estimate (enter code in box provided)	C. Type of Treatment/ Disposal (enter code in box provided)
6.1.____ Discharge to POTW (enter location number from Part II, Section 1.) 1 ☐	[ ] [ ] [ ]		6.1.___b ☐	
6.2.____ Other off-site location (enter location number from Part II, Section 2.) 2 ☐	[ ] [ ] [ ]		6.2.___b ☐	6.2.___c M☐☐
6.2.____ Other off-site location (enter location number from Part II, Section 2.) 2 ☐	[ ] [ ] [ ]		6.2.___b ☐	6.2.___c M☐☐
6.2.____ Other off-site location (enter location number from Part II, Section 2.) 2 ☐	[ ] [ ] [ ]		6.2.___b ☐	6.2.___c M☐☐

ADDITIONAL INFORMATION ON WASTE TREATMENT METHODS AND EFFICIENCY (Part III, Section 7)

A. General Wastestream (enter code in box provided)	B. Treatment Method (enter code in box provided)	C. Range of Influent Concentration (enter code)	D. Sequential Treatment? (check if applicable)	E. Treatment Efficiency Estimate	F. Based on Operating Data? Yes No
7.____a ☐	7.____b ☐☐☐	7.____c ☐	7.____d [ ]	7.____e %	7.____f [ ] [ ]
7.____a ☐	7.____b ☐☐☐	7.____c ☐	7.____d [ ]	7.____e %	7.____f [ ] [ ]
7.____a ☐	7.____b ☐☐☐	7.____c ☐	7.____d [ ]	7.____e %	7.____f [ ] [ ]
7.____a ☐	7.____b ☐☐☐	7.____c ☐	7.____d [ ]	7.____e %	7.____f [ ] [ ]
7.____a ☐	7.____b ☐☐☐	7.____c ☐	7.____d [ ]	7.____e %	7.____f [ ] [ ]
7.____a ☐	7.____b ☐☐☐	7.____c ☐	7.____d [ ]	7.____e %	7.____f [ ] [ ]
7.____a ☐	7.____b ☐☐☐	7.____c ☐	7.____d [ ]	7.____e %	7.____f [ ] [ ]
7.____a ☐	7.____b ☐☐☐	7.____c ☐	7.____d [ ]	7.____e %	7.____f [ ] [ ]
7.____a ☐	7.____b ☐☐☐	7.____c ☐	7.____d [ ]	7.____e %	7.____f [ ] [ ]

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Appendix D

Charge to the National Academy of Sciences in Superfund Amendments and Reauthorization Act (SARA) Section 313(1) and U.S. Congress, 1986. SARA Conference Report on Mass Balance Study

MASS BALANCE STUDY SARA SECTION 313(1)

(1) IN GENERAL.-The Administrator shall arrange for a mass balance study to be carried out by the National Academy of Science using mass balance information collected by the Administrator under paragraph (3). The Administrator shall submit to Congress a report on such a study no later than 5 years after the date of the enactment of this title.

(2) PURPOSES.-The purposes of the study are as follows:

(A) To assess the value of mass balance analysis in determining the accuracy of information on toxic chemical releases.

(B) To assess the value of obtaining mass balance information, or portions thereof, to determine the waste reduction efficiency of different facilities, or categories of facilities, including the effectiveness of toxic chemical regulations promulgated under laws other than this title.

(C) To assess the utility of such information for evaluating toxic chemical management practices at facilities, or categories of facilities, covered by this section.

(D) To determine the implications of mass balance information collection on a national scale similar to the mass balance information collection carried out by the Administrator under paragraph (3), including implications of the use of such collection as part of a national annual quantity toxic chemical release program.

(3) INFORMATION COLLECTION.-(A) The Administrator shall acquire available mass balance information from States which currently conduct (or during the 5 years after the date of enactment of this title initiate) a mass balance-oriented annual quantity toxic chemical release program. If information from such States provides an inadequate representation of industry classes and categories to carry out the purposes of study, the Administrator also may acquire mass balance information necessary for the study from a representative number of facilities in other States.

(B) Any information acquired under this section shall be available to the public, except that upon a showing satisfactory to the Administrator by any person that the information (or a particular part thereof) to which the Administrator or any officer, employee, or representatives has access under this section if made public would divulge information entitled to protection under Section 1905 of title 18, United States Code, such information or part shall be considered confidential in accordance with the purposes of that section, except that such information or part may be disclosed to other officers, employees, or authorized representatives of the United States concerned with carrying out this section.

(C) The Administrator may promulgate regulations prescribing procedures for collecting mass balance information under this paragraph.

(D) For purposes of collecting mass balance information under subparagraph (A), the Administrator may require the submission of information by a State or facility.

(4) MASS BALANCE DEFINITION.-For purposes of this subsection[1], the term "mass balance" means an accumulation of the annual quantities of chemicals transported to a facility, produced at a facility, consumed at a facility, used at a facility, accumulated at a facility, released from a facility, and transported from a facility as a waste or as a commercial product or byproduct or component of a commercial product or byproduct.

U.S. CONGRESS, 1986. SARA CONFERENCE REPORT ON SECTION 313 [*]

SENATE AMENDMENT-The Toxic Chemicals Release Inventory Form submitted by each reporting facility would require the submission of information on the quantity of chemical substances transported to the facility, produced at the facility, and transported from the facility as wastes or products.

HOUSE AMENDMENT-No comparable provision.

CONFERENCE SUBSTITUTE-Subsection (1) requires the Administrator to arrange for a study to be conducted by the National Academy of Sciences to evaluate several concepts involving the use of mass balance information. The report on the study must be submitted to Congress within 5 years. The term "mass balance" is defined as the accumulation of annual quantities of chemicals transported to, produced at, consumed at, used at, accumulated at, released from, and transported from a facility as a waste or product. It is anticipated that these quantities will be determined by a variety of methods including direct measurements, engineering estimates, estimates derived from differences between measurements, and other methods. In carrying out its responsibilities under this section the National Academy of Sciences should include an assessment of the quality of these measurements and the effect of inaccuracies on the purposes of the study.

The Administrator is directed to acquire information form two sources. First, the Administrator must acquire available mass balance information from States' currently conducting or, within the study period, initiating mass balance-oriented annual quantity toxic chemical release programs. Second, if these programs fail to provide an adequate representation of classes and categories of industry, the Administrator may acquire mass balance information from a representative number of facilities in other States.

For example, assuming existing State programs include several facilities which manufacture organic chemical products but only one facility manufactures inorganic chemicals, the Administrator could acquire the information from inorganic manufacturing facilities in other States if the Administrator believed additional information was necessary for the study.

All information acquired under this section must be available to the public except upon a showing satisfactory to the Administrator that the information is entitled to protection under confidential business information provisions of section 1905 of title 18, United States Code.

There are several purposes for conducting the study. First, it should assess the value of mass balance analysis in determining the accuracy of information on toxic chemical releases. Although other provisions of this section require reporting of emissions, questions remain regarding the accuracy of these estimates. At issue is whether mass balance analysis provides an effective method of assessing the accuracy of these estimates.

Second, the study should answer questions regarding the value of mass balance or components of it, such as production rate, in determining the waste reduction efficiency of different facilities or categories of facilities, and the effectiveness of toxic chemical regulations. For example, can this information reasonably be used to compare different facilities in the same business to determine whether one is applying more rigorous environmental control than another, or delineate whether

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[*] Pages 300—302 of the SARA report provide additional information on the mass balance study mandated in SARA Section 313 (1).

reduced releases of chemicals reflect improved control or limited operation?

Third, the study should assess the utility of such information for evaluating toxic chemical management practices. For example, can this information enhance assessments of whether facilities are altering operations to reduce the presence or release of toxic chemicals?

Fourth, the study should evaluate the implications of implementing a mass balance program concept on a national scale.

This assessment should evaluate the value of information generated by such a program to the public and to regulators and policy makers at the local, Sate and national level together with the financial and other resources needed by governments and facilities to implement such a program and possible trade secret concerns that may arise.

Subparagraph (1)(3)(D) gives the Administrator enforceable authority to require submission of information necessary for this study.

Appendix E

Mass Balance Workshop Participants and Presentation Titles

The workshop was held on March 24 and 25, 1988, at the National Academy of Sciences in Washington, D.C. Written information provided by the workshop participants is maintained by the NRC.

WORKSHOP PARTICIPANTS OUTSIDE OF COMMITTEE

Name	Affiliation
Frank Altmayer	Scientific Control Labs
Jose Alvarez	Upjohn Co.
David Benforado	3M Corp.
Denny Beroiz	General Dynamics Corp.
Kenneth Bradley	Ontario Waste Management Corp.
Marvin Chlapek	Exxon Corp.
Joseph Chu (deceased)	General Motors Corp.
Richard Dime	New Jersey State Dept. of Environmental Protection
Max Eisenberg	Maryland State Dept. of Environment
Harry Fatkin	Polaroid Corp.
Kathleen Franklin	U.S. Environmental Protection Agency
Carl Fromm	Jacobs Engineering Group, Inc.
Hank Garie	New Jersey State Dept. of Enviromental Protection
Franco Godoy	The Earth Technology Corp.
Mark Griffiths	National Association of Metal Finishers
Khristine Hall	International Business Machines Corp.
Robert Ham	RMT, Inc.
Brian Harney	Mobil Oil Corp.
Russ Hawes	Mobil Oil Corp.
Robert Hawes	Polaroid Corp.
Jeanne Herb	New Jersey State Dept. of Environmental Protection
Martin Hillyer	Chevron Corp.
Josephine Huang	Tetra Tech
Ken Johnson	National Governors' Association
Stephen Jordan	E. I. du Pont de Nemours & Co., Inc.
Roger Kanerva	State of Illinois Environmental Protection Agency
Ron Kienle	Shell Oil Co.
Larry Longanecker	U.S. Environmental Protection Agency
Francis McMichael*	Carnegie-Mellon University
Lamar Miller	Univ. of Florida, Dept. of Environmental Engineering Science
Richard Morgenstern	U.S. Environmental Protection Agency
Andrew Nickolaus	E.I. du Pont de Nemours & Co., Inc.
Margo Oge	U.S. Environmental Protection Agency
Kirsten Oldenburg	U.S. Congress Office of Technology Assessment
Daniel Oman	RMT, Inc.
Richard Paul	Motor Vehicle Manufacturer's Association
Ward Penberthy	U.S. Environmental Protection Agency
Robert Pojasek	ChemCycle Corp.
Dennis Redington	Monsanto Co.
Merilyn Reeves	League of Women Voters
James Rogers	Digital Electronics Corp.
Niki Roy	State of Massachusetts Dept. of Environmental Quality Engineering
David Sarokin	U.S. Environmental Protection Agency

Name	Affiliation
Michael Shapiro	U.S. Environmental Protection Agency
Deborah Shaver	ICF, Inc.
Edward Clarence-Smith	Natural Resources Defense Council
James Solyst	National Governors' Association
Edward Stevenson	State of New Jersey Dept. of Environmental Protection
Paul Supple	General Electric Co.
Dennis Timberlake	U.S. Environmental Protection Agency
Lial Tischler	Tischler/Kocurek Environmental Engineers
Scott Tufts	PPG Industries, Inc.

[*] Did not attend, but sent information.

WORKSHOP PRESENTATIONS

Session I, Part I-Policy Needs for Mass Balance Approaches to Assess Waste Minimization/Reduction Efforts

"Meaning of Mass Balance in Relation to Policy Needs" David Sarokin (U.S. Environmental Protection Agency)

"The Need for Alternatives Within the System of Environmental Protection" Kirsten Oldenburg (U.S. Congress Office of Technology Assessment)

"A Proposed Model Waste Reduction Program" Edward Clarence-Smith (Natural Resources Defense Council)

Session I, Part II-Policy Needs for Mass Balance Approaches to Estimate Toxic Chemical Releases

"Facilitating Source Reduction Requirements" Niki Roy (State of Massachusetts Dept. of Environmental Quality Engineering)

"Illinois' Perspective" Roger Kanerva (State of Illinois Environmental Protection Agency)

"The Citizen's Viewpoint" Merilyn Reeves (League of Women Voters)

Session II, Part I-Mass Balance Applications: Feasibility of Estimating Toxic Releases Across Industry Sectors

"An Integrated Perspective from the U.S. EPA" Richard Morgenstern (U.S. Environmental Protection Agency)

"New Jersey's Experience with the Industrial Survey Project" Edward Stevenson (State of New Jersey Dept. of Environmental Protection)

"Industrial Perspective" Robert Pojasek (ChemCycle Corp.)

"Applications for Petroleum, Petrochemical, and Pesticide Production" Lamar Miller (Univ. of Florida, Dept. of Environmental Engineering Science)

Session II, Part II-Mass Balance Applications: Feasibility of Estimating Toxic Releases Within Industry Sectors

"The Electronics Industry" James Rogers (Digital Electronics Corp.)

"Mass Balance Technology in the Petrochemical Industry" Marvin Chlapek (Exxon Corp.)

"Difficulties with the Approach and Alternatives for the Electroplating Industry" Frank Altmayer (Scientific Control Labs)

Session III, Part I-Mass Balance Applications: Feasibility of Assessing Hazardous Waste Minimization/Reduction Efforts Across Industry Sectors

"Experiences with Electronics Manufacturing, Solvent Users, and Petroleum Refineries" Carl Fromm (Jacobs Engineering Group, Inc.)

"Why the Material Balance Focus?" Kenneth Bradley (Ontario Waste Management Corp.)

"Developing Baseline Data and Tracking Progress" Franco Godoy (The Earth Technology Corp.)

Session III, Part II-Mass Balance Applications: Feasibility of Assessing Hazardous Waste Minimization/ Reduction Efforts Within Industry Sectors

"The Application of Mass Balance Techniques in the Foundary Industry" Daniel Oman and Robert Ham (RMT, Inc.)

"Measurement Error in the Chemical Manufacturing Industry" Lial Tischler (Tischler/Kocurek Environmental Engineers)

"Applications in the Photographic Processing and Electroplating Industries" Deborah Shaver (ICF, Inc.)

"The Petroleum Refining Industry" Martin Hillyer (Chevron Corp.)

Session IV-Mass Balance Applications: Feasibility of Estimating Toxic Releases: Facility Perspective

"Estimating Methyl Chloride Releases from a Chemical Manufacturing Facility" Paul Supple (General Electric Corp.)

"The Engineering Role of Process Material Balance" Dennis Redington (Monsanto Co.)

"Mass Balance for an Adipic Acid Facility" Andrew Nickolaus (E.I. du Pont de Nemours & Co., Inc.)

"Approaches and Uncertainties Within a Multi-Chemical Production Facility" Scott Tufts (PPG Industries, Inc.)

Session V-Mass Balance Applications: Feasibility of Assessing Waste Minimization/Reduction Efforts

"Measurements Within a Defense Weaponry Manufacturing Facility" Denny Beroiz (General Dynamics Corp.)

"Multi-product Manufacturing Facilities: The Practical Problems with Aggregated Wastes" David Benforado (3M Corp.)

"Use of Total Carbon Mass Balance to Define High Boiling Waste Formation" Stephen Jordan (E. I. du Pont de Nemours & Co., Inc.)

"Polaroid's Toxic Use and Waste Reduction Program" Harry Fatkin (Polaroid Corp.)

"Experiences Within Chemical Manufacturing Facility" Tim Hawes (Polaroid Corp.)

Appendix F

National Governors' Association Mass Balance Survey of State Governments

INTRODUCTION

In late 1988, the National Governors' Association (NGA) conducted a mass balance survey of state governments under a subcontract with the National Research Council (NRC). The survey was designed to provide information on state governments' actions and plans with respect to mass balance-oriented programs. The NGA survey asked about the characteristics of mass balance activities in states that had conducted or planned to conduct them, including the types of sites covered, the types of environmental releases or waste reduction activities covered, and levels of funding. The survey also solicited opinions on the value and affordability of mass balance activities.

The survey was sent to chief environmental protection officials in each of the 50 states; a total of 49 states responded. The questionnaire and a list of the survey respondents are presented at the end of this appendix.

STATUS OF MASS BALANCE ACTIVITIES

States were asked to describe their involvement in mass balance-oriented activities. The majority of respondents 37 indicated that they have reservations about the mass balance approach and that they either do not plan to conduct mass balance activities or they are undecided. The remaining respondents 12 reported either some experience with mass balance activities or plans to conduct them (see Table F-1).

The 12 states reporting some experience with or plans for mass balance were somewhat evenly divided among the first three response categories shown in Table F-1. Connecticut, New Jersey, Rhode Island, Vermont, and Virginia indicated they conduct regular mass balance activities. Delaware, Massachusetts, Ohio, and Utah reported plans for mass balance efforts. Maryland, Nebraska, and Wisconsin noted they have conducted or plan to conduct a one-time mass balance survey. Specific state information on mass balance activities is presented in Table F-2.

TABLE F-1 Summary of States Mass Balance Activities

Number of States	Response
5	**Conduct continuing mass balance activities**
4	**Plan continuing mass balance activities**
3	**Conduct or plan to conduct a one-time mass balance survey**
8	**Definitely do not plan mass balance activities**
29	**Undecided**

New Jersey's Department of Environmental Protection is the prime example of a state agency with a comprehensive mass balance program. Under the New Jersey Worker and Community Right-To-Know Act of 1983, the state compiles mass balance-related data from selected manufacturers. For each New Jersey facility producing or using hazardous substances beyond thresholds established under SARA, the following information is required:

- starting inventory, in pounds,
- quantity produced on site,
- quantity brought on site,
- quantity consumed on site, and
- quantity shipped off site.

These data are collected as a supplement to the Toxic Release Inventory (TRI) data reported by manufacturers affected by Section 313 of SARA. This collection program followed the New Jersey Industrial Survey discussed in Chapter 3.

Rhode Island's mass balance activity involves a more narrow focus compared to the approach taken by New Jersey. Its department of environmental management requires certain industries to complete air pollution inventory questionnaires. Particular air pollution inventory questions involve a mass balance orientation. For example, the questionnaire for "degreasers and dryers" requires industries to report, for certain volatile organic substances, the amount purchased, the amount removed for disposal or reclamation, and the quantity recovered in carbon absorbers. The amount purchased minus the amount removed or recovered is assumed to have entered the atmosphere through evaporation.

Rhode Island's use of a limited mass balance approach in air pollution matters is not atypical of other states with mass balance activities. Because actual measurements of emissions are often difficult, particularly where unconfined emission sources are involved, state air pollution agencies sometimes rely on emission estimates. In these cases, mass balance calculations are used as a way to estimate emissions. Connecticut, Vermont, and Virginia also use such an approach in their air pollution control programs.

Air, pollution control inspectors in the Connecticut Department of Environmental Protection commonly use mass balance calculations to estimate the quantities of solvents emitted into the atmosphere from industrial operations. The calculations are used to determine compliance with mass emission limits for the hydrocarbons that react in the atmosphere to form the pollutant ozone.

Vermont's Air Pollution Control Division currently uses mass balance techniques in its "State Emissions Inventory" for planning purposes and in case-specific permitting activities.

Certain permits issued by the Virginia Department of Air Pollution Control to construct and operate an air pollution source include requirements for demonstrating compliance with emission limitations by use of a mass balance-oriented calculation. Principal targets of such requirements are the same solvents that are of concern in Connecticut. Virginia also accepts mass balance information from applicants for air

TABLE F-2 Mass Balance Activities by State

Region/State	Activities	Region/State	Activities
NORTHEAST		SOUTH (cont.)	
Connecticut	Regular[a]	Georgia	None
Maine	None	Kentucky	None
Massachusetts	Planned[b]	Louisiana	None
New Hampshire	None	Maryland	One-time[f]
New Jersey	Regular[c]	Mississippi	None
New York	None[d]	North Carolina	None
Pennsylvania	None	Oklahoma	None
Rhode Island	Regular	South Carolina	None
Vermont	Regular	Tennessee	None
		Texas	None
		Virginia	Regular[a]
MIDWEST		West Virginia	None
Iowa	None		
Kansas	None	WEST	
Michigan	None	Alaska	None
Minnesota	None	Arizona	None
Missouri	None	California	None
Nebraska	One-time[a]	Colorado	None
North Dakota	None	Hawaii	None
Ohio	Planned	Idaho	None
South Dakota	None	Montana	None
Wisconsin	Planned	Nevada	None
		New Mexico	None
SOUTH		Oregon	None
Alabama	None	Utah	Planned
Arkansas	None	Washington	None
Delaware	Planned	Wyoming	None
Florida	None[e]		

[a] Respondents representing other environmental areas from this state reported no current activities or plans for collecting mass balance data.

[b] Regular program will be established if pending legislation is passed.

[c] Also conducted the New Jersey Industrial Survey discussed in Chapter 3.

[d] The response from the New York Department of Environmental Conservation referred to use of mass balance calculations in the Lake Ontario Toxics Management Plan. However, this effort will apparently be directed toward determining toxic inputs to the lake and outputs from it rather than toward inputs and outputs for individual water pollution sources affecting the lake. The use of mass balance calculations similar to those slated for Lake Ontario have long been a feature of water basin planning projects.

[e] Conducted as necessary.

[f] Due to a low rate of response to the initial survey, the questionnaire was redesigned and mailed a second time.

pollution source permits to indicate the expected level of solvent emissions. In addition, Virginia has a long-term survey effort under way to obtain detailed chemical-use information from 4,000 to 5,000 sources of toxic chemicals. Mass balance information is sought in this survey where it is believed to be available.

Delaware, Massachusetts, Ohio, and Utah plan to institute regular mass balance activities. Massachusetts will have a regular mass balance requirement as part of its source reduction program only if proposed state legislation passes in its current form.

Maryland, Nebraska, and Wisconsin indicated they have conducted or plan to conduct a one-time mass balance survey. In 1982 the Toxics Information Center in the Maryland Department of Environment sent a true mass balance questionnaire to 1,200 manufacturing sites. Data were requested on 274 carcinogens and other toxic chemicals. No more than 1 percent of the questionnaires was returned with complete data. A redesigned questionnaire that asked only for "annual throughput" data (i.e., amounts of chemicals routed through a facility) was mailed to the same manufacturers in 1985. In the second mailing information was sought on 227 carcinogens and 570 other toxic substances. The 1985 questionnaire had a response rate of 90 percent. Although the 1985 information compilation did not reflect a complete manufacturing-site input/output mass balance, the data received has been used by the Maryland agency to set priorities for regulatory actions. The Air Quality Division of the Nebraska Department of Environmental Control mentioned the use of mass balance calculations for release estimates for toxic materials. This mass balancing will be associated with Nebraska's annual Toxic Air Emissions Inventory.

STATE ASSESSMENTS OF MASS BALANCE DATA

States also were asked for their opinions on the value of mass balance data and about the cost of mass balance activities. The answers were approximately evenly distributed among the different response categories (Table F-3).

Value of Mass Balance Data

As shown in Table F-3, a majority of the states 24 indicated mass balance activities may provide valuable data. The next largest group 15 states expressed uncertainty about the value of mass balance compilation. Finally, a small but significant number 8 expressed a negative opinion of mass balance data. Information on how each state views mass balance data is presented in Table F-4.

States that found mass balance data to be unreliable or unproven seemed to have concluded that while the concept mass balance is theoretically sound, it is too complex to be applied successful. Georgia's respondent commented, "One can never realistically obtain all the information needed to do mass balances that are accurate enough to be worth anything." Michigan stated:

> To be a useful information tool, mass balance information must be collected on a facility-specific basis and must include all significant sources of release to the environment.... Aggregated information must be evaluated on an ecosystem basis rather than according to political or institutional boundaries. Such comprehensive data collection and evaluation may well be infeasible.

Minnesota provided the most specific comments on the complexity of measuring data for mass balance:

> It is difficult at best to measure the quantities of chemicals consumed or released at a site. For example, companies do not measure how much solvent is lost through volatilization. Similarly, industrial sites may or may not measure or accurately report quantities of released chemicals. Without good data for all components, there is not true mass balance. The most that could be hoped for would be to collect good data for all but one component—the one released—and derive that from a mass balance equation. However, the opportunity for significant inaccuracy in other measured components makes this of dubious value.

TABLE F-3 Summary of State Evaluations of Mass Balance Data[a]

Number of States	Response
6[b]	**Data are valuable and worth expending resources now.**
15[c]	**Data are of unproven merit.**
8	**Data are unreliable.**
18[d]	**Data may be valuable but budget limits prevent implementation.**

[a] This information was not available for Vermont's air pollution mass balance activities.

[b] In three of these states, respondents representing other environmental areas expressed an opinion indicated the data were unproven or unreliable.

[c] In one of these states, respondents representing other environmental areas indicated the data were unreliable.

[d] In one of these states, respondents representing other environmental areas indicated the data are unproven.

TABLE F-4 Opinions on the Value of Mass Balance Data by State

Data Potentially Valuable

Alabama
Alaska
Colorado
Connecticut[a]
Florida[a]
Hawaii
Idaho
Louisiana
Maine
Massachusetts
Mississippi
Missouri
Montana
Nebraska[a]
Nevada
New Jersey
New Mexico
North Carolina
Ohio
Oklahoma
Pennsylvania
Rhode Island
Tennessee
Utah
Virginia[a]

Data's Merit Unproven

Arkansas[b]
California
Delaware
Indiana
Maryland
Michigan
Minnesota
New York
Oregon
South Carolina
South Dakota
Washington
West Virginia
Wisconsin
Wyoming

Data Unreliable

Arizona
Georgia
Iowa
Kansas
Kentucky
New Hampshire
North Dakota
Texas

[a] Respondents representing other environmental areas within this state did not indicate the data was potentially valuable.

[b] Another respondent within this state found the data unreliable.

Not surprisingly, all of the programs conducting mass balance activities judged them to be valuable. New Jersey, the state with the most successful mass balance effort, also was the most enthusiastic: "We recommend that mass balance information be collected on a national scale." The Virginia State Air Pollution Control Board, while confident of the value of the mass balance approach, did have reservations:

> We believe that mass balances are useful over a long enough time period to determine overall efficiency of utilization of a particular compound, but you cannot always quantify where the material was lost. For example, solvents are lost in printing operations, but frequently, the loss occurs gradually from the printed material after the publication is shipped. Many air agency toxic regulations are based on twenty-four hour or shorter time periods. Mass balances can give you an indication of how much is lost to the atmosphere, but over a short time span, they may not be that accurate. Mass balances are a useful tool, however, in determining overall losses from a process.

Funding

Of the 24 states that viewed mass balance data as valuable, only six thought the technique worthy enough to expend current state resources. Four of these (Connecticut, New Jersey, Rhode Island, and Virginia) conduct regular mass balance activities. Ohio plans a mass balance effort. Florida uses mass balance data on an as-needed basis. Two states that indicated mass balance data would be valuable (Massachusetts and Utah) plan to establish mass balance activities, but are presently subject to budget limitations. (Delaware also plans to establish a program if resources permit, although it is not convinced mass balance data would be valuable.) This leaves 16 states that believe mass balance data to be valuable but cannot fund a program (Table F-5).

Several states that indicated a desire to institute or examine mass balance activities but cannot afford to do so called for additional funding. Missouri commented:

> . . . [the state is] unaware of any funding sources or other resources that are available to the states to assist in evaluating, establishing, or planning such a program. In the absence of such support, it is unlikely that states such as Missouri will be in a position to implement a mass balance program within the next five years.

South Carolina commented:

> This program has some merit and should have a useful application in an overall environmental protection strategy—but—our environmental protection programs are overworked and underfunded now. We have a hard time with just the basic programs and to put time and effort into mass balance at this time would not be possible. Unless some specific program funding (either state or federal) becomes available, it will be some time before we would be able to accomplish this task.

Tennessee was the most emphatic in its call for additional funding:

> It is unfortunate that the potential for mass-balance as a tool to describe environmental risk was not recognized fully by Congress. To pass a law and not adequately fund or provide for funding is a travesty of health protection.

Information on expected fiscal year 1989 expenditures for planning or conducting mass balance information compilation is presented in Table F-6. The amounts budgeted in states regular mass balance activities are small in relation to total agency expenditures. Even in New Jersey, with its relatively sophisticated approach, the expected annual budget for its mass balance program is no more than $100,000. In the states where mass balance budgets appear to be larger, they are usually associated with air pollution control activities.

For states planning regular mass balance activities, budgeted amounts range from $2,000 to $100,000. These states do not yet administer regular mass balance activities, and so these figures could refer to planning or start-up costs.

TABLE F-5 Funding for Mass Balance Activities by States Considering Mass Balance Data as Valuable

State	Funding
Alabama	None
Alaska	None
Colorado	None
Connecticut	Funded
Florida	Funded[a]
Hawaii	None
Idaho	None
Louisiana	None
Maine	None
Massachusetts	Funded[b]
Mississippi	None
Missouri	None
Montana	None
Nebraska	None
Nevada	None
New Jersey	Funded
New Mexico	None
North Carolina	None
Ohio	Funded
Oklahoma	None
Pennsylvania	None
Rhode Island	Funded
Tennessee	None
Utah	Funded[b]
Virginia	Funded

[a] Funded as necessary.

[b] Subject to budget limitations.

TABLE F-6 Fiscal Year 1989 Funding of Mass Balance Activities by States Administering or Planning to Administer Such Activities

State	Funding
Connecticut	$200,000[a]
Delaware	$35,000
Massachusetts	2,000
New Jersey	87,500[b]
Ohio	65,000
Rhode Island	260,000[a]
Utah	100,000
Virginia	275,000[a]

[a] Funds may include costs not related to mass balance activities.

[b] Represents the average of the $75,000 to $100,000 estimated by the state.

Delaware, Massachusetts, and Utah indicated that their plans for mass balance activities are constrained by budget limitations, and so their figures definitely do not reflect the costs associated with a functioning program.

SURVEY QUESTIONNAIRE NATIONAL GOVERNORS' ASSOCIATION "MASS BALANCE" SURVEY OF STATE GOVERNMENTS

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The National Research Council has requested the National Governors' Association to conduct this survey. Its purpose is to determine the extent to which state governments now use, or plan to use, a "mass balance" approach in compiling data on environmental releases of toxic, or other harmful, chemicals.

The term "mass balance" in the context of the survey means an accumulation of any or all of the following components: the quantities of chemicals transported to a site, produced at a site, consumed at a site, accumulated at a site, released at a site, and transported from a site as a waste or as a commercial product or byproduct or component of a commercial product or byproduct. Through equating site inputs and outputs, the mass balance approach seeks to determine if there are unaccounted for outputs that might represent previously unidentified waste quantities or releases of harmful chemicals. The National Research Council is currently evaluating whether any form of mass balance information would be helpful in assessing: 1) releases of toxic, or other harmful, chemicals across all environmental media (i.e., air, water, land) and 2) the waste reduction efficiencies of different sites.

Your answers should exclude data compilation activities (e.g., direct measurement of water pollution effluents, air pollution estimates based upon standard emission factors, etc.) that are not part of, or feature, a mass balance approach.

THERE ARE ONLY FIVE QUESTIONS IN ALL.

NATIONAL GOVERNORS' ASSOCIATION "MASS BALANCE" SURVEY OF STATE GOVERNMENTS

NAME OF RESPONDENT:
TITLE:
AGENCY:
UNIT (DIVISION, BRANCH, ETC.):
TELEPHONE NUMBER:

1. Section 313 (1)(3) of the Superfund Amendments and Reauthorization Act of 1986 (SARA) requires the federal EPA to "...acquire available mass balance information from States which currently conduct (or during the 5 years after the date of enactment of this title initiate) a mass balance-oriented annual quantity toxic chemical release program.... "Please check the box below which describes the activities of your agency with regard to such a "mass balance-oriented" annual program.

___ A. Have established an annual (or some other regular period) program to compile mass balance-oriented information on: 1) toxic, or other harmful, chemical releases, and/or 2) waste-reduction efficiencies.

___ B. Plan to establish a regularly scheduled mass balance-oriented information compilation program for harmful chemicals during the next 5 years.

___ C. Have established, or plan, a "one-time" mass balance-oriented survey related to harmful chemicals, but have no plans for a regularly scheduled program.

___ D. Definitely do not plan to establish a mass balance-oriented information compilation during the next 5 years.

___ E. Undecided about plans for a regularly scheduled mass balance-oriented data compilation effort related to harmful chemicals.

___ F. Other (e.g., plan a mass balance-oriented program for reasons other than to compile data on harmful chemical releases, etc.).

Explain:

___ G. Unfamiliar with term "mass balance."

2. Please check the statement below which comes closest to reflecting your basic opinion about the value to your agency of mass balance-oriented information compilations on harmful chemical releases.

NATIONAL GOVERNORS' ASSOCIATION "MASS BALANCE" SURVEY OF STATE GOVERNMENTS

Question 2 continued:

___ A. Mass balance-oriented information compilations can be expected to provide valuable data to complement information from other sources, and are worth expending agency resources at this time to establish, or plan them on a regular basis.

___ B. Mass balance compilations may provide valuable data for selected companies or institutions, but are of unproven merit for a broad population of sites and this uncertainty makes such compilations a low agency priority.

___ C. Mass balance compilations, for the foreseeable future, will not provide reliable information on harmful chemical releases because precise mass balance measurement or estimation methods do not exist for a large fraction of the industrial and institutional sites of interest.

___ D. Mass balance-oriented information compilations will provide valuable data, but budget limitations prevent my agency from establishing or planning such programs.

___ E. Other. Please specify:

___ F. No opinion.

IF YOU MARKED BOX "D" (DEFINITELY DO NOT PLAN) or "G" (UNFAMILIAR) IN ANSWER TO QUESTION #1, YOU NEED NOT ANSWER ANY MORE QUESTIONS. PLEASE RETURN THE FORM IN THE ENCLOSED ENVELOPE. IF YOU MARKED BOX "A", "B", "C", "E", OR "F" FOR QUESTION #1, PLEASE ANSWER QUESTIONS #3, #4, AND #5 BEFORE RETURNING THE FORM.

3. If you have established, plan, or might plan a mass balance-oriented data compilation activity, please indicate the types of sites that are involved, or most likely to be covered.

___ A. All private and public: 1) sources of toxic, or other harmful, chemical releases, and/or 2) waste generation sources.

___ B. All private sector sources of harmful chemical releases, and/or waste generation sources, but not public sources.

___ C. Only those manufacturing facilities now covered by the Toxic Release Inventory (TRI) requirements of Section 313 of SARA.

___ D. Other. Please specify:

___ E. Undecided.

NATIONAL GOVERNORS' ASSOCIATION "MASS BALANCE" SURVEY OF STATE GOVERNMENTS

4. If you have established, plan, or might plan a mass balance-oriented data compilation program, please indicate the types of environmental releases or waste reduction efficiencies that are covered, or are likely to be covered.

___ A. All environmental releases or waste reduction efficiencies of selected harmful chemicals, such as those on the TRI list or a comparable list.

___ B. All environmental releases of all polluting materials.

___ C. Releases of selected harmful chemicals to one environmental medium or a combination of media (e.g., to the atmosphere, to surface waters and groundwater, etc.) but not to all media.

___ D. Releases of all polluting materials to one medium or a combination of media, but not to all environmental media.

___ E. Other. Please specify:

___ F. Undecided.

5. What amount of agency funding, if any, is expected to be expended for planning and/or conducting a mass balance-oriented information compilation program in fiscal year 1989?

$_____

◇◇◇◇◇◇◇◇◇◇◇◇◇◇◇

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R. Lewis Shaw
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Department of Health and Environmental
Control
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SOUTH DAKOTA
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Quality Program
Department of Water and Natural Resources
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TENNESSEE
Wayne E. Cantrell
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Epidemiology
Department of Health and Environment
100 Ninth Avenue North
Nashville, Tennessee 37219-5405
(615) 741-5683
TEXAS
Bobby D. Whitefield, Chief, Information and
Technical Services, Hazardous and Solid
Waste Division/(512) 463-7780
Clyde E. Bohmfalk, Director, Water Quality
Division/(512) 463-8412
Texas Water Commission
1700 North Congress Avenue
Austin, Texas 78711-3087
James C. Myers, Director, Enforcement
Texas Air Control Board
6330 Highway 290 East
Austin, Texas 78723
(512) 451-5711
UTAH
Neil Taylor
Title III Manager
Department of Health
3266 State Office Building
Salt Lake City, Utah 84114
(801) 538-6121
VERMONT
John C. Miller
Hazardous Materials Specialist
Department of Environmental Conservation
103 South Main Street, West Building
Waterbury, Vermont 05676
(802) 244-8702
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Director, Office of Policy and Planning
Department of Waste Management
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Richard L. Cook, Executive Director
State Air Pollution Control Board
P.O. Box 10089
Richmond, Virginia 23240
(804) 225-3634
Bernard J. Caton
Deputy Executive Director
State Water Control Board
P.O. Box 11143
Richmond, Virginia 23230-1143
(804) 367-0120
WASHINGTON
Christine O. Gregoire, Director
Department of Ecology
Mail Stop PV-11
Olympia, Washington 98504-8711
(206) 459-6000
WEST VIRGINIA
Robert L. Jelacic
Assistant Chief, Hazardous Waste
Management
Department of Natural Resources
1260 Greenbrier Street
Charleston, West Virginia 25311
(304) 348-5935

WISCONSIN
Russ Dunst, Toxics Coordinator
Office of Technical Services
Department of Natural Resources
P.O. Box 7921
Madison, Wisconsin
(608) 266-9255
WYOMING
Randolph Wood, Director
Department of Environmental Quality
122 W. 25th Street
Cheyenne, Wyoming 82002
(307) 777-7938

Appendix G

New Jersey Industrial Survey[*]

List of Selected Substances (Table 1)
Selected Substance Report Questionnaire and Instructions

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[*] SOURCE: NJDEP, 1986.

Form COM-021 C
Rev. 2/80

TABLE 1
SELECTED SUBSTANCES

New Jersey Department of Environmental Protection

Let's protect our earth

All chemical compounds and/or complexes containing a selected substance (including organic, inorganic and organo-metallics) are to be reported under the given CAS code Number and identified on the survey form.

CAS NO.	HALOGENATED ALKANES AND ALKENES
107-05-1	Allyl chloride (1-Chloro-2-propene)
75-25-2	Bromoform (Tribromomethane)
56-23-5	Carbon tetrachloride
67-66-3	Chloroform
126-99-8	Chloroprene (2-Chloro-1, 3-butadiene)
106-93-4	1,2-Dibromoethane (Ethylene dibromide)
75-27-4	Dichlorobromomethane
107-06-2	1,2-Dichloroethane (Ethylene dichloride)
540-59-0	1,2-Dichloroethylene
78-87-5	1,2-Dichloropropane
542-75-6	1,3-Dichloropropylene
87-68-3	Hexachlorobutadiene
77-47-4	Hexachlorocyclopentadiene
67-72-1	Hexachloroethane
74-83-9	Methyl bromide
74-87-3	Methyl chloride
75-09-2	Methylene chloride (Dichloromethane)
79-34-5	1,1,2,2-Tetrachloroethane
127-18-4	Tetrachloroethylene (Perchloroethylene)
71-55-6	1,1,1-Trichloroethane (Methyl chloroform)
79-00-5	1,1,2-Trichloroethane
79-01-6	Trichloroethylene
75-69-4	Trichlorfluoromethane
593-60-2	Vinyl Bromide
75-01-4	Vinyl chloride
75-35-4	Vinylidene chloride (1,1-Dichloroethylene)

CAS NO.	PHENOLS
95-57-8	2-Chlorophenol
120-83-2	2,4-Dichlorophenol (DCP)
105-67-9	2,4-Dimethylphenol (m-xylenol)
534-52-1	4,6-Dinitro-o-cresol
51-28-5	2,4-dinitrophenol
88-75-5	2-Nitrophenol
100-02-7	4-Nitrophenol
87-86-5 +	Pentachlorophenol (PCP)
108-95-2	Phenol
·95-95-4	2,4,5-Trichlorophenol
88-06-2	2,4,6-Trichlorophenol

CAS NO.	HALOGENATED AROMATICS
108-90-7	Chlorobenzene
91-58-7	2-Chloronaphthalene
·1163-19-5	Decabromodiphenyl oxide
95-50-1	1,2-Dichlorobenzene
541-73-1	1,3-Dichlorobenzene
106-46-7	1,4-Dichlorobenzene
118-74-1	Hexachlorobenzene
13654-09-6	Polybrominated biphenyls (PBBs)
11097-69-1	Polychlorinated biphenyls (PCBs)
·1264-23-8	Polychlorinated Triphenyls (PCTs)
120-82-1	1,2,4-Trichlorobenzene

CAS NO.	PHTHALATES
117-81-7	Bis (2-ethylhexyl) phthalate
85-68-7	Butyl benzyl phthalate
84-74-2	Di-n-butyl phthalate
84-66-2	Diethyl phthalate
117-84-0	Di-n-octyl phthalate
131-11-3	Dimethyl phthalate

CAS NO.	ETHERS, EPOXIDES, ALDEHYDES AND ANHYDRIDES
107-02-8	Acrolein
111-44-4	Bis (2-chloroethyl) ethe·
542-88-1	Bis (2-chloromethyl) e.
1462-53-5	Diepoxybutane
123-91-1	Dioxane
106-89-8	Epichlorohydrin (1-chloro-2,3-epoxypropane)
50-00-0	Formaldehyde
108-31-6	Maleic anhydride
57-57-8	β-Propiolactone
75-56-9	Propylene oxide

CAS NO.	IMINES, NITRILES AND HYDRAZINES
107-13-1	Acrylonitrile
57-14-7	1,1-Dimethyl hydrazine
151-56-4	Ethyleneimine (Aziridine)
302-01-2	Hydrazine
75-55-8	Propyleneimine

CAS NO.	NITROSO COMPOUNDS
55-18-5	N-Nitrosodiethylamine
62-75-9	N-Nitrosodimethylamine
138-89-6	p-Nitrosodimethylaniline
86-30-6	N-Nitrosodiphenylamine
156-10-5	p-Nitrosodiphenylamine

CAS NO.	AMIDES AND AMINO COMPOUNDS
60-35-5	Acetamide
62-53-3	Aniline (and salts)
117-79-3	2-Aminoanthraquinone
60-09-3	p-Aminoazobenzene
·55-21-0	Benzamide
92-87-5	Benzidine
95-80-7	2,4-Diaminotoluene
91-94-1	3,3'-Dichlorobenzidine
101-14-4	4,4'-Methylene bis (2-chloroaniline) (MOCA)
134-32-7	α-Napthylamine
91-59-8	β-Napthylamine

CAS NO.	PESTICIDES
309-00-2	Aldrin
58-89-9	BHCs &Lindane
133-06-2	Captan
63-25-2	Carbaryl (1-Naphthalenol Methyl Carbamate)
133-90-4	Cloramben
57-74-9	Chlordane
510-15-6	Chlorobenzilate
74-75-7	2,4-D
50-29-3	DDT
96-12-8	1,2-Dibromo-3-chloropropane (DBCP)
60-57-1	Dieldrin
115-29-7	Endosulfan
72-20-8	Endrin
76-44-8	Heptachlor
115-32-2	Kelthane (Dicofol)
143-50-0	Kepone
·72-43-5	Methoxychlor
2385-85-5	Mirex
56-38-2	Parathion
87-86-5	Pentachlorophenol
82-68-8	Quintozene (PCNB) (Pentachloronitrobenzene)
61789-48-2	Strobane (Terpene polychlorinates)
93-76-5	2,4,5-T (2,4,5-(Trichlorophenoxy) acetic acid)
8001-35-2	Toxaphene

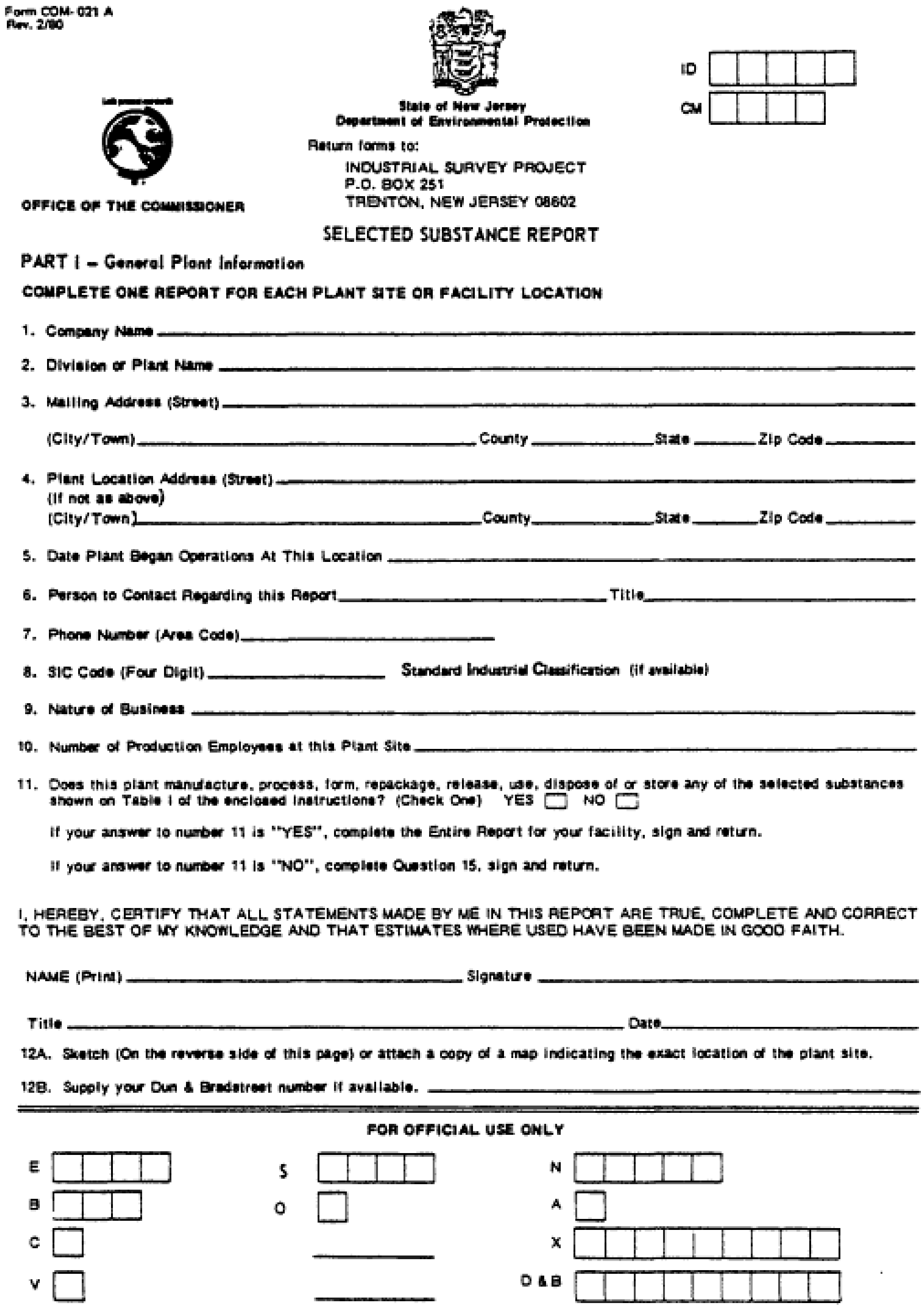
CAS NO.	AROMATIC HYDROCARBONS
120-12-7	Anthracene
71-43-2	Benzene
92-52-4	Biphenyl
100-41-4	Ethyl benzene
91-20-3	Napthalene
108-88-3	Toluene

CAS NO.	INORGANICS (Include Salts of these Elements)
7440-36-0	Antimony
7440-38-2	Arsenic
7440-41-7	Beryllium
7440-43-9	Cadmium
156-62-7	Calcium cyanamide
7440-47-3	Chromium
7440-50-8	Copper
57-12-5	Cyanide
7439-92-1	Lead
7439-97-6	Mercury
7440-02-0	Nickel
7782-49-2	Selenium
7440-22-4	Silver
7440-28-0	Thallium
7440-66-6	Zinc

CAS NO.	NITRO COMPOUNDS
121-14-2	2,4-Dinitrotoluene
606-20-2	2,6-Dinitrotoluene
98-95-3	Nitrobenzene
79-46-9	2-Nitropropane

CAS NO.	DYES
2650-18-2	Brilliant Blue FCF salts
129-17-9	(Sodium) Blue VRS
60-11-7	C.I. Solvent Yellow 2
6358-53-8	Citrus Red No. 2
128-66-5	C.I.Vat Yellow 4
1937-37-7	Direct Black 38
2602-46-2	Direct Blue 6
10300-74-0	Direct Brown 95
2832-40-8	C.I. Disperse Yellow 3
569-64-2	Fast Green 0
4680-78-8	Guinea Green B
5141-20-8	Light Green SF
2646-17-5	Oil Orange SS
3761-53-3	Ponceau MX
3564-09-8	Ponceau 3R
81-88-9	Rhodamine B
989-38-8	Rhodamine 6G
842-07-6	Sudan I
3118-97-6	Sudan II

CAS NO.	MISC.
1332-21-4	Asbestos
62-56-6	Thiourea
·75-44-5	Phosgene



Form COM-021 A
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ID ☐☐☐☐☐
CM ☐☐☐☐

State of New Jersey
Department of Environmental Protection

OFFICE OF THE COMMISSIONER

Return forms to:

INDUSTRIAL SURVEY PROJECT
P.O. BOX 251
TRENTON, NEW JERSEY 08602

SELECTED SUBSTANCE REPORT

PART I – General Plant Information

COMPLETE ONE REPORT FOR EACH PLANT SITE OR FACILITY LOCATION

1. Company Name ____________________
2. Division or Plant Name ____________________
3. Mailing Address (Street) ____________________
(City/Town) __________ County __________ State ______ Zip Code ______
4. Plant Location Address (Street) ____________________
(If not as above)
(City/Town) __________ County __________ State ______ Zip Code ______
5. Date Plant Began Operations At This Location ____________________
6. Person to Contact Regarding this Report __________ Title __________
7. Phone Number (Area Code) __________
8. SIC Code (Four Digit) __________ Standard Industrial Classification (if available)
9. Nature of Business ____________________
10. Number of Production Employees at this Plant Site ____________________
11. Does this plant manufacture, process, form, repackage, release, use, dispose of or store any of the selected substances shown on Table I of the enclosed instructions? (Check One) YES ☐ NO ☐

If your answer to number 11 is "YES", complete the Entire Report for your facility, sign and return.

If your answer to number 11 is "NO", complete Question 15, sign and return.

I, HEREBY, CERTIFY THAT ALL STATEMENTS MADE BY ME IN THIS REPORT ARE TRUE, COMPLETE AND CORRECT TO THE BEST OF MY KNOWLEDGE AND THAT ESTIMATES WHERE USED HAVE BEEN MADE IN GOOD FAITH.

NAME (Print) ____________________ Signature ____________________

Title ____________________ Date __________

12A. Sketch (On the reverse side of this page) or attach a copy of a map indicating the exact location of the plant site.

12B. Supply your Dun & Bradstreet number if available. ____________________

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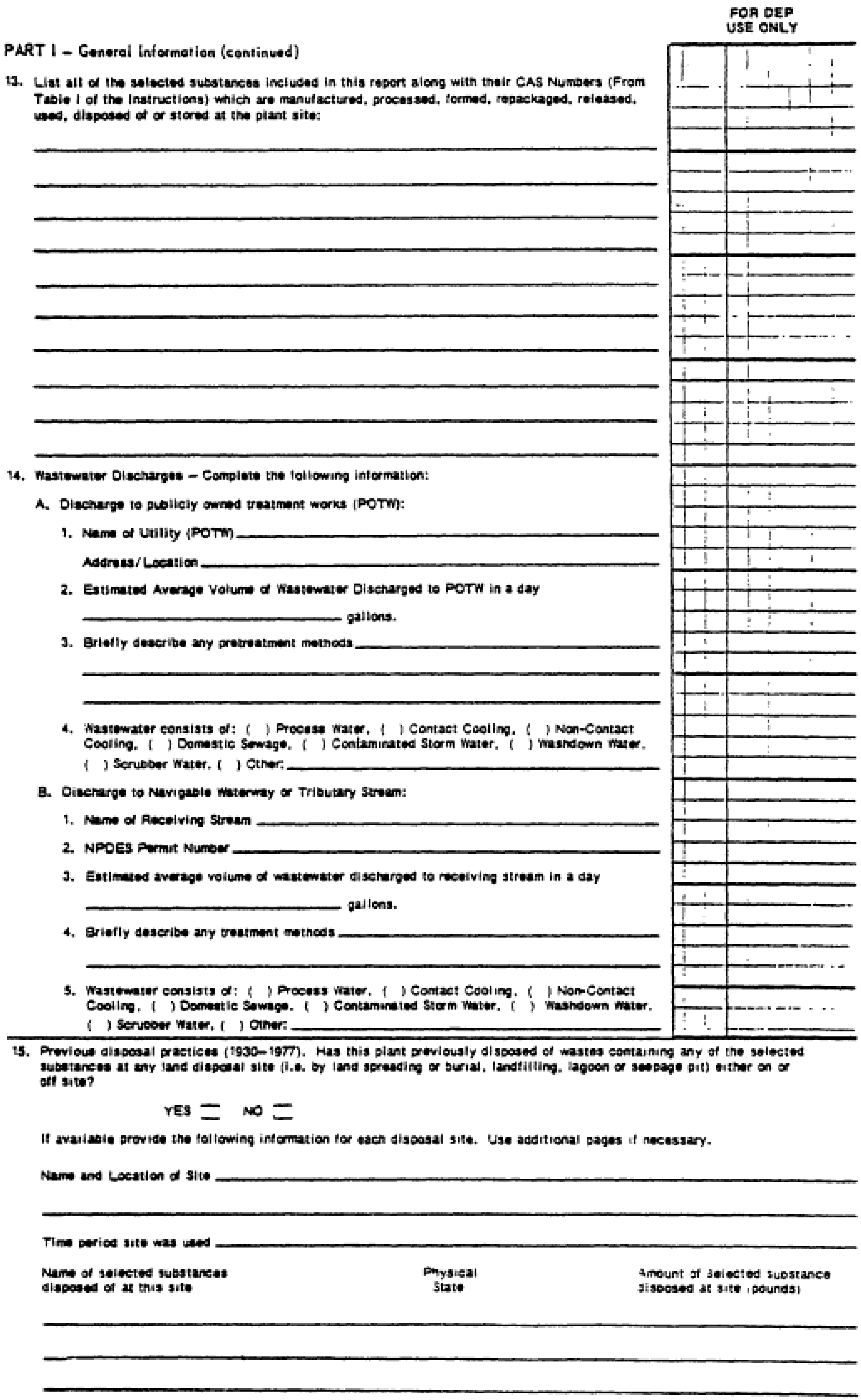


FOR DEP USE ONLY

PART I – General Information (continued)

13. List all of the selected substances included in this report along with their CAS Numbers (From Table I of the Instructions) which are manufactured, processed, formed, repackaged, released, used, disposed of or stored at the plant site:

14. Wastewater Discharges – Complete the following information:

A. Discharge to publicly owned treatment works (POTW):

1. Name of Utility (POTW) ____

Address/Location ____

2. Estimated Average Volume of Wastewater Discharged to POTW in a day ____ gallons.

3. Briefly describe any pretreatment methods ____

4. Wastewater consists of: ( ) Process Water, ( ) Contact Cooling, ( ) Non-Contact Cooling, ( ) Domestic Sewage, ( ) Contaminated Storm Water, ( ) Washdown Water, ( ) Scrubber Water, ( ) Other: ____

B. Discharge to Navigable Waterway or Tributary Stream:

1. Name of Receiving Stream ____

2. NPDES Permit Number ____

3. Estimated average volume of wastewater discharged to receiving stream in a day ____ gallons.

4. Briefly describe any treatment methods ____

5. Wastewater consists of: ( ) Process Water, ( ) Contact Cooling, ( ) Non-Contact Cooling, ( ) Domestic Sewage, ( ) Contaminated Storm Water, ( ) Washdown Water, ( ) Scrubber Water, ( ) Other: ____

15. Previous disposal practices (1930–1977). Has this plant previously disposed of wastes containing any of the selected substances at any land disposal site (i.e. by land spreading or burial, landfilling, lagoon or seepage pit) either on or off site?

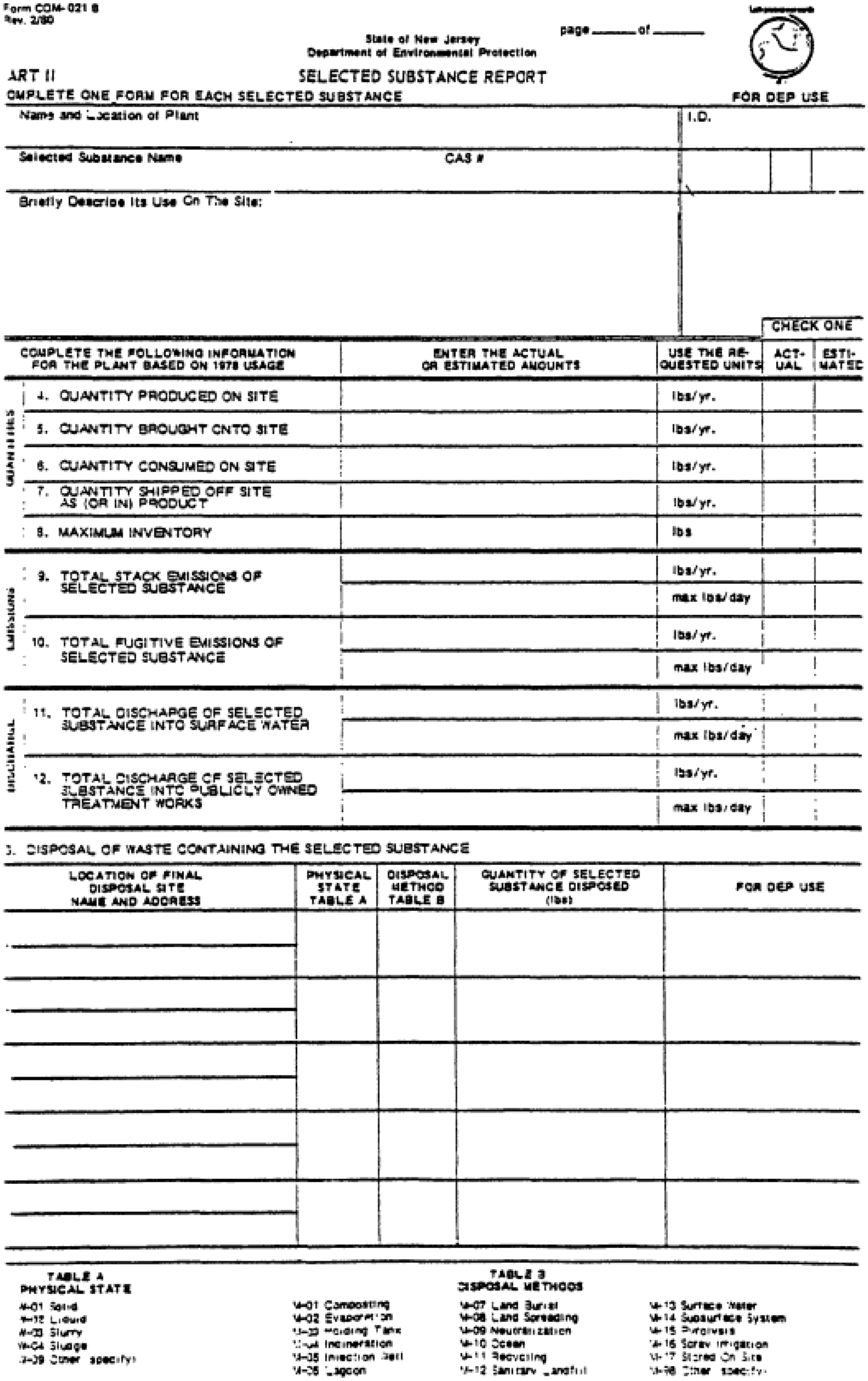
YES ☐ NO ☐

If available provide the following information for each disposal site. Use additional pages if necessary.

Name and Location of Site ____

Time period site was used ____

Name of selected substances disposed of at this site	Physical State	Amount of Selected substance disposed at site (pounds)



Form COM-021 B
Rev. 2/80

page ______ of ______

State of New Jersey
Department of Environmental Protection

ART II

SELECTED SUBSTANCE REPORT

OMPLETE ONE FORM FOR EACH SELECTED SUBSTANCE

FOR DEP USE

Name and Location of Plant	I.D.
Selected Substance Name CAS #	
Briefly Describe Its Use On The Site:	

	COMPLETE THE FOLLOWING INFORMATION FOR THE PLANT BASED ON 1978 USAGE	ENTER THE ACTUAL OR ESTIMATED AMOUNTS	USE THE REQUESTED UNITS	CHECK ONE ACTUAL	 ESTIMATED
QUANTITIES	4. QUANTITY PRODUCED ON SITE		lbs/yr.		
	5. QUANTITY BROUGHT ONTO SITE		lbs/yr.		
	6. QUANTITY CONSUMED ON SITE		lbs/yr.		
	7. QUANTITY SHIPPED OFF SITE AS (OR IN) PRODUCT		lbs/yr.		
	8. MAXIMUM INVENTORY		lbs		
EMISSIONS	9. TOTAL STACK EMISSIONS OF SELECTED SUBSTANCE		lbs/yr.		
			max lbs/day		
	10. TOTAL FUGITIVE EMISSIONS OF SELECTED SUBSTANCE		lbs/yr.		
			max lbs/day		
DISCHARGE	11. TOTAL DISCHARGE OF SELECTED SUBSTANCE INTO SURFACE WATER		lbs/yr.		
			max lbs/day		
	12. TOTAL DISCHARGE OF SELECTED SUBSTANCE INTO PUBLICLY OWNED TREATMENT WORKS		lbs/yr.		
			max lbs/day		

3. DISPOSAL OF WASTE CONTAINING THE SELECTED SUBSTANCE

LOCATION OF FINAL DISPOSAL SITE NAME AND ADDRESS	PHYSICAL STATE TABLE A	DISPOSAL METHOD TABLE B	QUANTITY OF SELECTED SUBSTANCE DISPOSED (lbs)	FOR DEP USE

TABLE A
PHYSICAL STATE

W-01 Solid
W-02 Liquid
W-03 Slurry
W-04 Sludge
W-09 Other (specify)

TABLE B
DISPOSAL METHODS

M-01 Composting
M-02 Evaporation
M-03 Holding Tank
M-04 Incineration
M-05 Injection Well
M-06 Lagoon
M-07 Land Burial
M-08 Land Spreading
M-09 Neutralization
M-10 Ocean
M-11 Recycling
M-12 Sanitary Landfill
M-13 Surface Water
M-14 Subsurface System
M-15 Pyrolysis
M-16 Spray Irrigation
M-17 Stored On Site
M-98 Other (specify)

State of New Jersey

DEPARTMENT OF ENVIRONMENTAL PROTECTION
OFFICE OF CANCER AND TOXIC SUBSTANCES RESEARCH CN-402 TRENTON. N.J.08625
THOMAS BURKE,M.P.H.
DIRECTOR

INDUSTRIAL SURVEY PROJECT INSTRUCTIONS

I. General Information

The Industrial Survey Project is part of an effort by the Department of Environmental Protection (DEP) to assemble a computerized data base on the uses and release into the environment of about 155 carcinogenic and toxic chemicals. The enclosed questionnaire forms, entitled "Selected Substance Report", will be mailed to approximately fifteen thousand industrial establishments in the State of New Jersey over a year's time. When returned to the Department, the information contained on them will be coded for entry and stored in a computer system. The data will then be correlated with other information, such as death and disease statistics, to try to identify areas of the state and population groups who may be subjected to an increased risk of disease due to chemical exposure.

The Industrial Survey Project is being conducted by DEP's Toxic Substances Program. If you have questions about the survey or the questionnaire forms, or if you need additional information, you may contact:

Industrial Survey Project
1474 Prospect Street
CN 405
Trenton, New Jersey 08625
Tel. (609) 292-1520

Participation in the Industrial Survey is mandatory. Willful failure to return a completed Selected Substance Report may result in legal action against your firm. You will be notified by letter before any legal action is brought, however, and given adequate time to submit the report if it has been lost or delayed for any legitimate reason.

Regulations governing the Industrial Survey Project have been adopted and codified as Chapter IF of Title 7 of the New Jersey Administrative Code (N.J.A.C. 7:1F-1.1 et. seq.). These regulations describe the project in somewhat greater detail, provide for the protection of confidential information submitted by survey respondents, and set penalties for persons who fail to return questionnaires or who make unauthorized disclosures of confidential information. You may obtain copies of the regulations by contacting the Industrial Survey Project at the above address.

II. Confidential Business Information

If any question on the Selected Substance Report requires you to submit information which is (or would lead a knowledgeable reader to deduce from it) a trade secret, proprietary business information or information related to national security, you may make a confidentiality claim. DEP will then treat that information as confidential and not disclose it in any form that would reveal the secret or proprietary information, unless the Department makes a formal finding that the material is not entitled to confidential treatment under the regulations. Unless an emergency (such as a fire in your plant which threatens to exposre nearby resident's to toxic materials) calls for the immediate release of information, you will be notified in advance if the Department intends to disclose information that you have claimed as confidential. You will be given an opportunity to challenge the Department's decision through administrative processes, and if not satisfied with the outcome, you will be given time (except in an emergency situation) to obtain a restraining order from a court, if you wish to pursue am appeal.

<u>To make a confidentiality claim for information contained in the Selected Substance Report you must do the following</u>:

1. Submit two copies of the report. The first must contain all the information requested. The second contain <u>no</u> information which you believe entitled to confidential treatment. (The second copy can be a photocopy of the first with the confidential material blaced or whited out).
2. Mark the top of each page containing confidential information with the heading "CONFIDENTIAL" in bold type, stamp or hand lettering. <u>Do not</u> mark every page-only the ones that contain confidential information.
3. Identify all information which you claim to be confidential by underlining or highlighting it in a clear manner. Translucent in markers are accetable for this purpose. Example: Question 6. Quantity Consumed On Site-140,500 lbs/yr.
4. Seal the copy of the report which contains confidential information into an envelope, and mark the envelope on both sides with the work "CONFIDENTIAL" in bold type, stamp or hand lettering. Place this envelope, together with the second (non-confidential) copy of the report, inside another envelope for transmittal to the Industrial Survey Project.

5. Send the complete package to the Industrial Survey Project at the address listed in Part III, Instruction C, below. For your own protection, we recommend the use of certified mail, return receipt requested, a messenger service, personal delivery, or some other means that will give you verification that the Project has received your material. You may use ordinary mail, but the Project assumes no responsiblity for materials not signed for until they are actually received in the project office.

Please give careful consideration to what material you claim as confidential. Be sure it really is proprietary or a trade secret. Do not mark a report "Entire Contents Confidential" or in some similar fashion. Doing so will result in the Project refusing to recognize any confidentiality claim, or in our sending it back to you to be revised. You should also be aware that under State and federal laws, emissions of toxic materials into the environment are not entitled to be kept confidential.

III. Instructions For Completing The Selected Substance Report

General Instructions

A. The data requested are to be supplied as they pertain to the selected substances of concern to the Department of Environmental Protection listed in Table 1 (attached). If your plant does not manufacture, process, form, repackage, release, use, dispose or store any of the selected substances, either as a pure substance or as part of a mixture; and has not disposed of selected substances by landfilling, lagooning, underground injection or other subsurface methods in past years since 1930, only Items 1 through 10 of Part I need be completed.

B. If you have more than one plant location, a separate complete report must be filed for each location. However, you will receive a separate survey package for each plant location on file with the State.

C. The report forms are to be completed and returned within 90 days addressed to:

INDUSTRIAL SURVEY PROJECT
CN 405
TRENTON, NEW JERSEY 08625

Be sure to address the envelope exactly as shown in the box above. Do not add references to "Department of Environmental Protection" or "State of New Jersey" as this may cause misrouting of mail.

If you use a messenger service or deliver the forms in person, return them to:

1474 Prospect Street
Trenton, New Jersey
ATTN: Edward Stevenson or Cindie Scott

NOTE: The 90 day deadline may be extended by the Project for additional periods, not to exceed 90 days each, for good cause shown by the respondent.

D. All information is to be based on calendar year 1981, if possible. If information of 1981 is not readily available, contact the Industrial Survey Project (609-292-1520) for further instructions.

E. Please give your answer in terms of the units specified in the forms (i.e., pounds per year, maximum pounds per day, gallons per day, etc.). Leave boxes marked "DEP use only" blank.

F. Complete all sections of the report that pertain to your firm or plant site. If a section does not apply to your operations, write in "NA" for "not applicable".

G. Please attach process descriptions, explanatory notes, flow charts, lists, etc., that will assist in clarifying entries made on the report if you feel the answers require further explanation. If information needed to complete a section is not readily available, provide a written explanation describing the nature of the operations involved and the reasons for not supplying the data.

H. It is intended that you use existing or readily ascertainable data to complete the Selected Substance Report. Where quantities can be determined from existing records (e.g. inventory or production figures) or the cost of testing is nominal, actual figures are to be supplied. Otherwise, estimates may be given. You may use engineering estimates and computations; process material balance studies; field tests or measurements made by the plant, equipment manufacturers or government agencies, or other technically sound bases.

I. If you do not know the formulation of trade name chemicals you use in your plant operations, you should make reasonable inquiries of your supplier or the manufacturer to ascertain whether the material contains any selected substances. (For example, Tri-Clene a solvent, is a trade name for trichloroethylene, a selected substance).

J. Exempt from this report are quantities of selected substances which are manufactured, used, formed or processed for purposes of scientific experimentation, analysis or chemical research (including research or analysis for product development), provided such quantities of each substance are less than 1,000 pounds in a one-year period.

Also exempted are quantities of selected substances which are present as impurities, without regard to the purpose for which the material in which such impurities are contained is produced, provided the concentration of selected substance present as impurity is less than 1% and the total amount of selected substance present as impurity is less than 1,000 pounds in a one-year period.

Example: You produce 100,000 pounds per year of xylene in which benzene is present as an impurity at a concentration of .65 percent. You do not have to report the presence of benzene since it is present in a concentration less than 1% and annual production is only 650 pounds.

Example: You produce 50,000 pounds per year of xylene in which benzene is present as an impurity at a concentration of 1.3 percent. You must report the presence of benzene because the concentration is greater than 1%, even though annual production is only 650 pounds.

Example:You produce 1,000,000 pounds per year of xylene in which benzene is present as an impurity at a concentration of .5 percent. You must report the presence of benzene, *even* though its concentration is less than 1%, because annual production is 5,000 pounds.

In the case of the third example (involving a concentration less than 1%) you would not be required to report the presence of the impurity unless you know or have reason to know of its presence. See paragraph H.

Specific Instructions

The Selected Substance Report is divided into two parts. Part I consists of 15 questions about the plant site, its operations and its use of selected substances. Part II consists of separate sheets, each of which is to be filled out with information about only one selected substance. Three copies of the form for Part II have been sent to you; if you need extra ones, you may make photocopies or request additional forms from the Project.

The questions in Part I should be self-explantory. Refer to the following for guidance in completing Part II.

QUESTION 1-enter the plant name and location

QUESTION 2-enter the name of the selected substance and the corresponding CAS number, as listed in Table 1.

QUESTION 3-"use" refers to any use made of the selected substance at your plant site. It includes synthesis, whether the substance is incorporated into a finished product or produced only as an intermediate; use as raw material, where the substance is chemically changed or incorporated into another; mixing, blending, repackaging or transshipment; use as supplementary fuel or for cleaning, and anything else. If the substance is used for more than one purpose at your plant site, list all uses.

Example: vinyl chloride (monomer) is used in the production of polyvinyl chloride resin.

Example: 1,1,1 trichloroethane is used as a parts degreaser.

THROUGH-PUT QUANTITIES (Questions 4-8): These questions seek specific information about the quantities of selected substances used in your production or processing operations. The figures you supply in your answers to the questions will not necessarily give rise to a material balance. Some substances may be counted in more than one category. The Project is aware of this, and it has been taken into account in the design of the computer programs that will analyze the survey responses.

QUESTION 4-Quantity Producted on Site: this refers to quantities of the substance synthesized in your plant production processes. It includes isolated intermediates (those drawn off and stored for later use in the production process), but not transient intermediates (i.e., substances formed in the production process as intermediates (i.e., substances formed in the production process as an intermediate step but immediately transformed into something else). Also included are by products and quantities generated as impurities or waste.

QUESTION 5-Quantity Brought onto Site: This refers to quantities of the substance brought into your plant from suppliers off-site, including other plants or divisions of your own firm. Include all quantities shipped onto the site, whether they are to be used as raw materials, cleaning materials, or simply repackaged for reshipment.

QUESTION 6-Quantity Consumed on Site: In some cases a selected substance is consumed in a chemical reaction either through incorporation into the molecular structure of the product or by combining with a reactant or solvent to alter its structure and thus lose its identity.

Example: You make nitrobenzene by reacting benzene and nitric acid. Benzene is "consumed" in the production process because it undergoes chemical change and ceases to exist as benzene.

On the other hand, quantities of selected substance which are used in plant processes but not chemically transformed should not be listed as "consumed".

Example: You use trichloroethylene (TCE) as a de-greasing agent for cleaning metal. Some of the chemical evaporates in the process, and the rest becomes too contaminated for reuse. The quantities should be recorded under "Air Emissions" and "Waste Disposal", not under "Quantity Consumed".

QUESTION 7-Quantity Shipped Off-site As (or In) Product: The information sought here is the amount of selected substance that leaves your plant site in product form-that is, in a form suitable for final use or for further processing leading to eventual final use. This includes materials shipped to other plants or divisions of your own firm. It does not, however, include wastes; these should be recorded in the "Waste Disposal" section. Enter only the quantity of <u>selected</u> substance shipped off-site, <u>not</u> the quantity of product in which it is contained.

Example: You ship to customers 100,000 pounds per year of a mixture containing 10% by weight of isophorene, that is, 10,000 pounds of isophorene. Your answer to Question 7 should be 10,000 pounds, not 100,000.

QUESTION 8-Maximum Inventory: In this question we are attempting to gain an idea of the quantities of selected substance stored on your site at a given moment in time. Since computing an average daily storage quantity would require averaging your daily inventory records over an entire year, to simplify your response we have requested only the <u>maximum</u> quantity stored. Enter the largest amount of selected substance you had in storage on-site at any time during 1981. Again, enter the quantity of <u>substance</u> only, not the amount of material in which it is contained.

AIR EMISSIONS (Question 9 and 10): These questions seek to learn the amounts of selected substances your plant releases into the atmosphere from all sources. Please attach explanatory notes, itemized sources of emissions, calculations, etc., that will assist in clarifying your responses.

QUESTION 9-Stack Emissions: These are emissions which are released into the atmosphere from a readily-identifiable point source, such as a chimney or exhaust vent.

QUESTION 10-Fugitive Emissions: These are emissions other than stack emissions. Included should be such items as evaporation from tanks, vapor or dust emissions during blending, transfer discharging reaction vessels, etc.

WASTEWATER DISCHARGES (Questions 11 and 12): These questions are concerned only with discharges into surface waters and publicly owned treatment works (POTW's). Discharges into subsurface waters or onto land (e.q. lagooning, spray irrigation) should be recorded under the section on Waste Disposal. Here again, the questions are concerned only with the quantity of selected substance discharged, not with the volume of effluent in which it is contained. Thus, if you discharge a million gallons of effluent containing 500 pounds of selected substance, you enter 500 pounds for Question 11 or 12.

QUESTION 11-Surface Water Discharges' Enter the total quantity of selected substance you discharged into surface water, other than quantities which went to surface waters via a POTW (Question 12).

QUESTION 12-Discharge into Publicly Owned Treatment Works' Enter the total quantity of selected substance you discharged into a municipal sewer system or one owned by an MUA, SA or regional utilities authority.

WASTE DISPOSAL (Question 13)' This question asks you to describe how you dispose of wastes containing selected substances which are not emitted into the atmosphere or discharged into surface waters or sewerage systems.

QUESTION 13-Disposal of Waste Containing the Selected Substance. This question is organized in tabular form. In the first column, list the name and location of each final disposal site to which you send waste containing the selected substance. This includes disposal facilities located on your own plant site, e.g., a chemical landfill or lagoon. In general, "final disposal site" means final with respect to you. If the operator of the disposal site makes further economic use of the waste (for example, he recovers solvents from it) you do not have to report this further use. (Note: do not list a transfer station as a final disposal site.)

In the second column, you are to characterize the physical state of the waste you sent to the disposal sites listed in column one. Consult Table A and enter the appropriate physical state code or codes. If selected substance is contained in more than one type of waste, enter all appropriate code numbers.

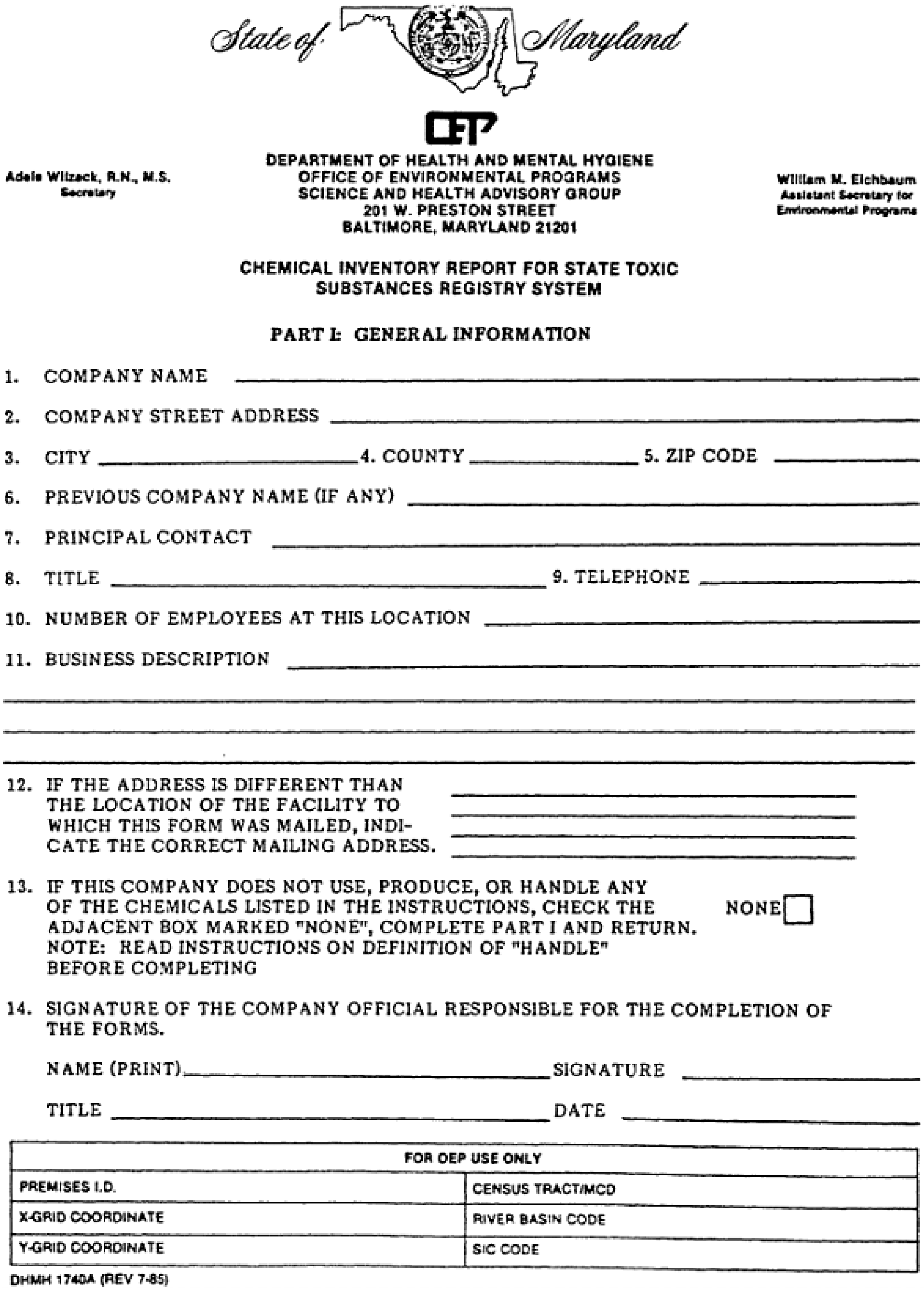
For the third column, consult Table B and enter the appropriate code or codes. Your entries should reflect the disposal method employed at the site you listed in the corresponding row.

In the fourth column enter the quantity of selected substance contained in the waste disposed at the site you listed in the corresponding row. Once again, enter only the quantity of selected substance, not the total quantity of waste in which it is contained.

The fifth column is for DEP use only. Leave it blank.

Appendix H

Maryland State Toxic Registry System Chemical Inventory



State of Maryland

OEP

Adele Wilzack, R.N., M.S.
Secretary

DEPARTMENT OF HEALTH AND MENTAL HYGIENE
OFFICE OF ENVIRONMENTAL PROGRAMS
SCIENCE AND HEALTH ADVISORY GROUP
201 W. PRESTON STREET
BALTIMORE, MARYLAND 21201

William M. Eichbaum
Assistant Secretary for
Environmental Programs

CHEMICAL INVENTORY REPORT FOR STATE TOXIC SUBSTANCES REGISTRY SYSTEM

PART I: GENERAL INFORMATION

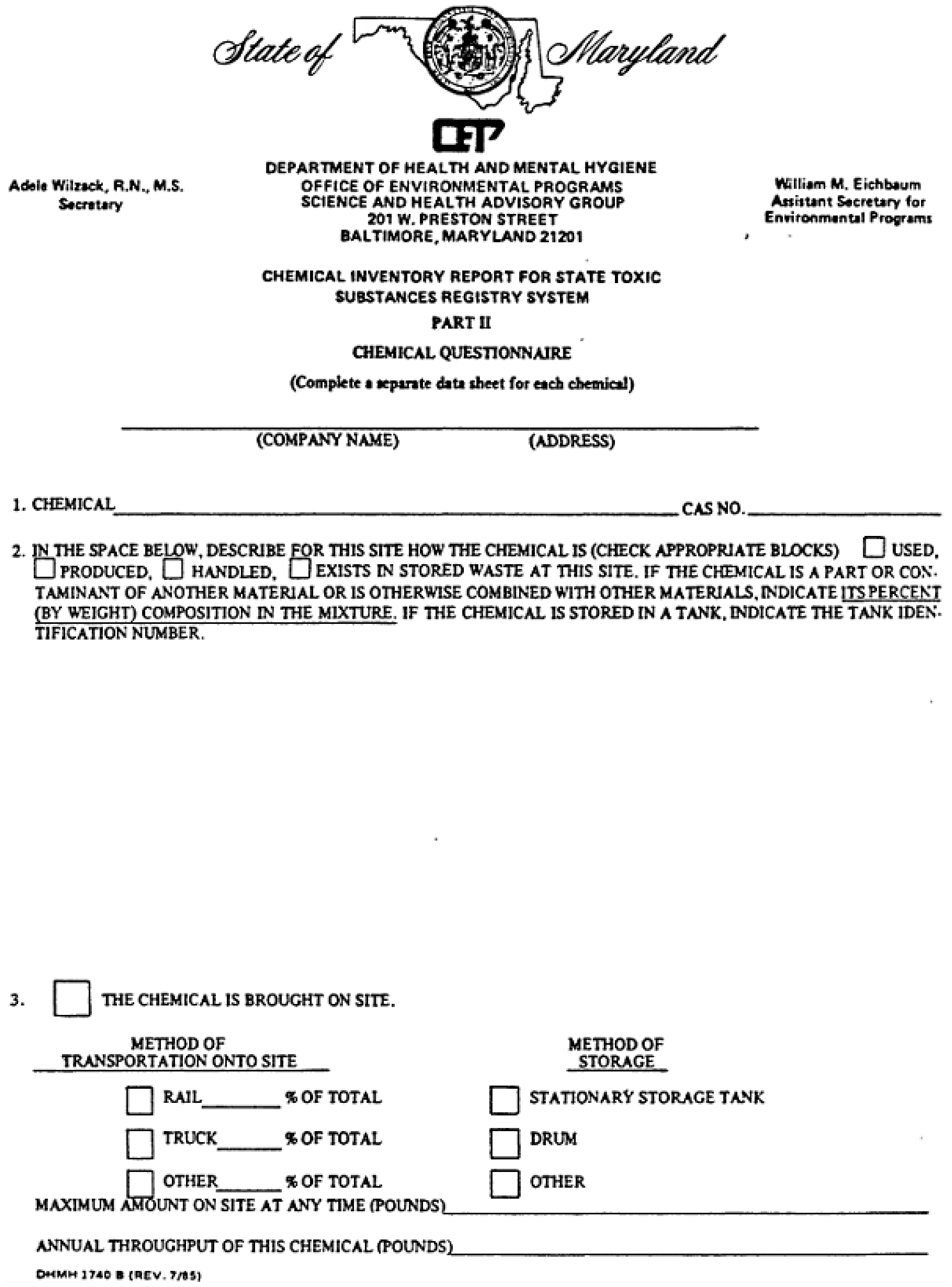
1. COMPANY NAME ______
2. COMPANY STREET ADDRESS ______
3. CITY ______ 4. COUNTY ______ 5. ZIP CODE ______
6. PREVIOUS COMPANY NAME (IF ANY) ______
7. PRINCIPAL CONTACT ______
8. TITLE ______ 9. TELEPHONE ______
10. NUMBER OF EMPLOYEES AT THIS LOCATION ______
11. BUSINESS DESCRIPTION ______
12. IF THE ADDRESS IS DIFFERENT THAN THE LOCATION OF THE FACILITY TO WHICH THIS FORM WAS MAILED, INDICATE THE CORRECT MAILING ADDRESS. ______
13. IF THIS COMPANY DOES NOT USE, PRODUCE, OR HANDLE ANY OF THE CHEMICALS LISTED IN THE INSTRUCTIONS, CHECK THE ADJACENT BOX MARKED "NONE", COMPLETE PART I AND RETURN. NOTE: READ INSTRUCTIONS ON DEFINITION OF "HANDLE" BEFORE COMPLETING NONE ☐
14. SIGNATURE OF THE COMPANY OFFICIAL RESPONSIBLE FOR THE COMPLETION OF THE FORMS.

NAME (PRINT) ______ SIGNATURE ______

TITLE ______ DATE ______

FOR OEP USE ONLY	
PREMISES I.D.	CENSUS TRACT/MCD
X-GRID COORDINATE	RIVER BASIN CODE
Y-GRID COORDINATE	SIC CODE

DHMH 1740A (REV 7-85)



State of Maryland

CEP

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CHEMICAL INVENTORY REPORT FOR STATE TOXIC
SUBSTANCES REGISTRY SYSTEM

PART II

CHEMICAL QUESTIONNAIRE

(Complete a separate data sheet for each chemical)

(COMPANY NAME) (ADDRESS)

1. CHEMICAL ____________________ CAS NO. ____________

2. IN THE SPACE BELOW, DESCRIBE FOR THIS SITE HOW THE CHEMICAL IS (CHECK APPROPRIATE BLOCKS) ☐ USED, ☐ PRODUCED, ☐ HANDLED, ☐ EXISTS IN STORED WASTE AT THIS SITE. IF THE CHEMICAL IS A PART OR CONTAMINANT OF ANOTHER MATERIAL OR IS OTHERWISE COMBINED WITH OTHER MATERIALS, INDICATE ITS PERCENT (BY WEIGHT) COMPOSITION IN THE MIXTURE. IF THE CHEMICAL IS STORED IN A TANK, INDICATE THE TANK IDENTIFICATION NUMBER.

3. ☐ THE CHEMICAL IS BROUGHT ON SITE.

METHOD OF TRANSPORTATION ONTO SITE	METHOD OF STORAGE
☐ RAIL ______ % OF TOTAL	☐ STATIONARY STORAGE TANK
☐ TRUCK ______ % OF TOTAL	☐ DRUM
☐ OTHER ______ % OF TOTAL	☐ OTHER

MAXIMUM AMOUNT ON SITE AT ANY TIME (POUNDS) ____________________

ANNUAL THROUGHPUT OF THIS CHEMICAL (POUNDS) ____________________

DHMH 1740 B (REV. 7/85)

PART II

CHEMICAL QUESTIONNAIRE (CONTINUED)

☐ THE CHEMICAL IS PRODUCED AS AN INTERMEDIATE OR FINAL PRODUCT OR HANDLED AS A BY-PRODUCT OR WASTE ON SITE.

METHOD OF SHIPPING OFF SITE

☐ RAIL__________ % OF TOTAL

☐ TRUCK__________ % OF TOTAL

☐ OTHER__________ % OF TOTAL

METHOD OF STORAGE

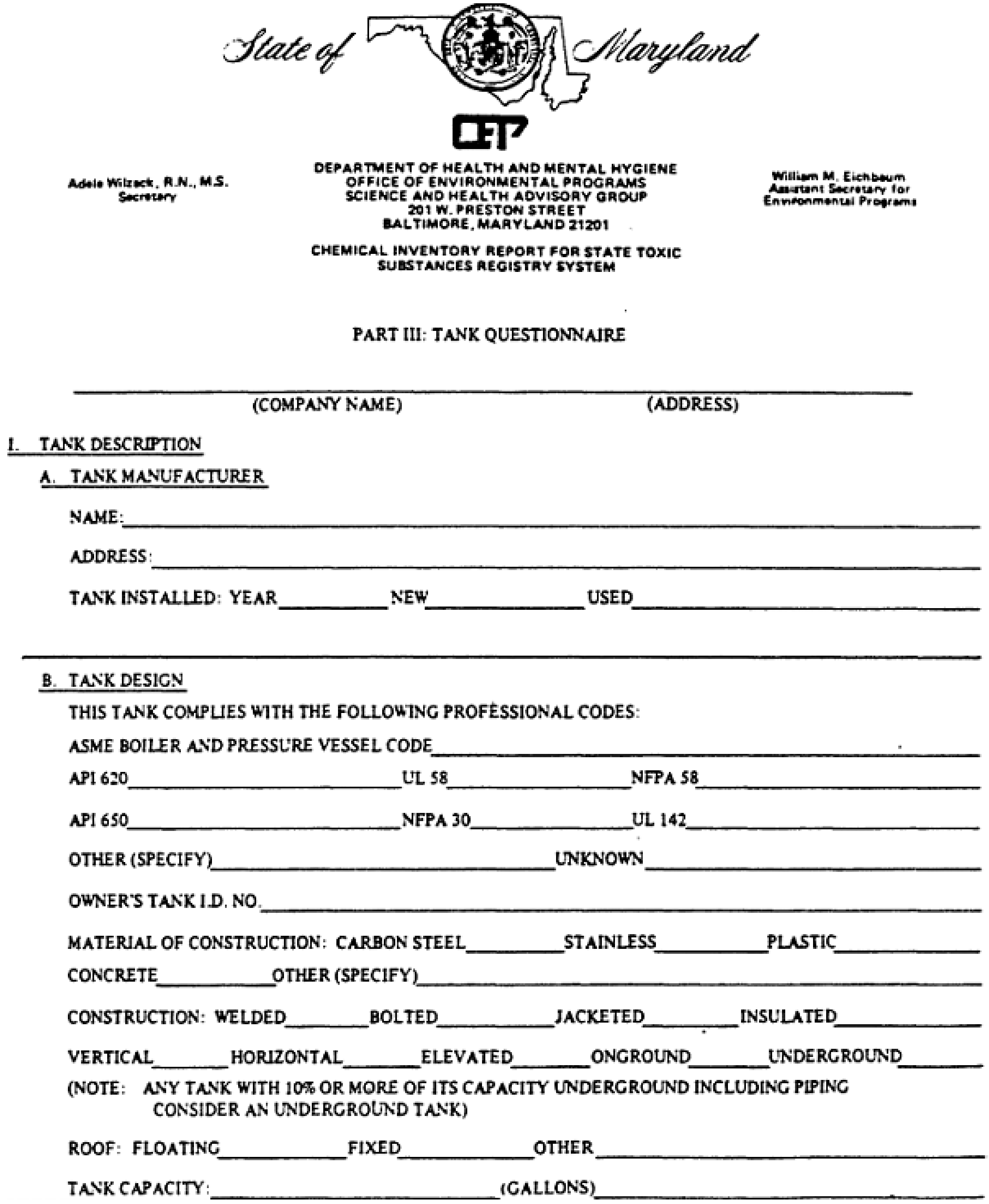
☐ STATIONARY STORAGE TANK

☐ DRUM

☐ OTHER

MAXIMUM AMOUNT ON SITE AT ANY TIME (POUNDS)______________________________

ANNUAL AMOUNT PRODUCED (POUNDS)______________________________



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CHEMICAL INVENTORY REPORT FOR STATE TOXIC
SUBSTANCES REGISTRY SYSTEM

PART III: TANK QUESTIONNAIRE

(COMPANY NAME) (ADDRESS)

I. TANK DESCRIPTION

A. TANK MANUFACTURER

NAME: ____

ADDRESS: ____

TANK INSTALLED: YEAR ____ NEW ____ USED ____

B. TANK DESIGN

THIS TANK COMPLIES WITH THE FOLLOWING PROFESSIONAL CODES:

ASME BOILER AND PRESSURE VESSEL CODE ____

API 620 ____ UL 58 ____ NFPA 58 ____

API 650 ____ NFPA 30 ____ UL 142 ____

OTHER (SPECIFY) ____ UNKNOWN ____

OWNER'S TANK I.D. NO. ____

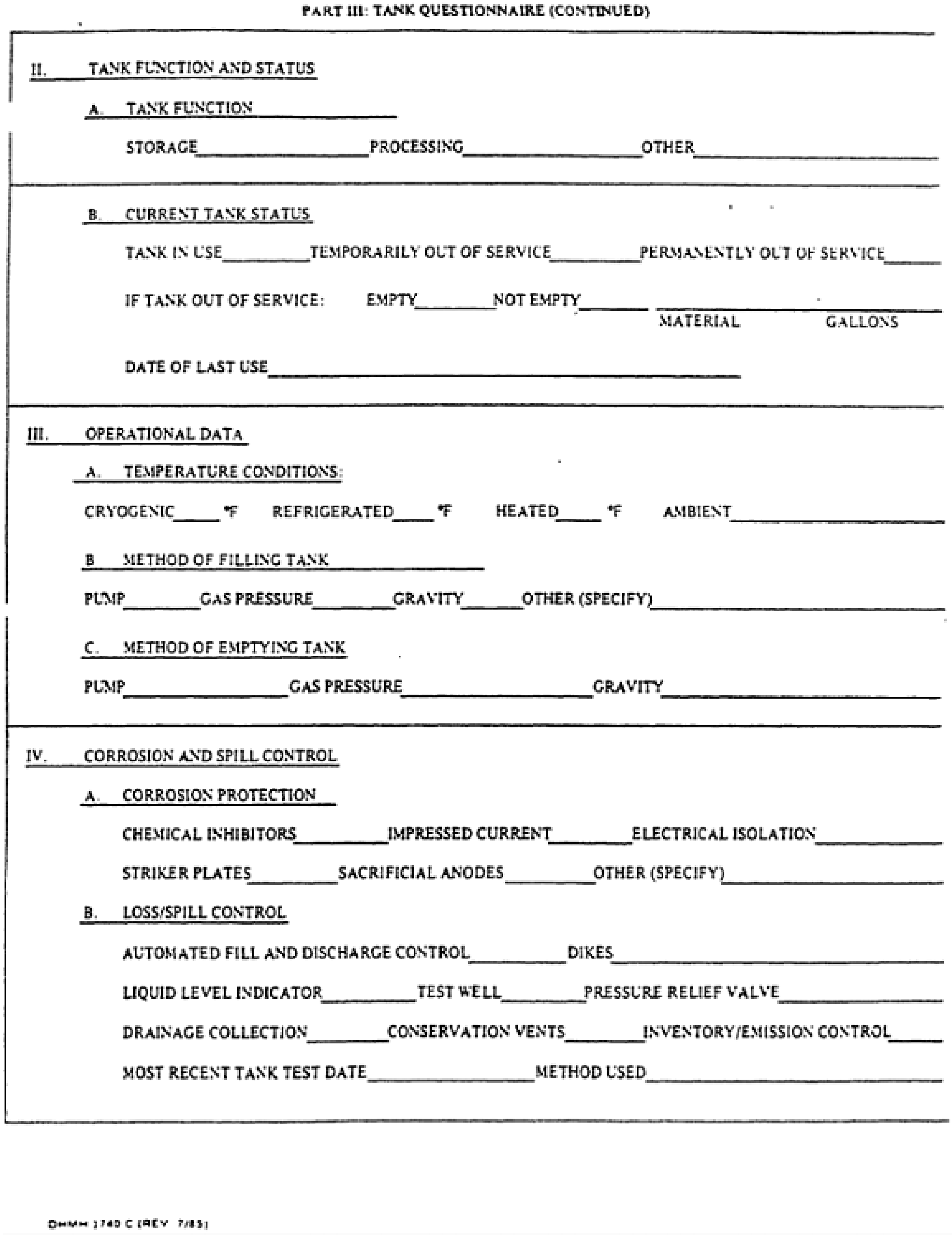
MATERIAL OF CONSTRUCTION: CARBON STEEL ____ STAINLESS ____ PLASTIC ____
CONCRETE ____ OTHER (SPECIFY) ____

CONSTRUCTION: WELDED ____ BOLTED ____ JACKETED ____ INSULATED ____

VERTICAL ____ HORIZONTAL ____ ELEVATED ____ ONGROUND ____ UNDERGROUND ____
(NOTE: ANY TANK WITH 10% OR MORE OF ITS CAPACITY UNDERGROUND INCLUDING PIPING
CONSIDER AN UNDERGROUND TANK)

ROOF: FLOATING ____ FIXED ____ OTHER ____

TANK CAPACITY: ____ (GALLONS) ____



PART III: TANK QUESTIONNAIRE (CONTINUED)

II. TANK FUNCTION AND STATUS

A. TANK FUNCTION

STORAGE__________ PROCESSING__________ OTHER__________

B. CURRENT TANK STATUS

TANK IN USE__________ TEMPORARILY OUT OF SERVICE__________ PERMANENTLY OUT OF SERVICE__________

IF TANK OUT OF SERVICE: EMPTY__________ NOT EMPTY__________ __________ MATERIAL __________ GALLONS

DATE OF LAST USE__________

III. OPERATIONAL DATA

A. TEMPERATURE CONDITIONS:

CRYOGENIC_____ °F REFRIGERATED_____ °F HEATED_____ °F AMBIENT__________

B METHOD OF FILLING TANK

PUMP__________ GAS PRESSURE__________ GRAVITY__________ OTHER (SPECIFY)__________

C. METHOD OF EMPTYING TANK

PUMP__________ GAS PRESSURE__________ GRAVITY__________

IV. CORROSION AND SPILL CONTROL

A. CORROSION PROTECTION

CHEMICAL INHIBITORS__________ IMPRESSED CURRENT__________ ELECTRICAL ISOLATION__________

STRIKER PLATES__________ SACRIFICIAL ANODES__________ OTHER (SPECIFY)__________

B. LOSS/SPILL CONTROL

AUTOMATED FILL AND DISCHARGE CONTROL__________ DIKES__________

LIQUID LEVEL INDICATOR__________ TEST WELL__________ PRESSURE RELIEF VALVE__________

DRAINAGE COLLECTION__________ CONSERVATION VENTS__________ INVENTORY/EMISSION CONTROL__________

MOST RECENT TANK TEST DATE__________ METHOD USED__________

DHMH 1740 C (REV. 7/85)

PART III: TANK QUESTIONNAIRE (CONTINUED)

V. SECURITY

CONTROLLED ACCESS: FENCE________________STAFF SECURITY________________BUILDING________________

CONTRACTUAL SECURITY__________________OTHER (SPECIFY)____

VI. CURRENT PERMITS

HEALTH DEPARTMENT: PERMIT NUMBER______________________AUTHORIZED USE____________________

NATURAL RESOURCES: PERMIT NUMBER______________________AUTHORIZED USE____________________

VII. WASTE STORAGE

USE THE SPACE BELOW TO IDENTIFY WASTE CONTAINING A LISTED CHEMICAL THAT IS STORED IN A TANK. IF NOT PREVIOUSLY COVERED UNDER PART II, INDICATE HOW THE WASTE IS GENERATED AND ITS PERCENT COMPOSITION IF IN A MIXTURE.

Revised 850620

SCIENCE AND HEALTH ADVISORY GROUP INSTRUCTIONS FOR COMPLETING CHEMICAL INVENTORY REPORT

I GENERAL INSTRUCTIONS FOR COMPLETING PARTS I, II AND III

A. The information to be reported pertains only to the chemicals listed in Table 1 (attached). If your plant does not use, produce, or handle any of the chemicals, either as a pure substance or as part of a mixture or does so in quantities identified as exempt in Appendix A, only Part I need be completed. The term "handle" includes the generation or handling of the chemical as a waste or as part of a waste.

Part III of the questionnaire is to be completed if the chemical is stored in a tank. If the chemical is part of a waste, the tank questionnaire is to be completed only if the waste is stored in a tank on site.

B. You will receive a separate survey package for each plant location on file with the State. Please file a separate complete report for each location. A complete report for each location means a separate chemical questionnaire completed for each chemical and a separate questionnaire for each tank.

C. The completed forms are to be returned to:

Maryland Department of Health and Mental Hygiene
Science and Health Advisory Group
O'Conor Building, 2nd Floor
201 West Preston Street
Baltimore, Maryland 21201

If you use a messenger service, deliver the forms in person or require additional forms, contact:

The Chemical and Storage Tank Survey Coordinator
Maryland Department of Health and Mental Hygiene
Science and Health Advisory Group
O'Conor Building, 2nd Floor
201 West Preston Street
Baltimore, Maryland 21201
301-225-5790

D. All information is to be based on the latest calendar year for which complete data are available.

E. Complete all sections of the report that pertain to your firm or plant site. If a section does not apply to your operations, write "NA" for "not applicable."

F. Attach process descriptions, explanatory notes, flow charts, lists, etc., that will assist in clarifying entries made on the report if the answers require further explanation. Supply page numbers for this material. If information needed to complete a section is not readily available, provide a written explanation describing the nature of the operations involved and the reasons for not supplying the data.

G. Use existing or readily ascertainable data to complete the Chemical Questionnaire. Where quantities can be determined from existing records (e.g., inventory or production figures) or the cost of testing is nominal, actual figures are to be supplied. Otherwise, use engineering estimates and computation; process material balance studies; field tests or measurements made by the plant, equipment manufacturers or government agencies, or other technically sound bases.

H. If you do not know the formulation of trade name products used in plant operations, make reasonable inquiries of suppliers or manufacturers to ascertain whether the material contains any of the selected chemicals. (For example, Tri-Clene, a solvent, is a trade name for trichloroethylene, a listed chemical.)

I. List all quantities of chemicals unless the quantity is less than the minimum established in Appendix A.

II. SPECIFIC INSTRUCTIONS FOR COMPLETING PART II

Question 1-Indicate the name of the chemical and its CAS number. The CAS number is found in Table I.

Question 2-Describe how the chemical is used, produced or handled. Use of the chemical refers to its use as a pure component or as a part of another material. If the chemical is used for more than one purpose or exists in more than one form, provide all pertinent information relating to the chemical.

Example: Trichloroethane may be used as a solvent in production process and may also be used as a metal degreaser in some other part of the operation.

Question 3-This part is to be completed only if the chemical is brought on site. If the chemical is used as a raw material or is otherwise brought on to the site as · pure component or a mixture, so indicate in the first block and indicate how it is transported to the site. If transportation involves more than one method, indicate for the year the percent use of each method. If it is stored in a permanent stationary storage tank or drum, so indicate. The method of storage is "other" if the chemical is stored in any portable container other than a drum or if it is stored and used directly from a railroad car, tank truck, or other portable container. If it is not stored on site, indicate "none" in the "other" block. The maximum amount on site at any time is the maximum amount in inventory at any time. Annual amount is the total throughput of the material for the calendar year. When reporting a mixture, indicate the total amount of the mixture in pounds. If the chemical is stored on site in a tank, it is necessary to complete Part III questionnaire.

Question 4-If the chemical is produced or generated on site as a by-product or waste on site, its handling should have been described in Question 2. In completing Question 4, the method of shipping and storing must be indicated for the chemical or mixture. The annual amount should clearly indicate that you are reporting the total mixture, if it is not a pure component, with a composition consistent with that reported in Question 2. Complete Part III if the chemical is stored in a tank.

If the chemical is an intermediate that is not stored longer than 24 hours and is used to produce a final product that does not contain the chemical, the method of shipping and storing would be indicated as none.

III. SPECIFIC INSTRUCTIONS FOR COMPLETING TANK QUESTIONNAIRE

The tank questionnaire consists of seven parts. Answer each part in full as instructed below.

Question IA-Indicate the name and address of the tank manufacturer and what year the tank was installed at this site. Also indicate whether the tank was new or used when installed.

Question IB-Indicate the professional ASME codes that the tank meets and check any other applicable code(s). Codes are defined in current ASME, NFPA, API, etc. publications. If your code is other than those listed, then specify in the space provided. Check all items which describe material of construction, method of construction, orientation, and roof type, and give the tank's loading capacity.

Question II-Indicate the tank function as "storage" if it is used solely to store a chemical and there is no blending, reacting, etc. involved. The tank is "processing" if it is used to blend or mix substances including a listed chemical. The tank is "other" if it is part of a process and used more as a temporary holding tank for intermediates and other process material. A reactor is not a tank.

Question III-In this part, provide information with respect to tank conditions and the method of transferring the chemical to and from the tank.

Question IV-Indicate all devices used for corrosion and spill control. In addition, give the date that tank was most recently tested, if ever, and the method used.

Question V-Describe the security that you have specifically for the tank being reported. If the property is enclosed with a fence and the tank is within the enclosed area, indicate "fence." If you have a security guard stationed at the gate, indicate both "fence" and "staff" or "contractual" security.

Question VI-List all current permits that relate to the tank and chemical being reported.

Question VII-The questionnaire is to be completed for waste materials only if the waste includes a chemical listed in Table I and only if the waste is stored in a tank. Report the composition of the waste and the total quantity (pounds) generated for the reporting year.

IV. CONFIDENTIAL BUSINESS INFORMATION

If any question requires you to submit information which is (or would lead a knowledgeable reader to deduce from it) a trade secret, proprietary business information or information related to national security, make a confidentiality claim. OEP will then treat that information as confidential and not disclose it in any form that would reveal the secret or proprietary information, unless the Department makes a formal finding that the material is not entitled to confidential treatment as provided by Maryland law. Unless an emergency (such as fire in your plant which threatens to expose nearby residents to toxic materials) calls for the immediate release of information, you will be notified in advance if the Department intends to disclose information that you have claimed as confidential. You will be given an opportunity to challenge the Department's decision through administrative processes, and if not satisfied with the outcome, you will be given time (except in an emergency situation) to obtain a restraining order from a court, if you wish to pursue an appeal.

To make a confidentiality claim for information reported you must:

A. Submit two copies of the report. The first must contain all the information requested. The second should contain no information which you believe is entitled to confidential treatment. (The second copy can be a photocopy of the first with the confidential material blanked out.)

B. Print, in red ink, at the top left corner "CONFIDENTIAL." Also, if desired mark the top of each page containing confidential information with the heading "CONFIDENTIAL" in large bold type, stamp or hand lettering. Do not mark every page, only the ones that contain confidential information.

C. Identify all information which you claim to be confidential by underlining or highlighting it in a clear manner. Translucent ink markers are acceptable for this purpose.

Example: Question 3: Quantity Consumed On Site = $\boxed{140{,}500}$ lbs/yr.

D. Seal the copy of the report which contains confidential information into an envelope, and mark the envelope on both sides with the word "CONFIDENTIAL" in bold type, stamp or hand lettering. Place this envelope, together with the second (non-confidential) copy of the report, inside another envelope for transmittal to the Science and Health Advisory Group (SHAG).

E. Send the complete package to SHAG at the address listed in Item I. For your protection, we recommend the use of certified mail, return receipt requested, a messenger service, personal delivery, or other means that will give you verification that your material has been received. You may use ordinary mail, but SHAG assumes no responsibility for materials not signed for until actually received.

Please give careful consideration to the material you claim as confidential. Be sure it really is proprietary or a trade secret. Do not mark a report "Entire Contents Confidential" or in some similar fashion. Doing so will result in refusal to recognize any confidentiality claim, or in refusing the report.

TABLE 1: SELECTED CHEMICAL LIST

EXEMPT QUANTITY CLASSIFICATION 1
REQUIRES REPORTING OF QUANTITIES GREATER THAN 2.2 LBS. (1 KG) PER YEAR

CHEMICAL NAME	CAS NUMBER
2-Acetylaminofluorene	53-96-3
Acrylonitrile	107-13-1
2-Aminoanthraquinone	117-79-3
4-Aminobiphenyl	92-67-1
1-Amino-2-Methylanthraquinone	82-28-0
o-Anisidine	90-04-0
o-Anisidine Hydrochloride	134-29-2
Arsenic	7440-38-2
Arsenic Compounds (Specify)	
Asbestos (Friable)	1332-21-4
Auramine	492-80-8
Benzene	71-43-2
Benzidine	92-87-5
Benzoic Trichloride	98-07-7
Beryllium	7440-41-7
Beryllium Compounds (Specify)	
Bis(Chloromethyl)Ether	542-88-1
Cadmium	7440-43-9
Cadmium Compounds (Specify)	
Carbon Tetrachloride	56-23-5
Chloroform	67-66-3
Chloromethyl Methyl Ether	107-30-2
Chromium (fume or dust)	7440-47-3

CHEMICAL NAME	CAS NUMBER
Chromium Compounds (Specify)	
p-Cresidine	120-71-8
Cupferron	135-20-6
2,4-Diaminoanisole Sulfate	39156-41-7
2,4-Diaminotoluene	95-80-7
1,2-Dibromo-3-Chloropropane (DBCP)	96-12-8
1,2-Dibromoethane (Ethylene Dibromide)	106-93-4
3,3'-Dichlorobenzidine	91-94-1
1,2-Dichloroethane (Ethylene Dichloride)	107-06-2
Diepoxybutane	1464-53-5
Di(2-Ethylhexyl)Phthalate (DEHP)	117-81-7
Diethyl Sulfate	64-67-5
4-Dimethylaminobenzene	60-11-7
3,3'-Dimethylbenzidine (o-Tolidine)	119-93-7
Dimethylcarbamyl Chloride	79-44-7
Dimethyl Sulfate	77-78-1
3,3'-Dimethoxybenzidine	119-90-4
1,4-Dioxane	123-91-1
1,2-Diphenyl Hydrazine (Hydrazobenzene)	122-66-7
Direct Black 38	1937-37-7
Direct Blue 6	2602-46-2
Direct Brown 95	16071-86-6
Epichlorohydrin	106-89-8
Ethylene Oxide	75-21-8
Ethylene Thiourea	96-45-7

CHEMICAL NAME	CAS NUMBER
Formaldehyde	50-00-0
Hexachlorobenzene	118-74-1
Hydrazine	302'-01-2
Hydrazine Sulfate	10034-93-2
Lead (fume or dust)	7439-92-1
Lead Compounds (Specify)	
4,4'-Methylene Bis 2-Chloro-Aniline (MOCA)	101-14-4
4,4'-Methylene Bis (N-N-Dimethyl) Benzenamine	101-61-1
Michler's Ketone	90-94-8
Mustard Gas	505-60-2
b-Naphthylamine	91-59-8
Nickel (fume or dust)	7440-02-0
Nickel Compounds (Specify)	
Nitriloacetic Acid	139-13-9
5-Nitro-o-Anisidine	99-59-2
Nitrogen Mustard	51-75-2
N-Nitrosodi-N-Butylamine	924-16-3
N-Nitrosodiethylamine	55-18-5
N-Nitrosodimethylamine	62-75-9
p-Nitrosodiphenylamine	156-10-5
N-Nitrosodi-N-Propylamine	621-64-7
N-Nitroso-N-Ethylurea	759-73-9
N-Nitroso-N-Methylurea	684-93-5
N-Nitrosomethylvinylamine	4549-40-0
N-Nitrosomorpholine	59-89-2

CHEMICAL NAME	CAS NUMBER
N-Nitrosonornicotine	16543-55-8
N-Nitrosopiperidine	100-75-4
Polybrominated Biphenyls (PBBs) (Specify)	
Polychlorinated Biphenyls (PCBs)	1336-36-3
b-Propiolactone	57-57-8
Saccharin (manufacturing)	81-07-2
Safrole	94-59-7
Selenium (fume or dust)	7782-49-2
Selenium Compounds (Specify)	
Thioacetamide	62-55-5
Thiourea	62-56-6
Thorium Dioxide	1314-20-1
o-Toluidine	95-53-4
o-Toluidine Hydrochloride	636-21-5
Triaziquone	68-76-8
2,4,6-Trichlorophenol	88-06-2
Tris (2,3-Dibromopropyl) Phosphate	126-72-7
Urethane (Ethyl Carbamate) (monomer)	51-79-6
Vinyl Chloride (monomer)	75-01-4

EXEMPT QUANTITY CLASSIFICATION II

REQUIRES REPORTING OF QUANTITIES GREATER THAN 500 LBS. PER YEAR

CHEMICAL NAME	CAS NUMBER
Acetaldehyde	75-07-0
Acetamide	60-35-5
Acetone	67-64-1
Acetonitrile	75-05-8
Acrolein	107-02-8
Acrylamide	79-06-1
Acrylic Acid	79-10-7
Allyl Chloride	107-05-l
Aluminum (fume or dust)	7429-90-5
Aluminum Oxide	1344-28-1
4-Aminoazobenzene	60-09-3
Ammonia	7664-41-7
Ammonium Nitrate (solution)	6484-52-2
Ammonium Sulfate (solution)	7783-20-2
Aniline	62-53-3
p-Anisidine	104-94-9
Antimony (fume or dust)	7440-36-0
Antimony Compounds (Specify)	
Barium	7440-39-3
Barium Compounds (Specify)	
Benzamide	55-21-0
Benzyl Chloride	100-44-7
Biphenyl	92-52-4

CHEMICAL NAME	CAS NUMBER
Bis (Chloroethyl) Ether	111-44-4
Bromoform (Tribromomethane)	75-25-2
Bromomethane (Methyl Bromide)	74-83-9
1,3-Butadiene	106-99-0
Butyl Acrylate	141-32-2
n-Butyl Alcohol	71-36-3
Sec-Butyl Alcohol	78-92-2
tert-Butyl Alcohol	75-65-0
Butyl Benzyl Phthalate	85-68-7
Butyraldehyde	123-72-8
Calcium Cyanamide	156-62-7
Carbon Disulfide	75-15-0
Carbonyl Sulfide	463-58-1
Chlorinated Fluorocarbon (Freon 113)	76-13-1
Chlorine	7782-50-5
Chlorine Dioxide	10049-04-4
Chloroacetic Acid	79-11-8
2-Chloroacetophenone	532-27-4
Chlorobenzene	108-90-7
Chlorobenzilate	510-15-6
Chloroethane (Ethyl Chloride)	75-00-3
Chloromethane (Methyl Chloride)	74-87-3
Chlorophenols (Specify)	
Chloroprene	126-99-8
Cobalt (fume or dust)	7440-48-4
Cobalt Compounds (Specify)	

CHEMICAL NAME	CAS NUMBER
Copper (fume or dust)	7440-50-8
Copper Compounds (Specify)	
Cresol (Mixed Isomers)	1319-77-3
m-Cresol	108-39-4
o-Cresol	95-48-7
p-Cresol	106-44-5
Cumene	98-82-8
Cyanide	57-12-5
Cyclohexane	110-82-7
Diaminotoluene (Mixed Isomers)	25376-45-8
Diazomethane	334-88-3
Dlbenzofuran	132-64-9
Dibutyl Phthalate	84-74-2
Dichlorobenzene (Mixed Isomers)	25321-22-6
1,2-Dichlorobenzene	95-50-1
1,3-Dichlorobenzene	541-73-1
1,4-Dichlorobenzene	106-46-7
Dichlorobromomethane	75-27-4
1,2-Dichloroethylene	540-59-0
Dichloromethane (Methylene Chloride)	75-09-2
2,4-Dichlorophenol	120-83-2
1,2-Dichloropropane	78-87-5
1,3-Dichloropropylene	542-75-6
Diethanolamine	111-42-2
Diethyl Phthalate	84-66-2

CHEMICAL NAME	**CAS NUMBER**
N,N-Dimethylaniline	121-69-7
Dim ethyl Hydrazine	57-14-7
2,4-Dimethylphenol	105-67-9
Dimethyl Phthalate	131-11-3
4,6-Dinitro-o-Cresol	534-52-1
2,4-Dinitrophenol	51-28-5
2,4-Dinitrotoluene	121-14-2
2,6-Dinitrotoluene	606-20-2
n-Dioctylphthalate	117-84-0
2-Ethoxyethanol	110-80-5
Ethyl Acrylate	140-88-5
Ethyl Benzene	100-41-4
Ethyl Chloroformate	541-41-3
Ethylene	74-85-1
Ethylene Glycol	107-21-1
Ethyleneimine (Aziridine)	151-56-4
Glycol Ethers (Specify)	
Hexachloro-1,3-Butadiene	87-68-3
Hexachlorocyclopentadiene	77-47-4
Hexachloronaphthalene	1335-87-1
Hexamethylphosphoramide	680-31-9
Hydrochloric Acid	7647-01-0
Hydrogen Cyanide	74-90-8
Hydrogen Fluoride	7664-39-3

CHEMICAL NAME	CAS NUMBER
Isobutyraldehyde	78-84-2
Isopropyl Alcohol (manufacturing-strong acid process)	67-63-0
4-Isopropylidenediphenol	80-05-7
Maleic Anhydride	108-31-6
Manganese (fume or dust)	7439-96-5
Manganese Compounds (Specify)	
Melamine	108-78-1
Mercury	7439-97-6
Mercury Compounds (Specify)	
Methanol	67-56-1
2-Methoxyethanol	109-86-4
Methylene Bis(Phenylisocyanate) (MBI)	101-68-8
Methylene Bromide	74-95-3
4,4-Methylene Dianiline	101-77-9
Methyl Acrylate	96-33-3
Methyl Ethyl Ketone	78-93-3
Methyl Hydrazine	60-34-4
Methyl Isobutyl Ketone	108-10-1
Methyl Isocyanate	624-83-9
Methyl Iodide	74-88-4
Methyl Methacrylate	80-62-6
Methyl tert-Butyl Ether	1634-04-4
Molybdenum Trioxide	1313-27-5
Naphthalene	91-20-3
a-Naphthylamine	134-32-7

CHEMICAL NAME	CAS NUMBER
Nitric Acid	7697-37-2
Nitrobenzene	98-95-3
4-Nitrobiphenyl	92-93-3
Nitroglycerin	55-63-0
2-Nitrophenol	88-75-5
4-Nitrophenol	100-02-7
2-Nitropropane	79-46-9
Octachloronaphthalene	2234-13-1
Osmium Tetroxide	20816-12-0
Pentachlorophenol (PCP)	87-86-5
Phenol	108-95-2
p-Phenylenediamine	106-50-3
Phosgene	75-44-5
Phosphoric Acid	7664-38-2
Phosphorous (yellow or white)	7723-14-0
Phthalic Anhydride	85-44-9
Picric Acid	88-89-1
Propane Sultone	1120-71-4
Propionaldehyde	123-38-6
Propylene (Propene)	115-07-1
Propyleneimine	75-55-8
Propylene Oxide	75-56-9
Pyridine	110-86-1
Quinone	106-51-4
Quintozene (Pentachloronitrobenzene)	82-68-8

CHEMICAL NAME	CAS NUMBER
Silver (fume or dust)	7440-22-4
Silver Compounds (Specify)	
Sodium Hydroxide (solution)	1310-73-2
Sodium Sulfate (solution)	7757-82-6
Styrene (monomer)	100-42-5
Sulfuric Acid	7664-93-9
Terephthalic Acid	100-21-0
1,1,2,2-Tetrachloroethane	79-34-5
Tetrachloroethylene (Perchloroethylene)	127-18-4
Thallium	7440-28-0
Thallium Compounds (Specify)	
Titanium Dioxide	13463-67-7
Titanium Tetrachloride	7550-45-0
Toluene	108-88-3
Toluene-2,4-Diisocyanate	584-84-9
1,2,4-Trichlorobenzene	120-82-1
1,1,1-Trichloroethane (Methyl Chloroform)	71-55-6
1,1,2-Trichloroethane	79-00-5
Trichloroethylene	79-01-6
2,4,5-Trichlorophenol	95-95-4
1,2,4-Trimethyl Benzene	95-63-6
Vanadium (fume or dust)	7440-62-2
Vinyl Acetate	108-05-4
Vinyl Bromide	593-60-2
Vinylidene Chloride	75-35-4

CHEMICAL NAME	CAS NUMBER
Xylene (Mixed Isomers)	1330-20-7
m-Xylene	108-38-3
o-Xylene	95-47-6
p-Xylene	106-42-3
Zinc (fume or dust)	7440-66-6
Zinc Compounds (Specify)	

EXEMPT QUANTTIES

1. Exempt Quantity For Class I Chemicals

Report on the selected chemical if the total annual quantity exceeds 2.2 pounds per year. Report on a mixture if it contains greater than 0.1% of the chemical and the total weight of the selected chemical in the mixture exceeds 2.2 pounds.

2. Exempt Quantity For Class II Chemicals

Report on the selected chemical if the total annual quantity exceeds 500 pounds per year. Report on a mixture if it contains greater than 1.0% of the chemical and the total weight of the selected chemical in the mixture exceeds 500 pounds.

Appendix I

Defining Waste And Waste Reduction

DEFINING WASTE

Both SARA Section 313 and RCRA involve the collection of information on reducing waste generated at manufacturing facilities. Under RCRA it is necessary to report only the generation of *hazardous* wastes, which include some wastes destined for land disposal and some nongaseous wastes that are treated as typical solid wastes and wastewaters. Missing from the accounting are air emissions and other nonhazardous solids or wastewaters. Under SARA releases of certain chemicals to any environmental media are reported, but waste is not explicitly defined.

Data obtained under these two programs may lead to different conclusions regarding a facility's waste reduction progress. The basic reason for this potential discrepancy is that the two programs consider different universes of waste: hazardous wastes are reported under RCRA, while quantities of individual chemicals are reported under SARA Section 313. There is no information collected under either statute that can indicate whether a reduction in hazardous waste quantities generally correlates with reductions in releases of a specific chemical. Reductions in total hazardous waste but not a specific component may occur and be documented under RCRA reporting, while the reductions of a specific chemical but not of total hazardous waste may occur and be documented under SARA.

A complex system is employed by RCRA for determining whether a material is a solid waste which is subject to regulation as a hazardous waste. The definitions of solid waste and hazardous waste depend on both material type and the way in which the material is managed. For example, if a material is a characteristic byproduct that is reclaimed, it is not considered a solid waste (Code of Federal Regulations, 1989). The RCRA definition of solid waste also excludes large quantities of ignitable (flammable) materials commonly recycled throughout the petrochemicals industry. In addition, materials used as effective substitutes for commercial products or used as ingredients (nonreclaimed) are also not considered to be solid wastes when they are recycled. On the other hand, those wastes de fined as spent solvents are considered to be hazardous wastes and are subject to reporting and regulation, unless they are reclaimed in a closed-loop recycling system that returns the recycled material back to the process.

This discussion should not leave the impression that it is a simple task to define what is a hazardous waste and what is not. The EPA's final rule (Federal Register, 1985), which consumed over 50 pages in the Federal Register, consists of a very complex series of definitions that have numerous exclusions and exemptions to account for the many ways a material can be used legitimately as a nonwaste.

Conflicts arise, however, because of the inherent complexity of defining a waste. Recently, the U.S. Court of Appeals for the District of Columbia reviewed the definition of waste as it relates to the use of a listed hazardous waste in the manufacturing process. In this case the petitioners argued that even though a material may be a listed waste, it should not be subject to regulation if it is introduced into a process to be reclaimed and converted into a product. The court agreed, stating that "Congress clearly and unambiguously expressed its intent that solid waste (and therefore EPA's regulatory authority) be limited to materials that are discarded by virtue of being disposed of, abandoned, or thrown away." The court went on to say that it was clear that "discarded" did not include "in process secondary materials employed in ongoing manufacturing processes." (American Mining Congress vs. United States Environmental Protection Agency, No. 85-1206, D.C. Cir., July 31, 1987; pp. 33-34.)

DEFINING WASTE MINIMIZATION AND REDUCTION

As stated in Chapter 5, the committee chose to define waste reduction broadly so that its analysis of mass balance information would apply to any facility reporting waste information, regardless of the way the facility deals with the waste it generates. This definition of waste reduction is consistent with the one presented in a previous NRC report (NRC, 1985). The activities included in the definition of the terms waste minimization and waste reduction and their role in the waste management hierarchy have been the source of continuing debate (Wolf, 1988). The debate centers on whether waste management should focus on all activities that reduce the quantity of materials entering the environment, or whether it should be limited to the reduction of waste at the generation source prior to any treatment or disposal. The latter approach is often referred to as *source reduction* , rather than waste reduction. The issue has been further fractionated into whether or not recycling of waste internal to the process or waste reclaimed by a second party or an off-site party should be included in source reduction.

Under RCRA, the EPA defines waste minimization in terms of recycling and source reduction (EPA, 1986b), as follows:

- Source reduction refers to the reduction or elimination of waste generation at the source, usually within a process. Source reduction measures can include some types of treatment processes, but they also include process modifications, feedstock substitutions or improvements in feedstock purity, various housekeeping and management practices, increases in the efficiency of machinery, and even recycling within a process. Source reduction implies any action that reduces the amount of waste exiting from a process.
- Recycling refers to the use or reuse of a waste as an effective substitute for a commercial product, or as an ingredient or feedstock in an industrial process. It also refers to the reclamation of useful constituent fractions within a waste material or removal of contaminants from a waste to allow it to be reused. As used in the EPA report 1986b cited above, recycling implies use, reuse, or reclamation of a waste either on site or off site after it is generated by a particular process.
- Waste minimization means the reduction, to the extent feasible, of hazardous waste that is generated or subsequently treated, stored, or disposed of. It includes any source reduction or recycling activity undertaken by a generator that results

> in either (1) the reduction of the total volume or quantity of hazardous waste, or (2) the reduction of the toxicity of hazardous waste, or both, so long as the reduction is consistent with the goal of minimizing present and future threats to human health and the environment. [Note: Waste minimization could include some form of treatment after generation to detoxify or reduce the waste.]

Under SARA, the EPA has indirectly defined waste minimization through the TRI's Form R. For Part III Section 8 of Form R, all on-site and off-site recycling is included in waste minimization.

The EPA has recently provided a basis for consistency between regulatory programs, within the constraints of the various laws that govern waste minimization. The EPA has proposed a Pollution Prevention Policy Statement (Federal Register, 1989) that is designed to commit the EPA to "a program that reduces all environmentally harmful releases." The EPA is proposing to replace the term "waste minimization," which it has previously used in reference to source reduction and recycling activities in its hazardous waste program, with the term "pollution prevention." In this proposed policy, the EPA indirectly defines source reduction through the statement that "Industrial Source Reduction can be accomplished through input substitution, product reformulation, process modification, improved housekeeping, and on site, closed loop recycling." EPA continues by stating that "although source reduction is preferred to other management practices, the agency recognizes the value of environmentally sound recycling, and is committed to promoting recycling as a second preference, above treatment, control and disposal."

The OTA has concluded that waste management should focus on source reduction (in process changes to avoid or eliminate waste) and any recycling operation that is "environmentally acceptable and is an integral part of the waste generating industrial processor operation." Therefore, actions such as treatment or off-site recycling are not considered part of OTA's definition of waste reduction (OTA, 1986, 1987).

If the primary objective of waste reduction is to reduce multimedia releases, a variety of factors must be considered in evaluating progress in waste reduction given the complexities of industrial manufacturing processes. In the case of off-site recycling and reuse, it becomes apparent that there is no clear definition of waste reduction, particularly when overall regional or national reduction is considered. Is recycling—a practice that reduces the amount of waste ultimately generated—part of waste reduction? If so, then it should not be excluded from data collected for assessing waste reduction progress.

Appendix J

Uniform Waste Reduction Standard

The Natural Resources Defense Council (NRDC) has proposed the most comprehensive approach for mandating a waste reduction standard (Clarence-Smith, 1988a,b). This group defines efficiency as "the ratio of the total amount of each hazardous chemical released annually from the processes at a facility (and from subsequent recycling operations) to the throughput in the same year of that chemical at the facility." Total releases are the sum of losses from a manufacturing process prior to treatment, losses from on-site recycling, and losses leaving a facility as impurities in a product. Throughput is the sum of

- total releases,
- the amount leaving a facility in the product,
- the inventory change,
- the amount transformed on site,
- the amount recycled on site or sent off site for recycling, and
- the amount entering all downstream processes.

If a hazardous or toxic chemical is not found in the raw material, then a raw material other than that chemical is used in the throughput term, resulting in inconsistencies in reporting as discussed in Chapter 5.

Clarence-Smith (1988a,b) recommends that a uniform standard be set for all industries. Based on an analysis of the New Jersey data, he further suggests that an "efficiency" or a standard of 5 percent be adopted. This implies that the total releases from all facilities must be less than or equal to 5 percent of the throughput. Annual reporting requirements would apply to the chemicals listed in SARA Section 313, and facilities would be allowed 10 years to comply with the performance standard.

Clarence-Smith (1988a) gives an example of an efficiency calculation. He describes a facility in which TCA is used to degrease metal parts. TCA throughput includes 14,000 lb emitted to the atmosphere and 7,000 lb recycled off site, for a total throughput of 21,000 lb. Since the facility receives credit for the recycling, the efficiency is the ratio of the atmospheric loss to the throughput (14,000/21,000), or 67 percent.

The facility can meet the standard by

lowering its measure of efficiency to 5 percent in at least three ways. First, it could substitute a chemical that is not on the SARA Section 313 list. Indeed, several hydrocarbon solvents are currently being examined for use in place of the listed chlorinated solvents. The disadvantages of these replacement solvents are that they are combustible and photochemically reactive, and their health effects have not yet been thoroughly determined. In effect, they are too new to have been adequately scrutinized and may eventually prove to be carcinogenic or to pose other threats to human health. The facility could also convert to an aqueous cleaning method. In this case, organic and metal contaminants would be released to the sewer, posing a different threat. In both instances—conversion to the hydrocarbon solvent or to the aqueous cleaner—the facility could avoid the reporting requirement even though these processes may be hazardous.

The second way the facility can meet the efficiency requirement is to increase the amount of solvent sent for recycling. (Note that while the example credits solvent sent for off-site recycling, under present regulations reclamation or reuse may include usage of the solvent as fuel.) Thus the facility can simply sell the solvent to a recycler and the recycler can send it directly to an industrial furnace or an incinerator that does not perform the expected reclamation. In fact, the facility would have no knowledge or interest in the final destination of the solvent as long as it could prove it was sent to an off-site recycler.

The third method of meeting the efficiency standard is to decrease the atmospheric emissions of the solvent. For every pound of solvent used in a degreasing operation, between 0.43 and 0.85 lb is lost to the atmosphere; the balance is contaminated liquid solid waste (EPA, 1985b). Through the purchase of more conservative cleaning equipment, emissions can be reduced significantly. This reduction of emissions translates into a corresponding reduction in total solvent use. Even with this decline in the absolute level of solvent use, however, the proportions of solvent emitted and produced as waste remain roughly the same per pound of solvent used. Therefore for every pound of solvent used (Clarence-Smith's [1988a] concept of throughput), the atmospheric loss still amounts to 0.43 to 0.85 lb. For cleaning applications with solvents, then, the 5 percent efficiency standard can never be met.

There are probably hundreds of thousands of degreasers in the nation, ranging from small units holding less than a gallon to large conveyorized units containing thousands of gallons. These degreasers are used in numerous facilities that are classified under the SIC Codes in the Manufacturing Division and thus represent a significant number of the facilities covered by SARA Section 313. These facilities would be unable, even with a 10-year compliance period, to ever meet the efficiency standard specified in Clarence-Smith's (1988a) model. Thus this model, like others that attempt to treat all industries and all facilities uniformly, would not accomplish the intended goals. Instead, they may increase the threat to public health or cause small-and medium-size generators to close their plants.

Thus it is clear that significant problems arise when this uniform approach is used for even the most rudimentary processing situations. Serious problems can be expected when this concept is applied broadly within the many complex processing situations found throughout industrial facilities covered by SARA Section 313.

Appendix K

Commission On Physical Sciences, Mathematics, And Resources

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