UNIVERSITY OF CALIFORNIA
Santa Barbara

THE ROLE OF ISO 14001 IN ENVIRONMENTAL MANAGEMENT AT U.S. MANUFACTURING FACILITIES

A Group Project submittal in partial satisfaction of the requirements for the degree of
Master's in Environmental Science and Management
for the
Donald Bren School of Environmental Science & Management

by

RYAN A. HARDING
BRANDY C. O'GORMAN
JOHN S. ONDERDONK
DEREK M. SWEATT
GREGORY M. TAMBLYN

Committee in Charge:
MAGALI DELMAS
JAMES FREW
CATHERINE RAMUS

April 7, 2003

THE ROLE OF ISO 14001 IN ENVIRONMENTAL MANAGEMENT AT U.S. MANUFACTURING FACILITIES

As authors of this Group Project report, we are proud to archive it on the Bren School's web site such that the results of our research are available for all to read. Our signatures on the document signify our joint responsibility to fulfill the archiving standards set by the Donald Bren School of Environmental Science & Management.

Ryan A. Harding

Brandy C. O'Gorman

John S. Onderdonk

Derek M. Sweatt

Gregory M. Tamblyn

The mission of the Donald Bren School of Environmental Science & Management is to produce professionals with unrivaled training in environmental science and management who will devote their unique skills to the diagnosis, assessment, mitigation, prevention and remedy of the environmental problems of today and the future. A guiding principle of the School is that the analysis of environmental problems requires quantitative training in more than one discipline and an awareness of the physical, biological, social, political and economic consequences that arise from scientific or technological decisions.

The Group Project is required of all students in the Master's of Environmental Science and Management (MESM) Program. It is a three-quarter activity in which small groups of students conduct focused, interdisciplinary research on the scientific, management, and policy dimensions of a specific environmental issue. The Final Group Project Report is authored by MESM students and has been reviewed and approved by:

Magali Delmas

Catherine Ramus

James Frew

Dennis Aigner

April 7, 2003

THE ROLE OF ISO 14001 IN ENVIRONMENTAL MANAGEMENT AT U.S. MANUFACTURING FACILITIES

ABSTRACT

In the modern era of environmental management, regulators and businesses are seeking more collaborative approaches to addressing facility environmental impacts. Voluntary environmental initiatives, such as ISO 14001, have gained popularity for their flexibility and applicability to a wide range of businesses and organizations. Despite its increasing popularity, ISO 14001 has not gained complete approval because it lacks performance requirements and because of perceptions that it does not adequately address the management of environmental impacts.

This study explored the relationship between environmental management practices and ISO 14001 certification by comparing ISO 14001 certified facilities with a control group of non-ISO 14001 certified to see if there were differences in their environmental management practices. Additionally, this study will determine if there is a difference between the ISO group and the non-ISO group in the chemical toxicity of releases and the chemical management practices.

This study finds that facilities with ISO 14001 certification do differ significantly in environmental practices from non-ISO 14001 certified facilities. In particular, facilities with ISO 14001 certification tended to have a stronger tendency toward integration and empowerment of facility managers and employees. This study also found that there was no statistically significant difference in the chemical toxicity of releases between the ISO group and the non-ISO group.

Authors:
Ryan A. Harding, Brandy C. O'Gorman, John S. Onderdonk,
Derek M. Sweatt, Gregory M. Tamblyn

Faculty Advisors:
Magali Delmas, James Frew, Catherine Ramus

ACKNOWLEDGMENTS

The members of the ISO 14001 Group Project would like to thank the following people for their assistance in completing this project.

Dennis Aigner – Dean, Donald Bren School of Environmental Science & Management
Christopher Costello – Assistant Professor, Donald Bren School of Environmental Science & Management
Bruce Kendall – Assistant Professor, Donald Bren School of Environmental Science & Management
Arturo Keller – Associate Professor, Donald Bren School of Environmental Science & Management
Annette Killmer – PhD. Candidate, Donald Bren School of Environmental Science & Management
Ivan Montiel – PhD. Candidate, Donald Bren School of Environmental Science & Management
Rosalie Skefich – President and Founder, Custom Environmental Services
Mel Willis – PhD., Donald Bren School of Environmental Science & Management

We would like to extend a special thanks to our faculty advisors.

Magali Delmas – Assistant Professor, Donald Bren School of Environmental Science & Management
James Frew – Assistant Professor, Donald Bren School of Environmental Science & Management
Catherine Ramus – Assistant Professor, Donald Bren School of Environmental Science & Management

TABLE OF CONTENTS

LIST OF FIGURES & TABLES

Chapter Two: Background

Chapter Three: Methodology

Chapter Four: Results

Chapter Five: Analysis And Discussion

EXECUTIVE SUMMARY

ES

Introduction

Modern environmentalism was born during the 1960s when social activism pressured governments and regulatory bodies into enacting command-and-control regulations. Command-and-control regulations worked well, but were perceived by firms to be top-down, rigid and overly restrictive. Since then, environmental regulation has gradually evolved to include market based regulations and voluntary environmental initiatives.

One of the most widely used voluntary environmental initiatives in the world is the ISO 14001 environmental management standard. ISO 14001 is an international environmental management standard that offers a systematic approach to complying with environmental regulations and continual improvement while being flexible and widely applicable to a variety of organizations. Despite these advantages, ISO 14001 has not gained complete approval in the United States. It could be argued that its (ISO 14001) flexibility and lack of performance requirements make it ineffective, or it inadequately addresses the management of environmental impacts.

This study explored the relationship between environmental management practices and ISO 14001 certification by comparing ISO 14001 certified facilities with a control group of non-ISO 14001 certified to see if there were differences in their environmental management practices. Additionally, this study will determine if there is a difference between the ISO group and the non-ISO group in the chemical toxicity of releases and the chemical management practices.

A team of five masters students from the Donald Bren School of Environmental Science & Management at the University of California, Santa Barbara conducted the analysis and prepared this report.

Background

Facilities manage their environmental management issues in different ways. Frequently, facilities implement environmental management systems (EMSs) to address environmental impacts. Facilities also use environmental performance indicators to assess the effectiveness of their EMS.

There are three EMS standards that utilize systems-based approaches to create an EMS that manages a specific organization's environmental impacts. They include the British Standard 7750 (BS 7750), Eco-Management and Auditing Scheme (EMAS), and ISO 14001.

ISO 14001 is being quickly adopted by many organizations around the world. As of 2000, there were 22,897 organizations in 98 countries with EMSs certified under ISO 14001 (International Organization for Standardization 2003a). It is also the most common EMS standard used in the U.S. ISO 14001 is one standard in the ISO 14000 series of standards developed by the International Organization for Standardization to provide a template for environmental management systems around the globe. ISO 14001 does not mandate the use of a particular technology, but rather requires the organization to make a commitment to compliance with applicable regulations and to continual improvement. Because there are no environmental performance requirements associated with ISO14001, it is useful to use an environmental performance metric to assess the effectiveness of ISO 14001.

The Toxic Release Inventory (TRI) is one such environmental performance metric. It is commonly used because of the accessibility of the data and because it provides a thirteen year time series set of data.

Methodology

This report compares facilities with ISO 14001 certified environmental management systems (ISO group) with facilities that do not have an ISO 14001 certified environmental management system (non-ISO group) by using two analyses.

The population selected for study in this report included manufacturing facilities that reported to the TRI in 2000 and fell within the Standard Industry Classification codes 2000 to 3999. A total of 484 facilities were selected to participate in this study. Half of these (242) had EMSs certified to the ISO 14001 standard prior to the year 2000. The other half were not certified and were selected at random from the remaining firms in the 2000 TRI.

The first analysis measured the implementation of environmental management elements based on responses to a survey sent to facility environmental managers in both the ISO group and the non-ISO group. These responses were compared to determine the differences between the two groups. Eight environmental management elements were used to assess the comprehensive nature of environmental management for each group. The eight elements include: environmental policy, management involvement, employee participation, training, target setting, monitoring, auditing and reporting.

The second analysis assessed the difference between the chemical releases reported to the TRI by the two groups. This chemical release analysis measured the difference in toxicity over both a five-year and ten-year time period. To account for the difference in toxicity of chemicals, a chemical toxicity ranking system was devised to normalize all the releases. Additionally, emission pathways for different chemicals were analyzed using an exposure ranking system based on high, medium and low exposure potential.

Results and Discussion

A total of 198 facilities responded to the survey representing a 40.9% response rate. The data collected from those 198 facilities revealed statistically significant differences between the ISO group and the non-ISO group related to their use of specific environmental management practices.

Facilities in the ISO group were more likely to have more comprehensive implementation of the following elements: environmental policy, management involvement, employee participation, training and environmental initiatives. Additionally, when these results were studied in aggregate, an interesting trend emerged. The environmental management practices in the ISO group facilities permeated all levels of the organization, showing a stronger tendency toward integration and empowerment of facility managers and employees. This tendency had two dimensions; (1) facility managers participated in developing their facility's specific environmental practices; (2) non-management employees were included in the management decision-making processes. The data collected from the chemical release comparison did not reveal statistically significant differences between the ISO group and the non-ISO group. These findings may be explained by the high level of existing regulation associated with these industries. Additionally, the public nature of TRI data may motivate both groups equally to reduce emissions.

Further Study

Future research on ISO 14001 would benefit by further analyzing the impact of the new ISO standards, utilizing alternative environmental performance metrics and acquiring more detailed information at the facility level.

1 CHAPTER ONE – INTRODUCTION

In the United States, environmentalism came to the forefront of the nation's conscience during the 1960's and 1970's. During this period many important pieces of environmental legislation existing today were passed into law[1]. The Environmental Protection Agency (EPA) was tasked with enforcing these new regulations. The EPA implemented a command-and-control environmental policy framework that separately addressed pollution by environmental media such as water and air. That framework proved effective in mitigating environmental impacts, but was often perceived as being top-down, rigid and overly restrictive.

In response to the drawbacks of this regulatory framework, several new approaches arose. One approach used market instruments, such as tradable permits, to equate private and social costs, allowing the market to control pollution. Another approach grew from the private sector as firms started to manage the environmental impacts of their businesses to control costs and increase efficiency. This initial move toward proactive management has gained in popularity recently with an increase in toxic chemical torts, tarnished corporate images, and increased competitive pressures in the marketplace. Today, voluntary environmental initiatives are viewed to be a more flexible and systematic way of addressing environmental impacts than earlier command-and-control regulations.

To meet industry's needs for voluntary environmental initiatives, the International Organization for Standardization (ISO) created ISO 14001, a business-led voluntary initiative to manage environmental impacts. It offers a systematic approach to environmental management that promotes compliance with existing environmental regulations. In addition, it emphasizes continual improvement and incorporates environmental decision-making throughout all levels of the organization. ISO 14001 has gained international acceptance outside the U.S. because it is both flexible and widely applicable to a variety of organizations such as manufacturers, service providers and government agencies, enabling it to address both the increasing regulatory complexity and the growing social awareness of environmental impacts.

Despite its many perceived benefits, ISO 14001 has not gained complete approval in the U.S. As of 2000, there were 1,042 ISO 14001 certified facilities in the U.S. (International Organization for Standardization 2003b). It could be argued that its (ISO 14001)

[1] This includes the National Environmental Policy Act in 1969, the Clean Air Act in 1970, the Clean Water Act in 1977, the Endangered Species Act in 1973, the Resource Conservation and Recovery Act in 1976 and the Toxic Substances Control Act in 1976.

flexibility and lack of performance requirements make it ineffective, or it inadequately addresses the management of environmental impacts.

This study explored the relationship between environmental management practices and ISO 14001 certification by comparing ISO 14001 certified facilities with a control group of non-ISO 14001 certified to see if there were differences in their environmental management practices. Additionally, this study will determine if there is a difference between the ISO group and the non-ISO group in the chemical toxicity of releases and the chemical management practices.

This study will allow firms in the manufacturing industry to make a more educated choice on whether or not to adopt ISO 14001 as a tool to improve environmental management. The results will also provide environmental managers and external stakeholders with insights into the role of ISO 14001 in environmental management.

A team of five masters students from the Donald Bren School of Environmental Science & Management at the University of California, Santa Barbara conducted the analyses and prepared this report. Chapter 2 of this report provides the background of the major components of the analyses including environmental management systems, the ISO 14000 series and the Toxic Release Inventory. Chapter 3 details the methodology used in completing the analyses. Chapter 4 presents the survey and analysis results. A discussion of those results can be found in Chapter 5 and the student researchers' recommendations for future study can be found in Chapter 6. The appendices include a list of EMS elements, an EMS model, the ISO 14000 family of standards, a copy of the environmental management survey, chemical toxicity information and complete survey results.

2 CHAPTER TWO – BACKGROUND

In order to understand the role of ISO 14001 in modern environmental management, it is necessary to understand how firms approach the management of their environmental issues. This chapter, will describe environmental management systems, the role of the International Organization for Standardization in environmental management, the specifics of ISO 14000 series, and the Toxic Release Inventory and its role in assessing performance of environmental management.

2.1 Environmental Management Systems

An environmental management system (EMS) is a formal set of procedures and policies that define how an organization will manage its potential impacts on the environment, creating a system to assess, record, and quantify facility environmental impacts. Benefits from an effective EMS include:

- Direct savings from increased efficiency, reductions in waste disposal and energy costs;
- Indirect savings from improved corporate image;
- Avoided costs such as fines, legal costs, insurance premiums, and cleanup costs (Kirkland, Thompson 1993).

EMSs are intended to make complex environmental issues more manageable for firms but may require intricate implementation plans. To assist businesses with the implementation of EMSs, the Environmental Protection Agency (EPA) and the National Science Foundation have developed guidance documents that precisely define the key elements of an effective EMS such as an environmental policy, objectives and targets. These elements, presented in Appendix 1, can be applied to any type of organization that has an environmental impact. The EMS model includes a five-step framework to assess, monitor and track environmental impacts to ensure continual improvement and allow individual organizations to develop a tailored system that appropriately addresses their impacts. The five steps are listed below. A visual depiction of these five steps can be found in Appendix 2.

- First, an environmental policy is created that integrates key concepts and ideas that reflect the firm's commitment to the environment.
- Secondly, planning is undertaken to identify objectives and targets, legal requirements, environmental impacts, and an appropriate structure for the environmental management system.
- The third step is the implementation of processes that include responsibility, employee training, communication, documentation, and emergency preparedness.

- The fourth step, auditing the EMS and taking corrective action, is designed to continuously improve the EMS and give the company the ability to easily integrate changes in their business strategy with the management of their environmental impacts.
- The final step involves a management review of the audit results to identify opportunities for improvement. At this point, the environmental policy may be reworked to incorporate changes recommended by management. (Stapleton, Glover, Davis 2001)

There are three EMS voluntary standards that utilize systems-based approaches to create an EMS that manages an organization's environmental impacts. The three standards are British Standard 7750 (BS 7750), European Union's Eco-Management and Auditing Scheme (EMAS), and ISO 14001. All three standards allow for certification. These standards are designed for organizations of all different types and sizes. The subsequent paragraphs describe each of these three EMS standards in more detail.

The British Standards Institute created BS 7750 in 1992. It is designed to "describe the company's EMS, evaluate the performance and to define policy, practices, objectives and targets; and provides a catalyst for continual improvement" (Quality Network 1996a). BS 7750 has been re-designed to be compatible with EMAS and ISO 14001. The standard puts a heavy emphasis on the development of a publicly available environmental policy that is supported by upper management and that outlines the policies of the company.

EMAS is a European Union-based standard designed around adopted regulations. The standard assigns an important role to external communications through the Environmental Declaration in order to increase the clarity of communications on environmental performance between certified organizations, stakeholders, and the public. Within EMAS, it is mandatory that the policy statement, the environmental program, the management system, and audit cycles are reviewed and validated by an external auditor accredited by EMAS (Quality Network 1996b).

ISO 14001 requires a commitment to continual improvement and compliance with existing regulations. The broad standard does not specify the scope of the EMS, which can apply to any single process or a combination of processes. It does not specify specific levels of environmental performance, but rather requires the identification of environmental impacts and establishes a systematic way to address those impacts.

BS 7750, EMAS and ISO 14001 share many similar characteristics, but differ in their geographic area of acceptance. BS 7750 and EMAS are both primarily used in Europe. Recently, EMAS has replaced BS 7750 as the dominant standard in Europe. ISO 14001 is being quickly adopted by many organizations around the world. ISO 14001 is also the most common EMS standard used in the U.S. This analysis will focus on ISO 14001 because it is playing an increasingly important role in environmental management in the U.S.

2.2 International Organization for Standardization

The International Organization for Standardization is a non-governmental organization established in 1947. The mission of this worldwide federation of national standards bodies is to promote the development of standardization in order to facilitate the international exchange of goods and services. (International Organization for Standardization 2002a). Standards specify criteria that if used consistently will ensure that products, services, and processes work as they are intended. The overall goals of international standards are to facilitate trade and exchange through:

- enhanced product quality and reliability,
- improved health, safety and environmental protection, and
- greater compatibility and interoperability of goods and services (International Organization for Standardization 2002a)

ISO standards have addressed such diverse areas as credit cards, photographic film, quality management systems, freight containers, the scientific system of measurement, and international codes for country names, currencies and languages. The standards that are developed are completely voluntary. As a non-governmental organization, ISO does not have the ability to impose its standards on others (Cascio, Woodside, Mitchell 1996).

2.3 The ISO 14000 Series

Amidst a backdrop of a growing awareness of environmental problems, the United Nations announced its 1992 conference on Environment and Development to be held in Rio de Janeiro. The organizers requested the participation of ISO, and a commitment by the organization to create an international environmental standard (Cascio, Woodside, Mitchell 1996). By early 1993, a committee, comprised of business and government experts from 55 countries, had been established to oversee the development of a series of international environmental standards (Cascio, Woodside, Mitchell 1996). The ISO 14001 standard was finalized in 1996 (International Organization for Standardization 2003c).

Unlike most other ISO standards, which are specific to a particular product, material, or process, the ISO 14000 series applies to a generic environmental management system. It is intended to be applicable to any organization regardless of its size, ownership, product/service type, or current level of environmental performance. Appendix 3 presents the ISO 14000 family of standards. ISO 14001 is the first document in the series and lays out the elements of an effective environmental management system. This is the only part of the series that can be certified. The remaining 24 documents provide additional information and guidance on issues relevant to environmental management. (International Organization for Standardization 2002a)

2.4 ISO 14001

The ISO 14001 standard, entitled "Environmental Management Systems – Specification with guidance for use", outlines the core elements of an effective environmental management system and aims to integrate environmental management into the overall

management activities of an organization. ISO 14001's goal of "support[ing] environmental protection and prevention of pollution in balance with socio-economic needs" is not achieved by specifying technologies or levels of environmental performance. Instead, the standard requires that the organization make a commitment to both compliance with applicable environmental regulations and to continual improvement. Table 2.1 describes the elements of an EMS as outlined in the ISO 14001 standard (International Organization for Standardization 2002a)

Table 2.1 – Elements of the ISO 14001 Standard

Element	Description
Environmental Policy	Develop an adequate and appropriate statement on the organization's commitment to the environment
Environmental Aspects and Impacts	Identify environmental attributes of products, activities and services and their effects on the environment
Legal Requirements	Identify and ensure access to relevant laws and regulations
Objectives and Targets	Set environmental goals for the organization, and develop the means to achieve them
Environmental Management Program	Plan actions to achieve objectives and targets
Structure and Responsibility	Establish roles and responsibilities within the organization
Training, Awareness and Competence	Ensure that employees are aware and capable of their environmental responsibilities
Communication	Develop processes for internal and external communication on environmental management issues
EMS Documentation	Maintain information about the EMS and related documents
Document Control	Ensure effective management of procedures and other documents
Operational Control	Identify, plan and manage the organization's operations and activities in line with the policy, objectives and targets
Emergency Preparedness and Response	Develop procedures for preventing and responding to potential emergencies
Monitoring and Measuring	Monitor key activities and track performance
Nonconformance and Corrective and Preventive Action	Identify and correct problems and prevent recurrences
Records	Keep adequate records of EMS performance
EMS Audit	Periodically verify that the EMS is effective and achieving objectives and targets
Management Review	Top management periodically reviews the EMS to ensure that it is still suitable and appropriate

Adapted from: North Carolina Division of Pollution Prevention and Environmental Assistance 2002

2.5 Certification

If all of the elements of an EMS identified in Table 2.1 are in place, an organization may declare that it has successfully implemented the standard. An alternative to this self-declaration is to have an external party certify that the organization has implemented an EMS that meets the requirements of the ISO 14001 standard (International Organization for Standardization 2002a). An organization may choose to certify its environmental management system to comply with a business partner's request, to gain access to markets or capital, or as a public demonstration of environmental stewardship (Delmas 2000). For example, Ford has implemented a policy in which all suppliers shipping products to Ford must be ISO 14001 certified by July 1, 2003 (Ford Motor Company 2003).

Certification is performed by an independent auditing/registrar company, and can require several days at a facility to complete. The certification audit verifies the presence and maintenance of an effective EMS by reviewing objective evidence, such as documentation, and by interviewing managers and employees (International Organization for Standardization 2002a). ISO 14001 certification does not signify that products or services themselves are "green" or "environmentally friendly". No product can be certified under ISO 14001. The International Organization for Standardization specifically prohibits companies from labeling products as "ISO 14001-certified" (International Organization for Standardization 2002a).

2.6 Environmental Performance Indicators

Companies that have invested the resources to develop an EMS also require a means to track their environmental performance and their progress toward goals. To satisfy those needs, many companies have looked to environmental performance indicators (EPIs), which are quantifiable, widely accepted, and transparent measurements that provide information on the progress toward operational goals and objectives (Thompson 2002). Stakeholders also benefit from the use of EPIs since they improve corporate transparency.

Enhanced environmental performance can be measured by either operational, managerial or conditional performance indictors (EPIs) (Committee on Industrial Environmental Performance Metrics 1999). Operational EPIs focus on inputs and outputs and can be based on material or energy use, physical facilities or equipment, products, wastes and emissions. Some examples of managerial EPIs include the number of pollution prevention initiatives implemented, the number of levels of management with environmental responsibilities or the number of employees whose job descriptions include environmental responsibilities. Conditional EPIs have to do with the condition of the environment surrounding a particular facility, such as ambient air pollution levels, surface water pollution or biodiversity. In all cases, these EPIs focus on the efficiency and effectiveness of the EMS being implemented based on information that may only be available internally.

One EPI that is widely used by external stakeholders is the Toxic Release Inventory (TRI) because it is publicly available. Gerde, et. al. show that numerous studies have used the TRI as an EPI. (Gerde, Logsdon 2001) Despite its utility, TRI data by itself cannot be considered a complete indicator of environmental performance, but it is one of the most transparent and assessable components of a facilities' environmental performance.

2.7 The Toxic Release Inventory

The TRI is a publicly available database, administered by the EPA, that contains information on toxic chemical releases and other waste management activities reported by certain industries and federal facilities. This inventory was established under the Emergency Planning and Community Right-to-Know Act of 1986 and then expanded by the Pollution Prevention Act of 1990. (EPA 2002a) The advantage of using the TRI for environmental performance analysis is that the TRI data is available for 28,000 facilities from 1987 to 2000. Facilities in specific industries that manufacture, process, or use significant amounts of toxic chemicals, are required by law to report on their releases. Information, about the chemical and quantity released to the air, water and land is reported to the TRI each year. Similar information is also reported for chemicals sent to other facilities for further waste management. (EPA 2002b)

The information reported by TRI has changed over the years. Since 1987, the first year of TRI reporting, the number of chemicals listed has doubled and federal facilities have been added to the reporting population. (EPA 2001). The specific industry sectors that were originally required to report are designated by Standard Industry Classification (SIC) codes[2] 2000 through 4000 (EPA 2002d). In 1998, seven new industries were required to report to the TRI.[3] In 2000, a facility was required to report if it fell within specific industry sectors, had 10 or more employees, manufactured or processed more than 25,000 pounds or otherwise used more than 10,000 pounds of any of the 582 listed chemicals.

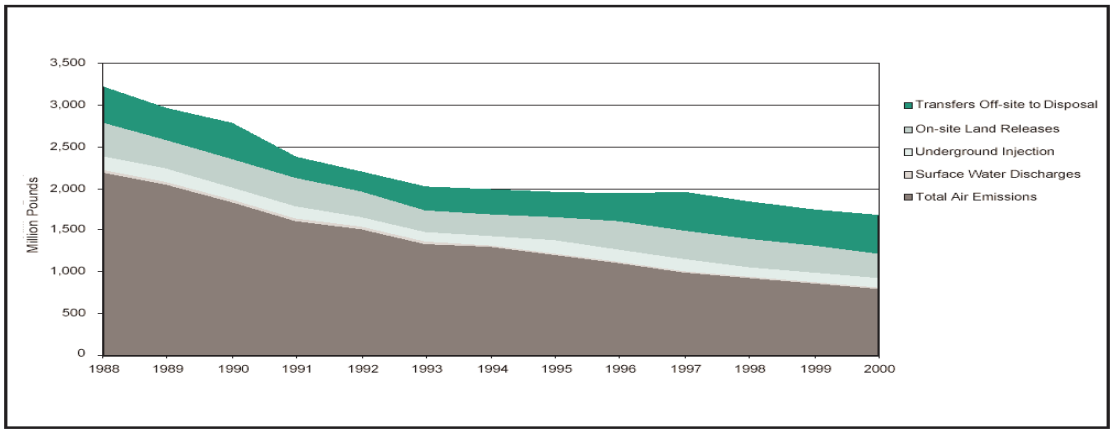
Since the TRI makes information on toxic releases public available, companies are encouraged to focus on their chemical management practices. The data also serves as an indicator of environmental progress over time. (EPA 2002c). As shown in Figure 2.1, since the introduction of TRI reporting, industries have reduced their on- and off-site releases of TRI chemicals by more than 48% or 1.6 billion pounds[4] (EPA 2001).

[2] The SIC code is a four digit industry identifier of which the first two digits organize industry into general categories.

[3] The seven industries added were: Metal mining (SIC 10, except 1011, 1081, and 1094), coal mining (SIC code 12, except 1241), electrical utilities (SIC 4911, 1931, and 4939), RCRA hazardous waste treatment and disposal facilities (SIC 4953), chemical wholesale distributors (SIC 5169), petroleum bulk plants and terminals (SIC 5171), and solvent recovery (SIC 7389).

[4] For chemicals reportable in all years.

Figure 2.1 – Distribution of TRI On-site and Off-site Releases, Original (Manufacturing) Industries, 1988-2000



Note: Does not include delisted chemicals, chemicals added in 1990, 1994 and 1995, aluminum oxide, ammonia, hydrochloric acid, PBT chemicals, sulfuric acid, vanadium and vanadium compounds. **On-site Releases** are from Section 5 of Form R. **Off-site Releases** are from Section 6 (transfers off-site to disposal) of Form R. **Off-site Releases** include metals and metal compounds transferred off-site for solidification/stabilization and for wastewater treatment, including to POTWs.

Source: 2000 Toxic Release Inventory Public Data Release Report – Executive Summary

3 CHAPTER THREE - METHODOLOGY

This report compared facilities with ISO 14001 certified environmental management systems (ISO group) with facilities that do not have an ISO 14001 certified environmental management system (non-ISO group) by using two analyses. Facilities in both groups were selected from U.S. manufacturing industries that report to the Toxic Release Inventory (TRI).

The first analysis measured the implementation of environmental management practices based on responses to a survey sent to facility environmental managers in both the ISO group and the non-ISO group. These responses were compared to determine the differences between the two groups. This analysis is referred to as the environmental management analysis.

The second analysis assessed the different trends in chemical releases between the chemical releases reported to the TRI by the two groups. This analysis is referred to as the chemical release analysis.

3.1 Sample Selection

For this study, the target population consists of United States manufacturing facilities that reported to the TRI in the year 2000. Quality Systems Update Publishing (QSU) provided a list of ISO 14001 certified facilities in the *ISO 14001 Registered Company Directory-North America*. (Quality Systems Update Publishing Company 2002) All facilities on this list that reported to the 2000 TRI, were certified between 1996 and 2000, and were within Standard Industry Classification (SIC) codes 2000 to 3999 were selected as the ISO group.

The year 1999 was chosen as the ISO certification cut-off date so that any changes in releases after certification could be observed. Facilities in the SIC code range of 2000 to 3999 were chosen because they were required to report to TRI since 1986 which is prior to all ISO 14001 certifications.

An additional 242 facilities (non-ISO group) that were not certified to the standard were selected from the remaining firms in the 2000 TRI (SIC codes 2000 – 3999). These non-certified facilities were selected using a random number generator. The total sample size was limited to 484 facilities in order to meet budget and time constraints. Figure 3.1 presents a graphical depiction of the sampled population.

Figure 3.1 – Graphic Representation of Sampled Population

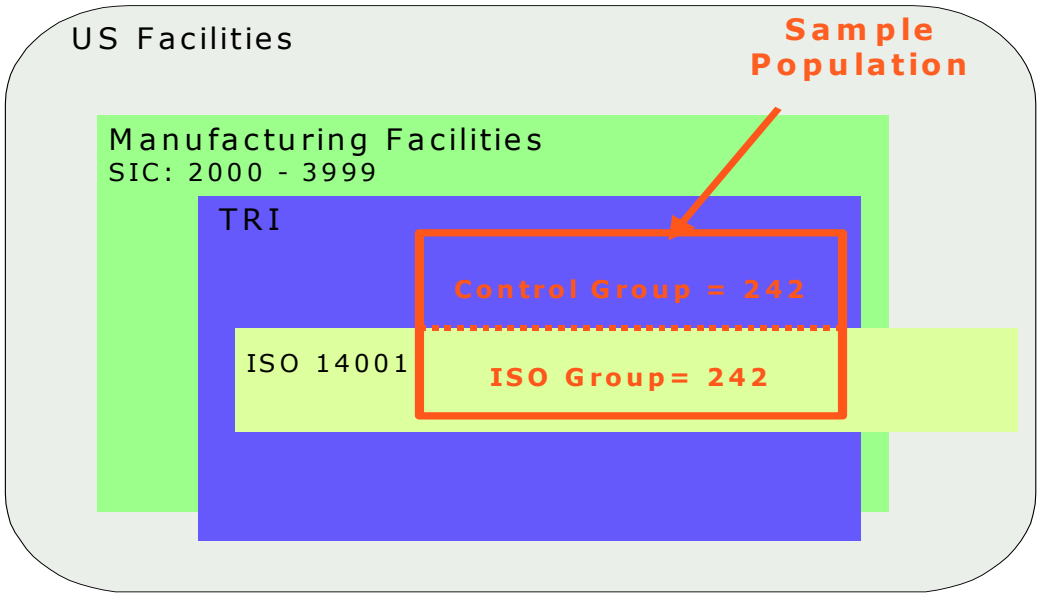


Figure not to scale

Table 3.1 presents the number of surveys mailed to the non-ISO group compared to the total number of TRI facilities by SIC code. The similarity in the distribution of all year 2000 TRI reporting facilities and the randomly selected non-ISO group indicates that the non-ISO group represents the underlying population well (Figure 3.2).

Table 3.1 – Non-ISO Group Sample Population and the Total Number of TRI Reporting Facilities (SIC codes 2000 – 3999)

SIC Code	SIC Description	All TRI Facilities	Non-ISO Group
2000	Food Manufacturers	1735	19
2100	Tobacco Manufacturers	27	0
2200	Textile Mill Products	321	3
2300	Apparel & Other Textiles	22	1
2400	Lumber & Wood Products	890	8
2500	Furniture & Fixtures	347	2
2600	Paper & Allied Products	544	7
2700	Printing & Publishing	220	1
2800	Chemical & Allied Products	3820	52
2900	Petroleum Refining	580	12
3000	Rubber & Misc. Plastic Products	2010	18
3100	Leather & Leather Products	73	1
3200	Stone, Clay & Glass Products	801	7
3300	Primary Metal Industries	2134	28
3400	Fabricated Metal Products	3097	34
3500	Industrial, Commercial Machinery	1218	9
3600	Electronic Equipment	1245	15
3700	Transportation Equipment	1398	16
3800	Instruments & Related Products	283	6
3900	Miscellaneous Manufacturing	328	3
Totals		21093	242

Figure 3.2 – Relative Distribution of Year 2000 TRI Facilities and Non-ISO Group Facilities Selected to Receive Survey

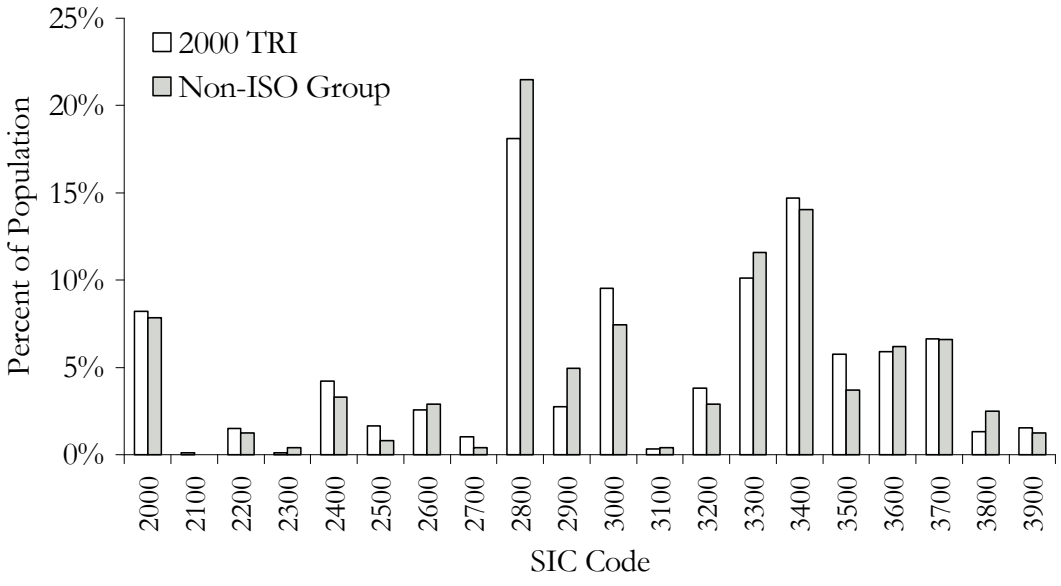
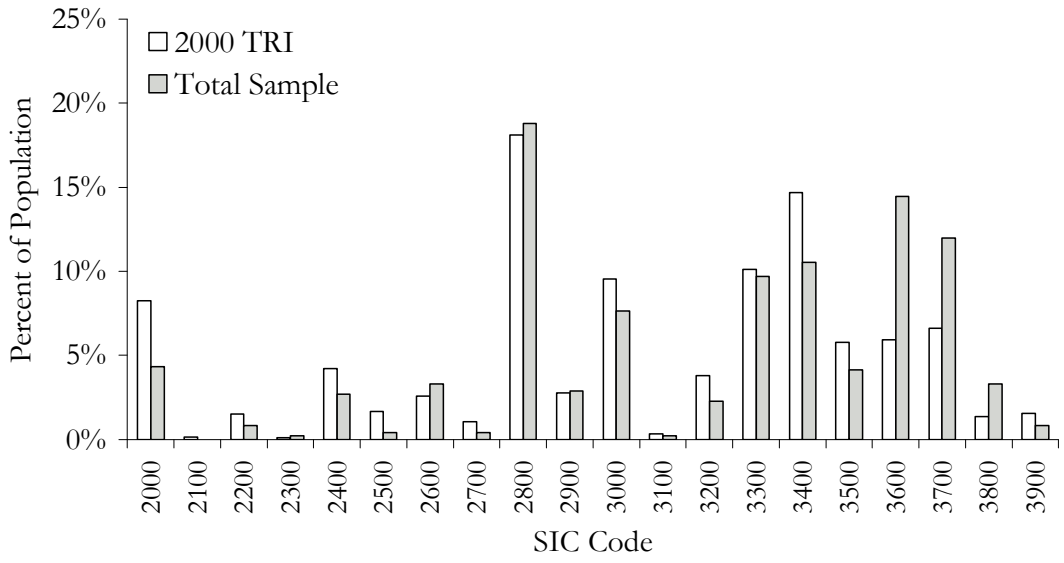


Figure 3.3 shows that the samples of the two strata taken together also approximate the distribution of all 2000 TRI reporting facilities well. The primary differences are that the total sample of 484 facilities contains a relatively smaller proportion of food manufacturers and fabricated metal producers (SIC codes 2000 and 3400), and a higher proportion of electronics producers and transportation equipment manufacturers (SIC codes 3600 and 3700).

Figure 3.3 – Relative Distribution of Year 2000 TRI Facilities and all Facilities Selected to Receive Survey



3.2 Environmental Management Analysis

A survey was developed to analyze the extent of implementation of environmental management practices of the ISO group and the non-ISO group. Prior to designing the survey, a literature review was conducted to determine which environmental practices to analyze. Based on this literature review, the authors of this study categorized the environmental management practices into eight elements that were found to be ubiquitous throughout environmental management. The importance of these eight elements of an EMS was confirmed during focus groups held with industry specialists. The eight elements of environmental management developed for this study are:

- Environmental Policy - statement of an organization's commitment to the environment
- Management Involvement – extent to which management employees are involved in environmental activities
- Employee Participation - extent to which non-management employees are involved in environmental activities
- Training – ensuring employees are trained and capable of carrying out their environmental responsibilities

- Target Setting – establish environmental goals for an organization, in accordance with their policy, environmental impacts and other factors
- Monitoring – monitor key activities and track performance
- Auditing – periodically verify that the EMS is operating as intended
- Reporting – provide environmental information regarding facility operations

Some facilities in this analysis may have an EMS while other facilities may not have a systematic procedure to manage environmental impacts, but these widely accepted elements are the basic components of environmental management, whether contained within a systematic framework, such as ISO 14001, or developed independently. (Stapleton, Glover, Davis 2001)

3.2.1 Question Development

Question development for the environmental management survey relied on published and unpublished questions from previous environmental management questionnaires as well as questions developed exclusively for this survey. Questions in the survey were tested with focus groups whose members included environmental managers at Toyota Motor Sales, CH2M Hill, Tetra Tech, and members of academia to ensure the questions were valid and readily understandable by environmental managers.

3.2.2 Survey Structure

The survey was structured to allow the respondent to answer questions regarding all eight environmental elements for both their facility and their corporate headquarters, if applicable. Questions regarding the environmental managers' facility preceded questions regarding the respondents' corporate headquarters because the survey authors felt the respondents were likely to have more knowledge about their specific facility and would therefore be more likely to fill out the survey. Questions that did not fit the respondents' facility were preceded by the appropriate 'skip' directions to allow the respondents to complete the survey in a timely manner. Please refer to Appendix 4 for a complete copy of the survey.

The respondents were guaranteed that information provided for this research would not be used against their company in the future, respondents were guaranteed that information would be kept strictly confidential and specific results would only be reported in aggregate. Survey respondents were also asked to provide additional information if they wished. The following paragraphs describe the various sections of the survey and provide sample questions for each section.

Section 1 – General Facility Information

The general facility questions characterize the respondents' facility. This information was used to characterize the population demographics.

> General Facility Information Sample Question:
> *Does your facility have an Environmental Manager or equivalent that is responsible for environmental issues at your facility?*

Section 2 – Facility Environmental Policy

This section was developed to determine whether or not the facility has an environmental policy as well as to determine to what the environmental policy applies and how the environmental policy is made available to employees.

> Facility Environmental Policy Sample Questions:
> *Please indicate to which of the following areas the facility environmental policy applies.*
> *How is the facility environmental policy made available to employees?*

Section 3 – Environmental Management System

Section three focused on the presence of an EMS for the facility and the extent to which the EMS addresses the facility's environmental issues.

> Environmental Management System Sample Questions:
> *Does your facility have a documented environmental management system?*
> *How effective is your EMS at helping the facility manage the following issues?*

Section 4 – ISO Certification

This section addressed whether or not the respondents' environmental management system and quality management system are ISO certified and the reasons for pursuing certification.

> ISO Certification Sample Question:
> *Is your Environmental Management System ISO 14001 certified?*

Section 5 – Environmental Performance Indicators

Section five addressed whether or not the respondents' facility uses environmental performance indicators (EPI) to measure the firm's management of environmental issues.

> Environmental Performance Indicator Sample Question:
> *What type of EPI does your Facility use?*

Section 6 – Employee Participation

Questions in this section focused on environmental information dissemination, environmental training, and environmental awards presented to employees for contributions to environmental performance.

> Employee Participation Sample Questions:
> *How do individual employees at your facility receive information regarding environmental issues?*
> *How is environmental training delivered to employees?*
> *Does your facility present awards to its employees for contributions to environmental performance?*

Section 7 – Facility EMS Review and Internal Audits

Questions in this section addressed the review and auditing of a facility's environmental management system.

> Facility EMS Review and Internal Audits Sample Questions:
> *How often is your facility's overall EMS reviewed?*
> *Does your facility have an environmental audit program?*

Section 8 – Corporate Environmental Management

The last section refers to corporate environmental management and addresses general questions that characterize the corporate headquarters, the parent company, communication between the facility and parent company, environmental reporting, corporate environmental target setting as well as company wide programs to formally assess the environmental impacts of the company. At the end of this section, the respondents were encouraged to provide feedback or any additional comments.

> Corporate Environmental Management Sample Question:
> *How does your facility receive information from the parent company or corporate headquarters regarding environmental issues?*

3.2.3 Survey Administration

In order to ensure a high response rate, firms were contacted via telephone to identify the correct respondent, correct mailing address and to determine if the respondent would prefer to reply via hard copy (mail) or electronic mail (e-mail). If the appropriate individual could not be reached directly, a message was left with a company representative. In order to allow respondents ample time to respond it was determined that the mail and e-mail surveys would be administered in three rounds with a three week lag between mailings. A cut-off date for receiving surveys was established so that the analysis of the results could be conducted. Table 3.2 provides the timetable for the administration of the survey.

Table 3.2 – Survey Administration Timetable

Mailing Round	Date
Round 1	October 11, 2002
Round 2	November 14, 2002
Round 3	December 13, 2002
Cut-off	January 10, 2003

3.2.4 Data Management

Contact information was collected into a database that enabled researchers to track which facilities had been notified of the survey by phone, had been mailed or emailed the survey, and had returned the survey. Returned survey data was entered into a Microsoft Access database and then modified in the following way. The 'other' categories were grouped and simplified and, if necessary, respondent comments in the margins were interpreted and used to clarify survey answers. Responses of 'don't know' were generally interpreted as 'no' for the purpose of this analysis. The reasoning for this was that the survey was being sent to persons knowledgeable of environmental practices at the facility (e.g., the environmental manager) and that this person would be aware of these practices if they existed. 'Don't know' responses were not changed if it was determined that a person reasonably familiar with environmental practices may not be aware of the answer to the question. Examples of this are questions that relate to the corporate headquarters or parent company of the facility.

3.2.5 Analysis of Survey Responses

The goal of the environmental management survey is to determine the difference in implemented environmental management practices between the ISO group and the non-ISO group.

The environmental management analysis hypothesis states that facilities with ISO 14001 certified EMSs will implement a more comprehensive combination of the eight environmental management elements. The environmental management analysis was done primarily through non-parametric statistics. Non-parametric tests are estimates of confidence to accept or reject hypotheses. Based on the type of data available for this study, Chi-squared tests and Fisher's Exact Test have been calculated using the SPSS® statistics package. For two-by-two cross tabulation tables, the Fisher's Exact test was used to determine the differences between the ISO group and the non-ISO group. For two-by-three and larger cross tabulation tables, Chi Squared tests were used to determine the differences between the two groups.

The Chi-square (X^2) test is a non-parametric test that can be used to determine statistical independence between rows and columns. It is based on the difference between observed frequencies and the frequencies that would be expected if there were no relationship between rows and columns. This test allows a researcher to statistically determine if there is, or is not, a statistically significant relationship between rows and columns.

$$X^2 = \sum \frac{(f_{observed} - f_{expected})^2}{f_{expected}}$$

For this analysis, the question was to determine whether or not the ISO group responded to the environmental manager survey differently than the non-ISO group. A Chi-square probability of 0.05 or less is commonly accepted by social scientists as a basis to reject the null hypothesis that the row and column variables are unrelated.

The Fisher's Exact Test is a nonparametric test that uses a hyper-geometric distribution. It produces a p-value that is the sum of the probability of observing a given cross-tabulation for two dichotomous variables or more extreme combinations of the rows and columns. The Fisher's exact test is appropriate when cell values are large, and even when cell values are less than five (Goetz 2002).

Environmental Management Analysis – Hypothesis:
Facilities with an ISO 14001 certified EMS will have more comprehensive environmental management practices than facilities with a non-certified EMS.

3.3 Chemical Release Analysis

This analysis used the U.S. EPA Toxic Release Inventory (TRI) as a metric for comparing the environmental performance of the ISO group with the non-ISO group within our sample population[5].

Chemicals released to the environment by manufacturing activities vary tremendously in relative toxicity and in the risk posed to human health. The fate and transport of chemicals once they are released to water, air, or land, is complicated and often depends on the local conditions. This makes it difficult to create a generalized nationwide model that can determine the human health risk associated with these emissions. Therefore, many studies that have used the TRI emissions as an environmental performance indictor have not incorporated the threat posed to the environment and the associated risk to human health, but rather have focused on the total quantity of emissions (Gerde, Logsdon 2001). This approach is problematic because a facility may reduce the toxicity of their releases by switching to a less toxic chemical, but may increase the quantity of their emissions. In this case, just measuring quantity would give the appearance that there was an increased environmental impact when in fact there was an overall improvement to the environment or human health. In addition, studies that aggregate emissions regardless of type of release do not take into account chemical disposal management practices in determining environmental performance. This analysis has

[5] The information in the TRI is compiled from reports completed by each facility. In some cases, facilities do not have monitoring equipment that gives precise measurements of releases. In these cases, releases are reported as estimates or as a range. The TRI reports ranges as the midpoint of that range and accepts estimated data. This should be taken into account when considering the precision of the reported data.

attempted to address these two challenges by ranking toxicity within three different exposure potential categories, in addition to comparing total releases for each chemical.

3.3.1 Toxicity Ranking

To account for the difference in toxicity of chemicals, a chemical toxicity ranking system using the Permissible Exposure Levels (PELs) was devised to normalize all the releases on the basis of acute toxicity. The toxicity scoring system was designed to maximize the number of facilities and emissions that could be used in this analysis.

Permissible exposure levels, developed by the Occupational Safety and Health Administration (OSHA), are a Time Weighted Average (TWA) expressed in milligrams of compound in a cubic meter of air (mg/m^3). Although the TWAs apply to air emissions, it infers a level of toxicity that has been used for the other medium in this study such as water and land. A TWA is the amount of a substance that an average worker is permissibly exposed to during an 8-hour work period. TWAs from OSHA and the National Institute for Occupational Safety and Health (NIOSH) create an acute toxicity index that when applied to the TRI emissions create a toxicity score for each facility, which can then be analyzed to determine differences in emission management.

The primary source for the TWAs used in the scoring system was OSHA, however, the NIOSH Recommended Exposure Levels were used as an alternate TWA if OSHA did not list a PEL for a released chemical. If neither source contained a TWA for a particular chemical, then the compound was eliminated from the study. TWAs were available for 58% of the chemicals released by the sample population of 484 facilities. All of the TWAs and toxicity rankings are listed in the Appendix 5.

To create the ranking system, the TWA was inverted (Carnegie Mellon University 2002). Inverting the TWA ranks compounds with a low TWA as more toxic. For instance, Arsenic has a TWA of .01 mg/m^3 implying that a human can only be exposed to small amounts due to its high toxicity. After inverting the TWA, Arsenic's toxicity ranking becomes 100. Compare that with Styrene, which has a TWA of 426 mg/m^3, which when inverted yields a toxicity ranking of 2.34×10^{-3}. In the ranking system, the highest ranked compound is the most toxic. Therefore, Arsenic is more toxic than Styrene.

All of the toxicity ranks for each chemical were then multiplied by the emissions reported to the TRI to gain a toxicity score for each emission per facility. All of the toxicity ranks were converted into pounds per cubic meter of air to match the units of the emissions. Toxicity scores were then summed for each facility for each reporting year.

$$\frac{1}{TWA_x}\left(Emissions_x\right) = Toxicity\ Score$$

3.3.2 Exposure Ranking

To account for emission pathways, each type of release reported by the TRI was divided into one of three categories: high exposure potential, medium exposure potential, and low exposure potential. The high exposure potential included all emissions that were directly released to air or water. The medium exposure potential included all direct emissions to land while the low exposure potential included all releases to off-site management activities such as recycling or landfilling. A complete list of the different release types and their corresponding exposure category can be found in the Appendix 6.

The medium exposure potential category includes emissions to land, from activities such as surface impoundments and farming operations. Due to the small number of facilities in the population with these types of releases, there was not enough information to run an analysis for the medium exposure potential category, but these emission were included in the analysis of total emissions.

The low exposure potential category does not imply the absence of immediate or future risk, but it is a way to include all emissions without aggregating them with direct emissions to the environment. This analysis does not attempt to determine the risk associated with long-term disposal practices, but simply acknowledges the relative difference between this disposal practice and direct emissions to the environment.

Each facility has a series of three toxicity scores, using the toxicity ranking methodology, that apply to the three exposure potentials. These scores were calculated for the emissions in the years 1990, 1995 and 2000.

These years were selected to evaluate the change in emissions over five and 10-year periods. The year 2000 was used because it is the most current year of data available. The year 1995 was chosen as a point of measurement because it is prior to most of the ISO certification dates and had the majority of the sample population reporting releases. The first ISO 14001 certification in our sample was in 1995 followed by two in 1996 with the remainder in 1997 or after. The year 1990 was chosen as a comparison to account for any irregularities in the five-year data. As a result, this analysis provides a picture of the reduction in releases before and after ISO 14001 certification. Firms that certified their EMS after 1999 were not included in this analysis.

Although this report uses TRI as the one indicator of a facility's environmental impact, there are many other impacts that are not measured by TRI. These are significant and include activities such as, but not limited to, recycling, improvements in energy efficiency, and source reduction of nontoxic raw materials.

3.3.3 Production Level

The toxicity scores do not provide a complete picture of trends over time because of manufacturing changes at the facility level. A 50% reduction in emissions may be the result of a reduction in production (King, Lenox 2001). Therefore, the ratio of the 5 and

10-year changes in toxicity scores were normalized with the corresponding changes in production at the facility level.

There are several indices to evaluate production level. Information from Moody's Company Data or Dun & Bradstreet is aggregated for the entire company and does not provide information at the facility level. Phone calls to facilities revealed several instances where manufacturing had been phased out and moved to another company facility. This would impact TRI emissions for a facility but not necessarily the revenue or sales for the entire company making it problematic to use company wide financial data from Moody's or Dun &Bradstreet. Additionally, detailed production levels at facilities are typically proprietary information and difficult to obtain.

The TRI provides a production ratio/activity index that is a ratio of business activity used by the EPA to determine source reduction activities. It is the amount of product produced in the current reporting year divided by the amount of product in the previous year (EPA 2002e). Although the EPA provides guidance on how to properly report the production ratio, a small portion of the data showed irregularity or unrealistic values. For a few facilities, it was necessary to convert the production ratio from a percent to a ratio. In several cases where the production ratio was unclear or left blank, the values for that company could not be calculated.

To obtain a ratio that reflects the change in production from 1995 to 2000, production ratios for each of the intervening years were multiplied together.

$$\frac{1996}{1995} * \frac{1997}{1996} * \frac{1998}{1997} * \frac{1999}{1998} * \frac{2000}{1999} = \frac{2000}{1995}$$

The same methodology was applied to the 1990 to 2000 time period. When the inverse of the five-year production ratio was multiplied with the ratio of toxicity scores (2000/1995), the resulting ratio accounted for changes in production and revealed the true change in toxicity score over the five-year period. The same methodology was used for the 10-year period.

$$\frac{\sum Toxicity\ Scores\ 2000}{\sum Toxicity\ Scores\ 1995} * \frac{\text{Pr}oduction\ Ratio\ 1995}{\text{Pr}oduction\ Ratio\ 2000} = normalized\ change\ in\ toxicity\ score$$

3.3.4 Exposure Potential Analysis

The toxicity scores, before normalization, were analyzed to evaluate a possible shift from high-medium exposure potential to low exposure potential. The following equation conceptualizes the analysis of the exposure potential.

$$\frac{High^{95} + Medium^{95}}{Low^{95}} - \frac{High^{00} + Medium^{00}}{Low^{00}} = \Delta\ Ratio$$

A positive value for the change in the ratio defines a shift from high and medium exposure potential to low exposure potential emissions. A negative value for the change in ratio defines a shift from low exposure potential to high and medium exposure potential. Although the ratio reveals a shift, the actual quantitative shift is not viewed and the ratio only reflects a measure of magnitude. Only facilities that had emission with both high and low exposure potentials were included in this analysis.

3.3.5 Statistical Evaluation

After being normalized for changes in production, the toxicity scores for total releases; low potential exposure and high potential exposure were evaluated to determine if the ISO group was different from the non-ISO group. This analysis used the t-test, which is considered the most commonly used method, to evaluate the differences in the statistical means of two groups.

Chemical Release Analysis – Null Hypothesis:
The difference in the means of the toxicity scores, either as totals or within exposure potential categories, between the ISO group and the non-ISO group is zero.

Chemical Management Analysis – Null Hypothesis:
The difference in the ratio of high to low exposure potentials between the ISO group and the non-ISO group is zero

A t-test will determine if there is a difference between the ISO group and non-ISO group in terms of a shift from high exposure routes such as air and water emissions to more managed low exposure potential emissions such as landfill disposal.

The underlying assumption of a t-test is that the data is normally distributed and that the variances of the two groups are approximately equal. The t-test and the Welch test were run and the variances of the two populations were determined to be approximately equal. In order to normalize the data, a Box-Cox transformation was used. The toxicity score for each of the exposure potentials was transformed separately using a Box-Cox transformation. The lambda values used in the Box-Cox transformation are presented in Table 3.3.

$$x = \frac{x^{\lambda} - 1}{\lambda}$$

Table 3.3 – Lambda Values Used in the Box-Cox Transformation

Toxicity Score	Lambda Value Used
Low Potential – 3 year	0
High Potential – 3 year	0
Total Releases – 3 year	.1
Chemical Management – 3 year	
Low Potential – 5 year	.15
High Potential – 5 year	.05
Total Releases – 5 year	.16
Chemical Management – 5 year	0.10
Low Potential – 7 year	.1
High Potential – 7 year	.1
Total Releases – 7 year	0
Chemical Management – 7 year	
Low Potential – 10 year	.15
High Potential – 10 year	.05
Total Releases – 10 year	.12
Chemical Management – 10 year	-0.13

4 CHAPTER FOUR – RESULTS

This section presents the results of the environmental management analysis and the chemical release analysis. The results of these analyses are only representative of the sampled populations.

4.1 Environmental Management Analysis

The environmental management analysis was conducted using data collected from a survey sent to environmental managers at U.S. manufacturing facilities.

4.1.1 Survey Response Rates

A total of 484 facilities were identified, contacted, and sent the environmental manager survey. The overall response rate for the three rounds of mailings and emails was 40.9%. Table 4.1 presents a breakdown of the survey responses by round and the method by which they were returned. The overall response rate for the ISO group was 51.7%, and the response rate for the non-ISO group was 30.2%. Table 4.2 presents the breakdown of responses for the ISO group and the non-ISO group.

Table 4.1 – Survey Responses by Round and Method of Survey Return

Method	Round 1	Round 2	Round 3	Total Responses	Response Rate
Mail	68	43	33	144	29.8%
Email	42	4	8	54	11.2%
Totals	110	47	41	198	**40.9%**

Table 4.2 – Survey Responses by Group

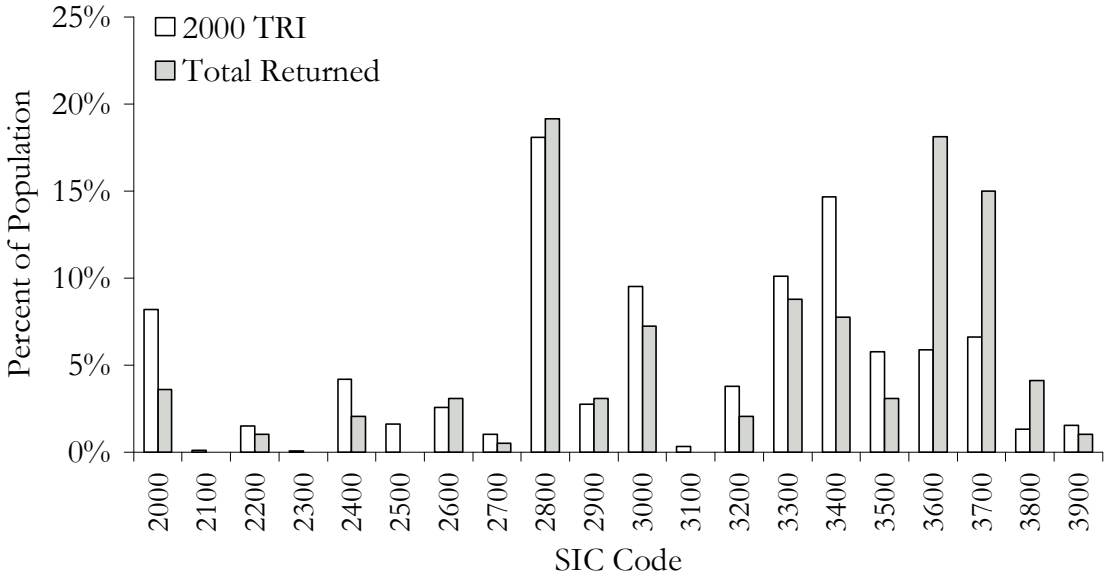
	Method	Round 1	Round 2	Round 3	Responses	Response Rate
ISO Group	Mail	36	29	21	86	
	Email	32	2	5	39	
	Total	68	31	26	**125**	**51.7%**
Non-ISO Group	Mail	32	14	12	58	
	Email	10	2	3	15	
	Total	42	16	15	**73**	**30.2%**

4.1.2 Survey Response Demographics

The distribution of returned surveys approximates well the distribution of all year 2000 TRI reporting facilities (Figure 4.1). As was observed in sample selection process, the returned surveys include a smaller proportion of food manufacturers and fabricated metal producers (SIC codes 2000 and 3400), and a higher proportion of electronics producers and transportation equipment manufacturers (SIC codes 3600 and 3700).

For this analysis five surveys could not be included as insufficient information was provided, or the survey was returned with a notice that the facility had ceased operations. The remaining 193 respondents were grouped on the basis of their answer to Question 16 of the survey, which asked if their EMS was certified to the ISO 14001 standard. The total sample sizes for this study were 126 ISO group facilities and 67 non-ISO group facilities. This change in proportion was due to six facilities that were certified to the ISO standard prior to 2000 having allowed their certification to expire, and 10 facilities having obtaining certification during or after the year 2000.

Figure 4.1 – Distribution of Returned Surveys Compared to the Entire 2000 TRI Population



4.1.3 ISO Group Demographics

The facility demographics for the ISO group are summarized in Table 4.3. Facilities in the ISO group ranged in size from 15 to 22,000 employees with a median value of 450 (Figure 4.2). The number of employees at these facilities with environmental responsibilities ranged from 1 to 4,600, and had a median value of 23.5. Viewed in terms of a percentage, employees with environmental responsibilities ranged from 0.1% to 100% of all employees with a median value of 7.1%. Environmental managers at these facilities devoted 5% to 100% of their time to environmental issues with a median value

of 55%. The average employee received anywhere from 0.5 to 50 hours of training with a median value of 4.0 hours.

All ISO Group facilities reported the presence of a documented EMS that had been implemented between the years of 1991 and 2002. The majority of these EMSs were implemented from 1997 through 1999 (83%). Additionally, Over 90% of the responding facilities indicated that they were certified to the ISO 9000 quality standard. Of those reporting the location of their parent company or corporate headquarters, 54% were from the United States and 21% were from Japan.

In 97% of the cases an external auditor certified ISO group facilities to the ISO 14001 standard, whereas only four facilities had self-declared their adherence to the standard. A high proportion of respondents (98%) indicated that their certification applied to the entire facility, and not just to a specific area of the facility. When asked to choose the most important reasons for certifying to the standard, the top responses provided were: due to a corporate mandate (77%), to improve regulatory compliance (57%), and to improve management of environmental impacts (52%).

4.1.4 Non-ISO Group Demographics

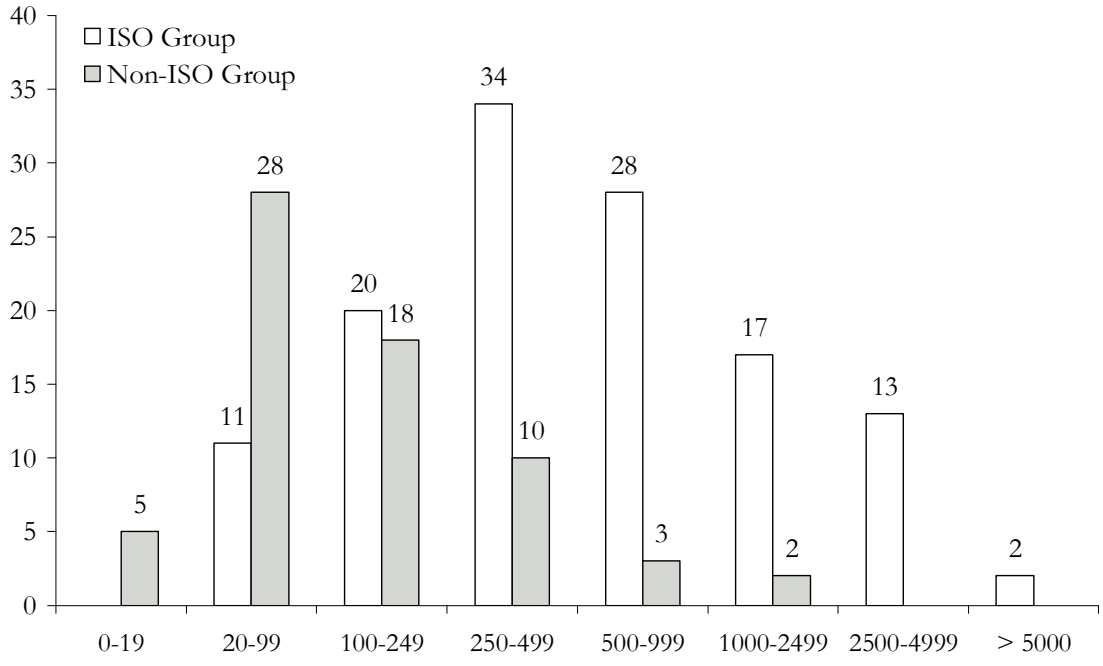
The facility demographics for the non-ISO group are summarized in Table 4.3. Facilities in the Non-ISO group ranged in size from 8 to 1,100 employees with a median value of 127 (Figure 4.2). The number of employees at these facilities with environmental responsibilities ranged from 1 to 900, and had a median value of 6.0. As a percentage, employees with environmental responsibilities ranged from 0.00% to 100% of all employees with a median value of 6.5%. Of the Non-ISO group facilities with an environmental manager, they devoted 1% to 100% of their time to environmental issues with a median value of 50%. The average employee received anywhere from 0 to 40 hours of training with a median value of 3.0 hours.

Of the non-ISO Group facilities, 36% reported the presence of a documented EMS that was implemented between the years of 1980 and 2001. Thirty-seven percent of the non-ISO facilities were certified to the ISO 9000 standard. Of those facilities reporting the location of their parent company or corporate headquarters, 54% were from the United States.

Table 4.3 – ISO Group Versus Non-ISO Group Demographics

	Median	Minimum	Maximum	n
ISO Group				
Number of Employees	450	15	22,000	121
Environmental Employees	23.5	1	4,600	118
Percent Environmental Employees	7.1%	0.1%	100%	118
Environmental Manager Percent	55%	5%	100%	116
Hours of Training	4.0	0.5	50	118
Non-ISO Group				
Number of Employees	127	8	1,100	70
Environmental Employees	6.0	1	900	68
Percent Environmental Employees	6.5%	0.00%	100%	68
Environmental Manager Percent	50%	1%	100%	62
Hours of Training	3.0	0	40	67

Figure 4.2 – Distribution of Facility Size For ISO and Non ISO Group Facilities



4.1.5 Summary Statistics

Summary statistics were performed on the data to provide a count of the responses to each question. A complete list of counts per question is presented in Appendix 7. The responses to questions that revealed particularly interesting results are presented below. Of the facilities that responded to this survey, the response rate to individual questions was generally in the range of 90 - 99%. Appendix 8 presents the response rates for each question.

In Question 5, 96% of the respondents from the ISO group indicated they had an environmental manager while only 87% of the non-ISO group responded in kind.

In Question 8, 83% of the ISO group said facilities were involved in writing the environmental policy while only 46% responded the same way for the non-ISO group.

In Question 10, 95% of the ISO group posted an environmental policy and 96% presented the environmental policy during training. That is compared to 52% and 73% respectively for the non-ISO group.

Question 23 revealed that 97% of the ISO group had a system in place to allow employees to suggest ways to improve environmental practices while only 75% of the non-ISO group had such a system on place.

There was a marked difference in the way the two groups answered Question 24 pertaining to training. Refresher training was offered by 89% of the ISO group while only being offered by 68% of the non-ISO group. Similarly, 74% of the ISO group provided training materials at any time and tested employee comprehension while 41% did the same in the non-ISO group.

In Question 26, 93% of the ISO group said they provide the environmental policy during training compared to 61% for the non-ISO group. Also in Question 26, 93% of the ISO group versus 67% for the non-ISO group trained employees on the environmental impacts of their job. Interestingly, 94% of both groups said they provide training regarding employees roles and responsibilities.

In Question 32, 53% of the ISO group said non-management employees were involved in the facility EMS review. In the non-ISO group only 20% said non-management employees were involved. Facility managers were involved in the EMS review at 74% of the ISO group facilities and 58% of the non-ISO group facilities. Corporate environmental managers were involved at 30% of the ISO group facilities and 49% for the non-ISO group.

Table 4.4 presents the results of the Chi-square test for questions regarding the effectiveness of EMS.

Table 4.4 – Effectiveness of Environmental Management System

Question	Chi-Square Value	df	Chi-Square p-value
14_Compliance	0.414	2	0.813(a)
14_Identify Impacts	21.88	3	0(a)
14_Managing Impacts	14.05	3	0.003(a)
14_Env Stewardship	5.74	3	0.125(a)
14_Internal Comm	3.75	3	0.290(a)
14_Community Comm	16.51	3	0.001(a)
14_Env Performance	12.00	3	0.007(a)

(a) Reported results are unreliable due to a violation of Chi-Square test assumption which require expected counts to be greater than 5.

4.1.6 Eight Elements of Environmental Management

Survey responses were analyzed using Fisher's Exact tests and Chi-Squared tests to determine if the ISO group implemented a more comprehensive combination of the eight environmental management elements than the non-ISO group. The results for these tests are presented in the tables below categorized by the eight environmental management elements.

Environmental Policy

Table 4.5 presents the results of the Fisher's Exact test for questions regarding the facility environmental policy. Significant results are in bold.

Table 4.5 – Environmental Policy Results

Question	Chi-Square Value	df	Chi-Square p-value	Fisher's p-value
7_Policy				**0*****
8_Facility				**0*****
8_Corporate				**0.01****
8_Other				0.080
9_Operations				NA(b)
9_Products				**0.009*****
9_Suppliers				**0.012***
10_Post				**0*****
10_Hire				**0*****
10_Training				**0*****
10_Web				**0*****
10_Supervisor				**0.001*****
10_Other				0.576
44_Corporate Env Policy	15.93	2	0(a)	

$^{***}p \leq 0.001$; $^{**}p \leq 0.01$; $^{*}p \leq 0.05$

(a) Reported results are unreliable due to a violation of the Chi-Square test assumption which require expected counts to be greater than 5.

(b) No statistics were computed because all respondents answered yes to Operations in Question 9.

Question 7 refers to the presence of an environmental policy, which shows there was a significant difference between the ISO group and the non-ISO group respondents. The results indicate there was significant differences between the two groups regarding whom authored the environmental policy, as shown in Table 4.5, Question 8. Question 9 refers to areas of the respondents' facility the environmental policy applies to. As shown in Table 4.5, respondents indicate significant differences in the application of environmental policy to facility products and services as well as facility suppliers and service providers. A test of difference could not be conducted for Question 9 regarding the facility's environmental policy applying to facility operations because all respondents in both groups indicated their environmental policy applied to facility operations. Question 10 shows that the two sample populations answered significantly different regarding how the environmental policy is made available. In particular, there was a significant difference in the responses for the written policy being posted; the policy being received at time of hiring; employees learning about the policy during environmental training; environmental policy being made available on the website or intranet; supervisor informing employees about the environmental policy. There were no significant differences in the answers provided for other responses in Question 10.

Management Involvement

Table 4.6 presents the results of the Fisher's Exact test and the Chi-Squared test for questions pertaining to management involvement. Significant results are in bold.

Table 4.6 – Management Involvement Chi-Square and Fisher's Exact Test Results

Question	Chi-Square Value	df	Chi-Square p-value	Fisher's p-value
4	7.08	2	0.029(a)	
5				**0.021***
8_Corporate				**0.011***
13_Fac Mngr	9.74	3	0.021(a)	
13_Env Mngr	14.50	3	0.002(a)	
13_Corporate	9.41	3	0.024(a)	
13_Consultant	9.35	3	0.025(a)	
32_Board				0.555
32_Corporate				**0.007****
32_Facility				**0.005****
32_Env Mngr				**0.008****
36_Fac Env Staff				0.093
36_Corp Staff				**0.019***
36_Consultant				0.073
40_Workshop				0.403
40_Report				**0*****
40_Manual				0.614
40_Newsletter				**0.001*****
40_Email				0.206
40_Convers				0.607
40_Other				0.081
41_Comm				**0.029***

***$p \leq 0.001$; **$p \leq 0.01$; *$p \leq 0.05$

(a) Reported results are unreliable due to a violation of the Chi-Squared test assumption which require expected counts to be greater than 5.

Table 4.7 – Management Involvement t-test Results

Question	t	df	p-value	Mean difference
6_Percent of Time	2.13	176	**0.034***	0.103

*$p \leq 0.05$

Question 5 refers to the presence of an environmental manager at the facility, which shows there was a significant difference between the ISO group and the Non-ISO group respondents. Question 8 shows a significant difference in respondents' responses to who wrote the facility's environmental policy. A significant difference existed between the management involvement for the two sample populations in Question 32, review of the

environmental management system. Of particular significance is the involvement of the corporate environmental manager, facility manager and the environmental manager. Question 36, corporate management involvement in environmental audits at the facility showed significance for corporate environmental staff involvement. The manner in which facilities receive information from their parent company, Question 40, showed significantly different results for information received from the corporate environmental report and newsletters and notices. Question 41 refers to facility communication with their parent company or corporate headquarters, which shows there was a significant difference between the respondents.

Employee Participation

Table 4.8 presents the results of the Fisher's Exact test and the Chi-Squared test for questions regarding employee participation. Significant results are in bold.

Table 4.8 – Employee Participation Chi-Square and Fisher's Exact Test Results

Question	Chi-Square Value	df	Chi-Square p-value	Fisher's p-value
13_Staff	3.17	3	0.366(a)	
13_Employees	36.18	3	0(a)	
23_Suggestion	23.39	1	**0*****	
28_Fac Mngr				**0.045***
28_Env Mngr				**0.009****
28_Employees				**0.002****
28_Other				1.00
28_None				**0.008****
29_Awards				**0*****
30_Bonus				0.204
30_Nonmonetary				0.720
30_Recognition				0.180
32_Employees				**0*****
32_Other				0.281
36_Employees				**0*****
36_Other				**0.045***

$^{***}p \leq 0.001$; $^{**}p \leq 0.01$; $^{*}p \leq 0.05$

(a) Reported results are unreliable due to a violation of the Chi-Squared test assumption which require expected counts to be greater than 5.

Table 4.9 – Employee Participation t-test Results

Question	t	df	p-value	Mean difference
2_Env Responsibility	2.76	184	**0.006****	219

$^{**}p \leq 0.01$

Question 2, number of employees with environmental responsibilities in their job title, showed significant differences between the two populations. Question 23 showed there is a significant difference within the population sampled regarding the facility allowing

employees to suggest ways to improve environmental practices. Question 28 refers to environmental goals being considered in job performance reviews. The respondents indicate significantly different responses for facility manager, environmental manager, employees and the absence of incentives. Question 29 refers to awards presented to employees for contributions to environmental performance, and showed the two groups responded significantly different. Question 30 refers to the type of rewards presented to employees for contributions to environmental performance, which shows there was not a significant difference between the respondents. Non-management employee involvement in environmental management review, Question 32, proved to be significantly different between the two groups sampled. Additionally employee participation in facility environmental audits, Question 36, showed a significant difference between the two populations.

Training

Table 4.10 presents the results of the Fisher's Exact test for questions related to training. Significant results are in bold.

Table 4.10 – Training Fisher's Exact Test Results

Question	Fisher's p-value
22_Workshop	0.421
22_AV	**0.032***
22_Report	**0*****
22_Manual	**0*****
22_Newsletter	**0*****
22_Evaluation	**0.003****
22_Supervisor	**0.022***
22_Env Mngr	0.483***
22_Coworker	0.205***
22_Other	0.345
24_Material	**0*****
24_Testing	**0.043***
24_Refresher	**0.001*****
24_Tailored	0.215
24_None	**0.012***
26_Policy	**0*****
26_Impact	**0*****
26_Role	0.159
26_Creative	0.282
27_Video	0.357
27_On Job	1
27_Written	**0.028***
27_Intstruction	0.392

***$p \leq 0.001$; **$p \leq 0.01$; *$p \leq 0.05$

Table 4.11 – Training t-test Results

Question	t	df	p-value	Mean difference
25_Hours	0.447	183	0.655	0.5

The manner in which employees receive information regarding environmental issues, Question 22, showed significantly different responses between the two groups for audiovisual or computer based materials; corporate environmental report; procedures manual; newsletters, posters and notices; during performance evaluations; and through informal conversations during work with supervisors. Question 24 demonstrated significant results regarding facility environmental training programs. The two populations revealed significantly different responses for training material made available to employees at any time; and employee comprehension testing; refresher training. Additionally the two sampled populations showed significantly different responses regarding the absence of a training program. Respondents also provided significantly different responses for information employees receive during training, Question 26. Significant responses include environmental policy and environmental impacts of employee job position. Question 27, environmental training media, showed significant results for written materials.

Target Setting

Table 4.12 presents the results of the Chi-Squared test for questions pertaining to target setting. Significant results are in bold. The target setting responses are unreliable due to a violation that requires at least five responses per cell.

Table 4.12 – Target Setting Results

Question	Chi-Square Value	df	Chi-Square p-value
45_Target setting	9.14	2	0.010(a)

(a) Reported results are unreliable due to a violation of the Chi-Squared tests assumption which require expected counts to be greater than 5.

Monitoring

Table 4.13 presents the results of the Fisher's Exact test of questions regarding monitoring. Significant results are in bold.

Table 4.13 – Monitoring Results

Question	Chi-Square Value	df	Chi-Square p-value	Fisher's p-value
20_EPI				**0*****
21_Energy				**0*****
21_Water				0.069
21_Solid Waste				**0.016***
21_Haz Waste				0.411
21_Air				0.252
21_Other				0.692
31_Review	74.22	5	0(a)	
46_Operations	6.95	3	0.073(a)	
46_Packaging	15.25	3	**0.002****	
46_Distribution	3.58	3	0.311(a)	
46_Use	2.10	3	0.551(a)	
46_Services	11.71	3	**0.008****	
46_Suppliers	8.55	3	0.036(a)	

$^{***}p \leq 0.001$; $^{**}p \leq 0.01$

(a) Reported results are unreliable due to a violation of the Chi-Squared tests assumption which require expected counts to be greater than 5.

Respondents provided significantly different responses to the use of environmental performance indicators, Question 20. Respondents also exhibited significantly different responses to the types of indicators used by the facility, Question 21. In particular, energy performance indicators appeared to be significantly different between the two groups. Respondents provided significantly different responses for Question 46, company wide programs to assess and minimize the environmental impacts associated with product packaging and company services provided.

Auditing

Table 4.14 presents the results of the Fisher's Exact test for questions regarding auditing. Significant results are in bold.

Table 4.14 – Auditing Results

Question	Fisher's p-value
33_Environmental Audit Program	**0*****
34_Internal Audit	**0.004****
34_Independent Audit	**0*****
35_Audit Follow up	0.251
37_Internal Audit	**0*****

$^{***}p \leq 0.001$

Respondents showed significantly different responses to the presence of an environmental audit program, Question 33. Respondents also exhibit significantly different responses for the presence of an internal audit program and independent facility auditing programs, Question 34. Furthermore, respondents provided significantly different responses to Question 37, the number of internal audits conducted each year in the facility.

Reporting

Table 4.15 presents the results of the Chi-Squared test. Significant results are in bold.

Table 4.15 – Reporting Results

Question	Chi-Square Value	df	p-value
42_Env Report	33.38	2	0(a)
43_Reporting	1.56	2	0.459(a)

(a) Reported results are unreliable due to a violation of the Chi-Squared tests assumption which require expected counts to be greater than 5.

The results for Questions 42 and 43, are unreliable due to a violation that requires at least five responses per cell.

Environmental Initiatives

Environmental initiatives are not one of the eight environmental management elements identified for this analysis, but they were identified as an indicator of environmental management that is above and beyond the standard eight elements. Table 4.16 presents the results of the Fisher's Exact test and the Chi-Squared test for questions pertaining to environmental imitative. Significant results are in bold.

Table 4.16 – Environmental Initiatives Results

Question	Chi-Square Value	df	Chi-Square p-value	Fisher's p-value
47_New Suppliers	31.39	3	**0*****	
47_Existing Supp	34.27	3	**0*****	
47_Green Products	8.34	3	**0.039***	
47_LCA	39.43	3	**0*****	
48_Project XL				0.095
48_Energy Star				0.268
48_WasteWise				0.309
48_Natural Step				NA(b)
48_LEED				1.00
48_Perf Track				**0*****

$^{***}p \leq 0.001$; $^{*}p \leq 0.05$

(a) Reported results are unreliable due to a violation of the Chi-Squared tests assumption which require expected counts to be greater than 5.

(b) No statistics were computed because all respondents answered yes to this part of the question.

Question 47 shows that there was a significant difference in firms implementing the following actions in the last five years: taken environmental performance into account in selection of new suppliers; placed demands on existing suppliers to take environmental action; introduction of green products and the implementation of product life cycle analysis. Respondents also display significant differences in participation in voluntary environmental initiatives, Question 48, such as Environmental Performance Track.

4.1.7 Respondents Comments

Survey respondents were given the opportunity to provide additional comments at the end of the survey. The comments present a variety of views on ISO 14001 and environmental management that encompass the entire range of opinions, from positive to negative. Some respondents felt ISO 14001 was beneficial and other felt it was costly or tedious. All comments have been rephrased to avoid revealing the identity of the person or facility that provided input. The following is a sample of comments that reflect the diversity of opinions expressed.

> An environmental management system, even in its most basic form, is critical to sustained environmental protection and regulatory compliance. What gets documented and measured, gets managed.
>
> ISO 14001 has been beneficial and produced cost savings.
>
> One of the greatest strengths of ISO 14001 is that every employee at the plant plays a role in the success of the EMS.
>
> ISO 14001 is a good program but it generates work and paper more than expected and it's trivial in some issues…Each auditor has his own interpretation of the standard.
>
> Certification was allowed to expire as a cost cutting measure due to the economic environment. The environmental manager was laid off with 20% of the workforce. Regulatory issues have received priority over the EMS since that time.
>
> ISO 9000 and ISO 14001 is a total waste of time, no doubt created by bureaucrats. Voluntary environmental initiatives are smoke screens for big companies that have the time to fill. The management process becomes the work.

4.2 Chemical Release Analysis

The chemical release and exposure potential analysis compared the chemical releases for the ISO group and the non-ISO group over ten years. Changes over three, five, seven and ten years were evaluated for low exposure potential releases, high exposure potential releases and total releases. There were not enough data points in the medium exposure potential category to perform a statistical analysis but the medium exposure potential

releases are included in the total releases. In addition shifts from high exposure potential to low exposure potential, such as air and water emissions to more managed low exposure potential emissions such as landfill disposal, were evaluated over the same time period. Table 4.17 presents the results of the t-tests to determine if the means of the toxicity scores and exposure potential ratios of the two groups are not statistically different.

Table 4.17 – Chemical Release Analysis Results for the 5 and 10-Year Periods

Toxicity Score	t value	Degrees of Freedom	P value
Low Potential – 3 year	-0.987	240	0.325
High Potential – 3 year	-1.084	240	0.280
Total Releases – 3 year	-1.349	291	0.178
Chemical Management – 3 year	0.153	305	0.880
Low Potential – 5 year	-0.180	236	0.074
High Potential – 5 year	-0.174	235	0.862
Total Releases – 5 year	-0.897	197	0.371
Chemical Management – 5 year	-1.429	320	0.154
Low Potential – 7 year	-1.309	159	0.192
High Potential – 7 year	-0.810	174	0.424
Total Releases – 7 year	-1.956	199	0.052
Chemical Management – 7 year	0.194	337	0.847
Low Potential – 10 year	0.301	134	0.764
High Potential – 10 year	-0.035	107	0.972
Total Releases – 10 year	0.403	76	0.688
Chemical Management – 10 year	-0.778	363	0.437

The p-values for each of the categories analyzed show that there is no significant difference between the chemical releases from the ISO group and the non-ISO group at the 0.05 level of significance.

5 CHAPTER FIVE – ANALYSIS AND DISCUSSION

The analysis and discussion presented in this chapter is based on the results provided in Chapter Four. The analysis and discussion that follows pertains only to the sampled population.

5.1 Environmental Management Analysis

The results of the environmental analysis showed statistical differences between the ISO group and the non-ISO group. These differences are discussed in the following paragraphs. In general, the ISO group tended to have more comprehensive implementation of the following elements:

- Environmental Policy
- Management Involvement
- Employee Participation
- Training

The ISO group also implemented more environmental initiatives than the non-ISO group. A discussion of each element is presented in the following paragraphs.

5.1.1 Environmental Policy

The results for questions regarding environmental policy indicate there are differences as well as similarities between the ISO group and the non-ISO group respondents.

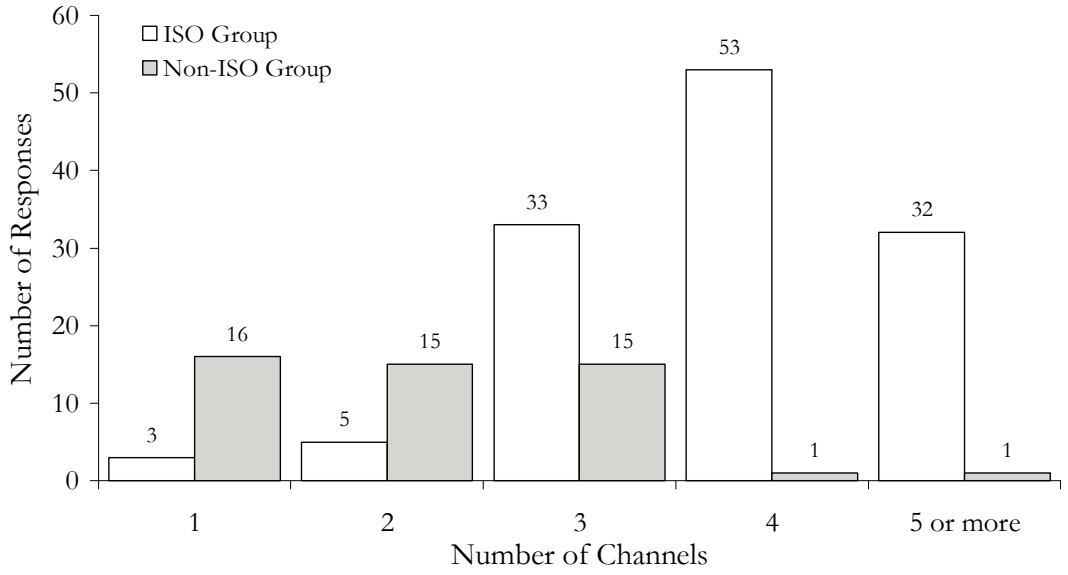
The ISO group showed a distinct difference from the non-ISO group in that 100% of the respondents indicated the presence of an environmental policy, while 75% of the non-ISO group respondents indicated the presence of an environmental policy. Even though the presence of a written policy may indicate more comprehensive management of environmental impacts, facilities with an ISO certified EMS are required to have an environmental policy. Of interest is the large number of non-ISO firms that have an environmental policy, which they are not required to have.

Survey respondents indicated that the ISO group and the non-ISO group showed a significant difference related to who drafted the environmental policy. Eighty two percent of the ISO group respondents indicated the facility was involved in writing the environmental policy. Conversely, 62% of the non-ISO group respondents indicated that their corporate headquarters drafted the environmental policy. It is difficult to determine which method is preferable with respect to managing environmental impacts, however the involvement of the facility may help to ensure a policy is tailored to the specific facility's impacts.

According to the results of the survey analysis, the ISO group and the non-ISO group show significantly different responses to the application of environmental policy to facility products and services as well as facility suppliers and service suppliers. Ninety percent of the ISO group respondents indicated that their environmental policy applies to facility products and services, while 72% of the non-ISO group indicated their policy applies to products and services. Additionally, 74% of the ISO group showed their policy applies to facility and service suppliers. The ISO group contrasts with the non-ISO group, which indicated that 54% of the respondents have environmental policies that apply to facility suppliers and service suppliers. Survey responses also show the two groups do not differ in their application of environmental policies to facility operations.

It is expected that the more ways a facility communicates the environmental policy to employees the more opportunity employees have to learn the policy and adapt the policy to their work. Figure 5.1 shows the ISO group offered more modes for communicating the environmental policy to employees. This may result in the ISO group more adequately informing employees about the environmental policy. However, it may be expected that the larger firms associated with the ISO group have more resources to provide more avenues of communication.

Figure 5.1 – Number of Channels used by Facilities to Communicate the Environmental Policy to Employees



The responses provided by the ISO group showed, as expected, that more facilities with an ISO certified EMS have a written environmental policy compared to the non-ISO group. The presence of an environmental policy is a key component to managing a facility's environmental impacts as well as setting environmental goals and providing a feedback system to ensure continual improvement. The distinction between who wrote

the environmental policy is interesting in that both groups provided significantly different results. The ISO group respondents indicated they tend to have an environmental policy that applies to facility products and services as well as suppliers. Finally, the ISO group respondents provide employees with more avenues to learn about the environmental policy. This may allow for facilities with an ISO certified EMS to teach more individuals within a facility about the environmental policy and consequently the goals of the facility to minimize environmental impacts.

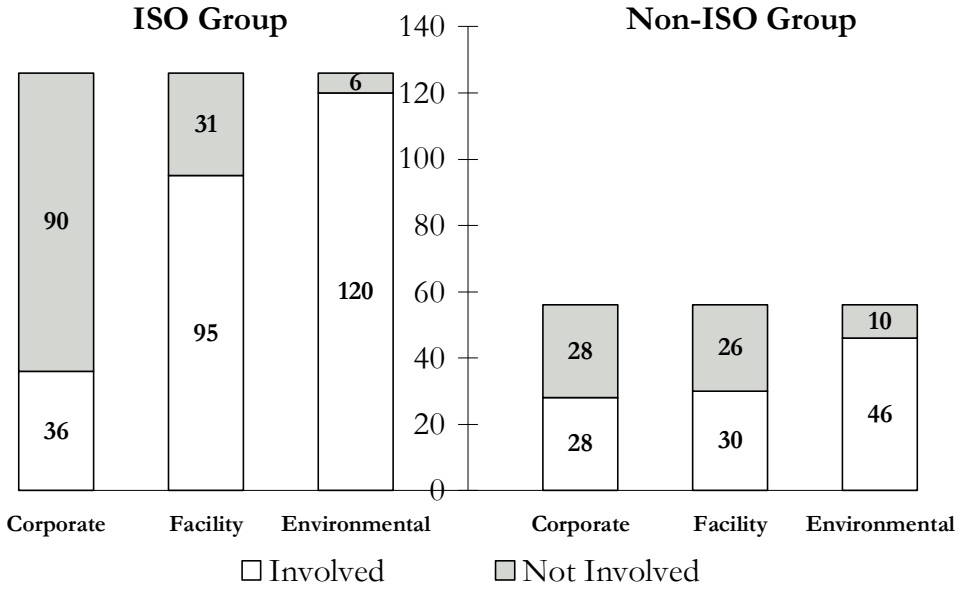
5.1.2 Management Involvement

According to the results of the survey, the ISO group had relatively more facility management involvement and less corporate management involvement than the non-ISO group. Also, the ISO group relies more heavily on corporate headquarters to disseminate information to the facility regarding environmental issues.

As mentioned earlier in Section 5.1.1, the non-ISO group relies more heavily on corporate headquarters to write their environmental policy while the ISO group tends to write it at the facility level. However, there was no significant difference between the two groups in terms the various personnel involved in EMS design (e.g. facility manager, corporate staff, consultants).

Ninety six percent of the ISO group responded that they had a facility environmental manager, while 87% of the non-ISO group responded similarly. ISO group responded that they had more management involvement in the review of the facility EMS. Seventy five percent of the ISO group responded that the facility manager was involved in the review of the facility EMS while only 54% of the non-ISO group answered similarly. Ninety five percent of the ISO group responded that the facility Environmental Manager was involved in the review of the facility EMS while only 82% on the non-ISO group responded similarly. Additionally, 50% of the non-ISO group replied that Corporate Environmental Managers were responsible for reviewing the facility EMS while only 29% of the ISO group responded similarly. These results are presented graphically in Figure 5.2. It appears that there is more corporate involvement in the non-ISO group in that respondents have greater corporate staff participation in facility environmental audits and facility EMS review than the ISO group.

Figure 5.2 – Involvement of the Corporate Environmental Manager, Facility Manager, and the Facility Environmental Manager in Review of the Facility EMS.



These data support the idea that the ISO group tends to use management resources at the facility level whereas the non-ISO group is more reliant on corporate management resources. The ISO group seems to depend more heavily on resources at the facility level to develop policy, implement EMS reviews, and perform facility environmental audits. As mentioned earlier, using the facilities resources may help better tailor facility environmental policy, implement EMS reviews, and perform facility audits for more effective use.

Although ISO tends to use management resources at the facility level, they tend to use corporate headquarters to disseminate information for environmental issues. Sixty five percent of the ISO group responded that their facility receives information regarding environmental issues via the corporate environmental report, while only 28% of the non-ISO group responded similarly. Additionally, 62% of the ISO group responded that they also disseminate information regarding environmental issues from corporate headquarters via newsletters or notices, while only 34% of the non-ISO responded similarly.

5.1.3 Employee Participation

Responses to questions regarding employee participation show that the ISO group respondents involved employees in facility environmental management more than the non-ISO group respondents.

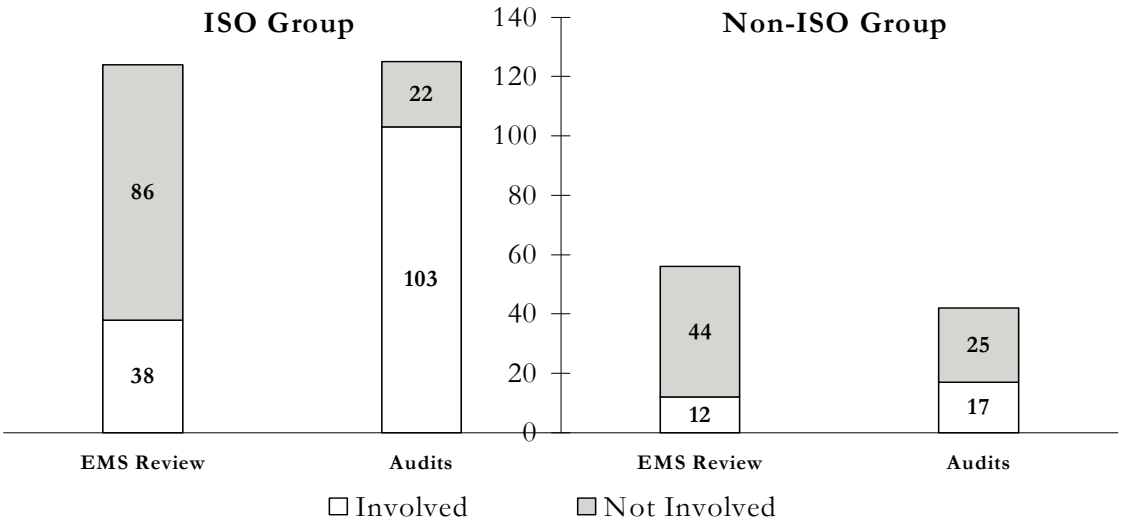
Within the ISO group respondents, 97% of respondents indicated that facilities have a system for employees to provide suggestions, while only 73% of non-ISO respondents indicated that employees have the opportunity to provide suggestions. Opening communication channels between employees and managers may help to create a more comprehensive EMS. It is expected that the more involved employees are in facility operations the more likely employees are to understand and attempt to mitigate the impact of facility operations on the environment.

The involvement of non-management employees in EMS review also proved to be significantly different between the ISO group and the non-ISO group. As presented in Figure 5.3, the ISO group indicated more involvement of non-management employees in the review of the EMS. Approximately 58% of the ISO group respondents indicated non-management involvement, while 21% of the non-ISO group respondents said non-management employees are involved in the EMS review. More comprehensive involvement of employees at multiple levels allows for more identification and communication of facility environmental impacts.

Employee participation in facility environmental audits also showed significant differences among the ISO group and the non-ISO group responses. Eighty two percent of the ISO group respondents indicated that employees participated in environmental audits at the facility. The participation of employees in audits may indicate increased awareness on the part of both management and employees on the environmental impacts present at the facility.

Overall, the ISO group respondents indicated they have more heavily involved employees by encouraging them to provide suggestions; involving them in the process of reviewing the EMS for continual improvement and involving them in the environmental audit of the facility.

Figure 5.3 – Involvement of Non-Management Employees in Review of the EMS and in Environmental Audits



5.1.4 Training

The analysis of responses to the questions pertaining to training showed that the ISO group facilities have more formalized and comprehensive environmental training programs.

The training at the ISO group facilities is more formalized because these facilities utilized procedures manuals, newsletters, posters and notices and written materials during training. Of the ISO group respondents, 76% said employees received environmental information regarding the environment through a procedures manual while only 38% of the non-ISO group respondents answered similarly. Eighty percent of the ISO group respondents indicated information regarding environmental issues was conveyed to employees via newsletters, posters and notices compared to 41% of the non-ISO group respondents. Additionally, 58% of the non-ISO group responded that employees receive information on environmental issues through informal conversations with their supervisor while only 40% of the ISO group indicated employees receive information in this manner. The trend toward highly formalized training in the ISO group facilities is also corroborated by the fact that 75% of the ISO group respondents delivered training to employees using written materials as opposed to 59% of the non-ISO group respondents.

The more formalized nature of training programs in the ISO group facilities is congruent with the requirement of the ISO 14001 standard to create a standardized training program that can be documented and verified.

In addition to being more formalized, environmental training programs at the ISO group facilities were also more comprehensive. This was indicated by the availability of materials, the presence of refresher training, tailored job training, education on environmental impacts of their jobs and the inclusion of the environmental policy in environmental training. Seventy one percent of the ISO group respondents indicated that training materials are available to employees at anytime. Only 44% of the non-ISO group responded similarly to that question. Of the ISO group respondents, 89% said refresher training was offered versus 67% of the non-ISO group respondents. Training in the ISO group facilities were more likely to be tailored to each job description. This assertion is supported by the fact that 63% of the ISO group respondents indicated training was tailored as opposed to 53% of the non-ISO group respondents. Another indication of the comprehensive nature of the environmental training in the ISO group is the fact that 94% of the ISO group indicated that training covers the environmental impact of an employee's job position compared to 63% for the non-ISO group. Additionally, 94% of the ISO group respondents provided the environmental policy to their employees during training versus 56% of the non-ISO group.

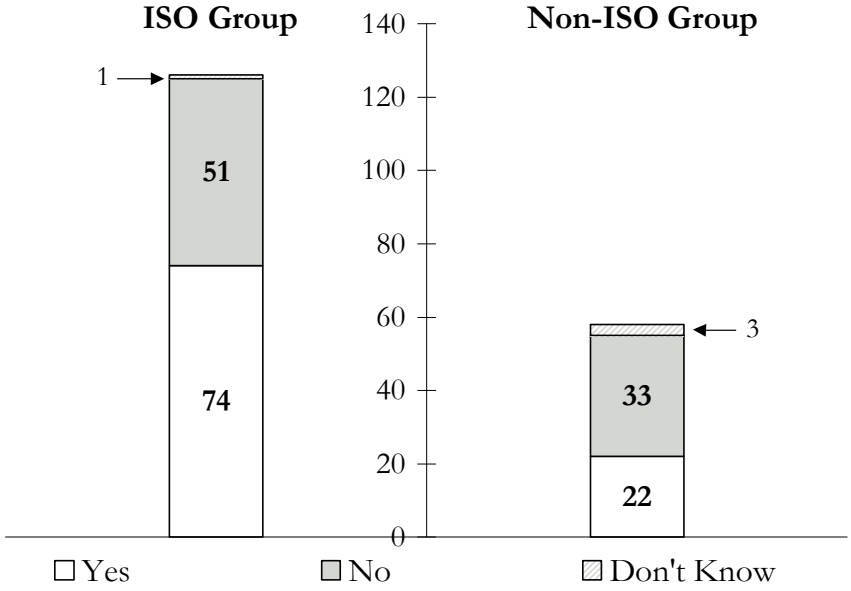
The ISO group environmental training programs tended to be more comprehensive than their non-ISO group counterparts indicating that employees trained in such a program are more likely to follow proper procedures when performing environmental duties.

Despite these differences between the two groups, there was one interesting similarity. Both the ISO group and the non-ISO group respondents indicated that the average hours of training received by an employee in one year was approximately six hours. The average training time for each group ($\bar{x} \pm SE$), with the ISO group reporting 6.20 ± 0.71 hours of training and the non-ISO group reporting 5.67 ± 0.87 hours of training.

5.1.5 Target Setting

The survey responses indicated that the ISO group had quantifiable targets set at the corporate level more often than the non-ISO group, although statistical significance could not be determined because one or more of the test assumptions were violated. Of the ISO group, 61% had targets set at the corporate level, while only 34% of the non-ISO group had targets set in the same manner. These results are presented in Figure 5.4.

Figure 5.4 – Target Setting for facilities by Corporate Headquarters

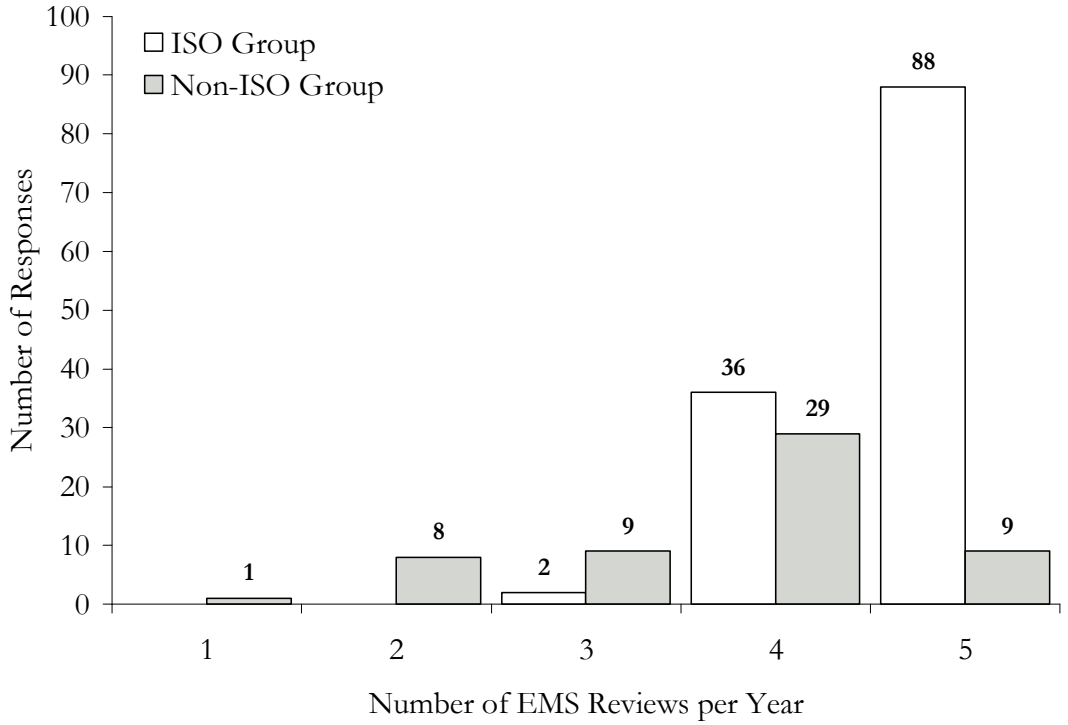


5.1.6 Monitoring

The ISO group tended to review their EMS more frequently and to monitor areas that do not normally require measurement under existing regulations.

As can be seen in Figure 5.5, the ISO group reviewed their EMS more frequently than did their non-ISO group counterparts. On average the ISO group reviewed their EMS five times a year and the non-ISO group reviewed their EMS four times a year. In addition, 93% of the ISO group used environmental performance indicators (EPIs), while only 54% of the non-ISO group used EPIs. While the results did not indicate whether the EPIs revealed improved environmental performance under ISO 14001, it may imply that environmental impacts receive more attention at the ISO group facilities than the non-ISO group facilities.

Figure 5.5 – Frequency of EMS Reviews Performed each Year



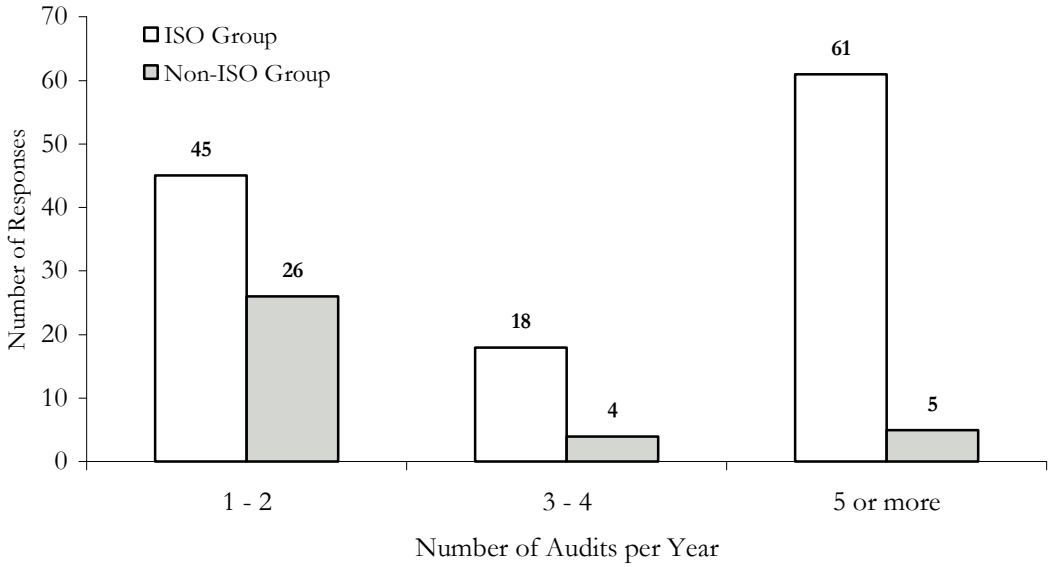
The ISO group also tended to monitor environmental impacts that do not normally require measurement or monitoring under existing regulations. The use of EPIs for water, air and hazardous waste did not differ between the ISO group and the non-ISO group but the ISO group responded that they used energy or solid waste EPIs significantly more than the non-ISO group. Eighty-five percent of the ISO group used energy EPIs versus only 60% of the non-ISO group. For solid waste, 89% of the ISO group used EPIs while 79% of the non-ISO group responded in kind. The majority, or 57%, of the ISO group also had programs to assess and minimize the impact of product packaging. Only 36% of the non-ISO group had this type of program. The reason for this may be that water use, air emissions and hazardous waste emissions are highly regulated. There are often state and federal mandated targets that require facilities to monitor these areas. ISO 14001 encourages facilities to address and monitor a wide range of environmental impacts including those not currently regulated. It appears, from the results of the survey, that facilities do indeed address a variety of impacts and go beyond regulatory compliance.

The ISO group reviewed their EMSs more often than their counterparts, indicating that the EMS may be more integrated into procedural operations. In addition, the ISO group monitored their environmental impacts areas more comprehensively than the non-ISO group and that monitoring addresses impact areas not traditionally covered by federal or state regulations.

5.1.7 Auditing

The presence of an auditing system was found to be significantly different between the two groups, with 100% of the ISO group facilities having an environmental auditing system and only 65% of the non-ISO group facilities having an audit program. Of these facilities with a program, the ISO group appears to audit more frequently, however statistical significance of audit review could not be determined since one or more of the test assumptions were violated. Figure 5.6 below indicates that the modal response for the ISO group was that they performed 5 or more audits per year, whereas the modal response for the non-ISO group was once per year.

Figure 5.6 – Number of Environmental Audits Performed Each Year



5.1.8 Reporting

The analysis of responses to questions pertaining to reporting violated the necessary assumptions of the Chi-squared test. As a result, conclusions cannot be drawn using this data. Interestingly, though, 68% of the ISO group respondents indicated their company published an annual corporate environmental report as opposed to 23% for the non-ISO group. This disparity may be explained by the large size of the ISO group firms relative to the non-ISO group firms.

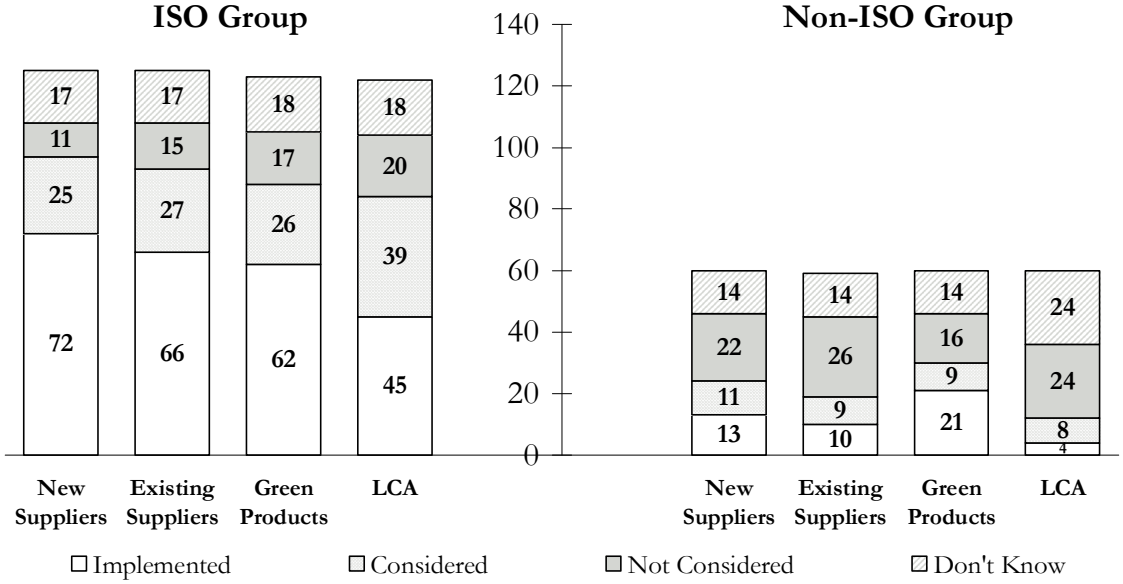
5.1.9 Environmental Initiatives

Analysis of the survey responses revealed that facilities in the ISO group implemented a more comprehensive set of environmental initiatives than the non-ISO group.

For example, 58% of the ISO group indicated that they had taken environmental performance into account in the selection of new suppliers while only 37% of the non-ISO group responded similarly. Fifty three percent of the ISO group placed demands on existing suppliers to take environmental actions while only 17% of the non-ISO group did so. Thirty seven percent of the ISO group indicated they implemented product life

cycle analysis while only seven percent of the non-ISO group had implemented product life cycle analysis. Figure 5.7 presents these results graphically. Additionally, there was not a significant difference between the two groups in regards to the adoption of voluntary environmental initiatives.

Figure 5.7 – Use of Environmental Considerations when Selecting New of Existing Suppliers, Introducing Green Products, or Implementing Life Cycle Analysis (LCA)



The ISO group revealed that they are applying external environmental pressure to suppliers by taking environmental performance into account when selecting suppliers. The ISO group is also placing demands on existing suppliers to take environmental action. It is likely that the ISO group is taking advantage of their buying power and restricting market access by forcing environmental initiatives throughout the supply chain. Consequently, the ISO group seems to influence environmental management practices outside their organizations by forcing environmental initiatives upon suppliers and promoting environmental management throughout their respected industries.

The environmental management analysis revealed that the ISO group facilities had more comprehensive programs in place to address environmental policy, management involvement, employee participation, training and environmental initiatives.

5.2 Chemical Release Analysis

The chemical release analysis compared the chemical releases for the ISO group and the non-ISO group over ten years and included releases before and after certification. Although ISO 14001 does not specifically apply to chemical releases it is feasible that the adoption of ISO 14001 and a comprehensive EMS could potentially reduce chemical

releases, thereby reducing toxicity. This may be true considering that the population sampled is by definition a large producer of chemical emissions.

This study looked at the following trends over time; the total chemical toxicity scores, the toxicity scores within exposure potential categories and the shift in chemical management practices from high to low exposure potential. The p-values for each of the categories analyzed showed that there is no significant difference for any of these three analyses.

While it is tempting to interpret these results as meaning that ISO 14001 does not influence environmental performance it is important to consider the following issues. One, toxic releases are only one of many impacts that may be managed using ISO 14001 and provide only one measure of environmental performance. Other impacts are significant and include activities such as, but not limited to; recycling, improvements in energy efficiency, reduced water use and source reduction of non-toxic raw materials. Secondly, ISO 14001 did not become popular in the United States until 1997 and many facilities in the sample did not become certified until 1999. There may be a lag time after certification before improvements in environmental performance can be recognized.

Finally, toxic releases already have comprehensive monitoring and reporting system in the US. The TRI is a public database and facilities on this list may have various pressures to reduce emissions. ISO 14001 was designed in part to go beyond compliance and existing regulations. This explanation is consistent with the findings of the survey, which asked both groups if they used any of the following five environmental performance indicators, air; hazardous waste; water; energy; and solid waste. There was no difference between the two groups in the use of environmental performance indicators for air, hazardous waste, and water. These three categories of environmental performance all have extensive monitoring and reporting under existing environmental regulations. However, the ISO group more frequently used environmental performance indictors for energy and solid waste, two categories which do not normally have federal or state mandated targets or monitoring requirements.

5.3 Conclusions

This study has analyzed the differences in implementation of environmental management practices and chemical releases between U.S. manufacturing facilities that are ISO 14001 certified and those that are not. Results of the environmental management survey suggest that there are differences in the environmental practices of ISO 14001 and non-ISO 14001 certified facilities. However, these differences do not translate into a greater reduction of chemical releases in U.S. manufacturing facilities. The high level of existing regulation associated with these industries and the public nature of TRI data may motivate both groups equally to reduce emissions. This study provides environmental managers and external stakeholders with insight into the role of ISO 14001 in environmental management.

5.3.1 Integration and Empowerment

An interesting trend is revealed when the significant results of the environmental management analysis are interpreted in aggregate. In general, the environmental management practices in the facilities, in the ISO group, permeated all levels within the facility and show a stronger tendency toward integration and empowerment of facility managers and employees. This tendency had two dimensions; (1) facility managers participated in developing their facility's specific environmental practices; (2) non-management employees were included in the management decision-making processes.

The ISO group facility manager is more involved in EMS development and review indicating that environmental management is more integrated into facility operations. Employees were given the proper training and education of environmental impacts so that they are able to participate in the EMS review and auditing process. Additionally, facilities in the ISO group were more likely to write the environmental policy pertaining to their facility.

People directly involved in the daily operations of a facility may be better suited to create an environmental management system that more effectively addresses the impacts of those operations. The enhanced integration and empowerment at ISO group facilities may result in more effective environmental practices because facility managers and non-management employees have a greater sense of ownership of the EMS.

5.3.2 Limitations of Study

This study was not able to establish a causal relationship between the implementation of ISO 14001 and improved environmental practices due to the lack of facility information prior to certification. Many of the practices analyzed in this study are dependant upon resources available to the facility, which may be influenced by the size of the facility. As presented in Chapter 4, the ISO group facilities tended to be larger than the non-ISO group facilities.

In regards to the chemical release analysis, TRI emissions are only one of the many environmental impacts that might be managed by ISO 14001. There may in fact be performance differences between the two groups that were not captured in this study.

6 CHAPTER SIX – FURTHER STUDY

Future research on ISO 14001 would benefit by analyzing the impact of a revised ISO 14001 standard, utilizing alternative environmental performance metrics and acquiring more detailed information at the facility level.

One of the main problems with determining the effects of ISO 14001 on environmental practices is the lack of firm and facility information prior to certification. This research provides baseline information regarding environmental practices, which could be compared to future developments in environmental management standards. The upcoming release of a revised standard could provide for interesting comparisons of the original and revised standards.

For this report, environmental performance was measured in the chemical release analysis, which used the TRI to compare releases for the ISO group and the non-ISO group. This analysis used the TRI because of the availability of information and its applicability to the manufacturing sector. There are other environmental performance metrics that if used may yield different results or may corroborate those found in this analysis by using the TRI. Future researchers should consider employing multiple environmental performance indicators to obtain a more thorough measurement of environmental performance.

Future analyses should make an attempt to acquire more detailed information pertaining to a facility's operations. With specific information on each facility, researchers could more accurately describe the effectiveness of the facility's environmental management system. Additionally, specific information from employees could be collected to determine their role in environmental management, which would expand on the information acquired from environmental managers. Future research should also explore if non-regulated issues, such as water and energy use, are impacted by ISO 14001 certification.

REFERENCES

Carnegie Mellon University, *Toxic Emissions Indices: A Tool for Green Design and Performance Measurement* [online]. Carnegie Mellon University, Engineering Design Research Center, Green Design Initiative. [cited 12 November 2002]. Available from World Wide Web http://www.ce.cmu.edu/GreenDesign/research/cmu-et.html.

Cascio, J., Woodside, G., and Mitchell, P. 1996. *ISO 14001 Guide: The New International Environmental Management Standard.* McGraw-Hill

Center for Disease Control and Prevention. NIOSH Pocket Guide to Chemical Hazards [online]. USA [cited 8 January 2003]. Available from World Wide Web http://www.cdc.gov/niosh/npg/npgd0000.html

Committee on Industrial Environmental Performance Metrics, National Academy of Engineering National Research Council, *Industrial Environmental Performance Metrics: Challenges and Opportunities*. National Academy Press. Washington D.C. 1999.

Delmas, M.A. Duke Environmental Law & Policy Forum. *Barriers and Incentives to the Adoption of ISO 14001 by Firms in the United States*. Volume XI, Number 1, Fall 2000.

EPA (United States Environmental Protection Agency) *Toxic Release Inventory Program* [online]. Washington D.C.: US Environmental Protection Agency, 2002a. [cited November 22, 2002]. Available from World Wide Web: http://www.epa.gov/tri/.

EPA (United States Environmental Protection Agency) *Toxic Release Inventory (TRI) Community Right to Know* [online]. Washington D.C.: US Environmental Protection Agency, 2002b. [cited November 22, 2002]. Available from the World Wide Web: http://www.epa.gov/tri/tri_program_fact_sheet.htm.

EPA (United States Environmental Protection Agency) *What is the Toxics Release Inventory (TRI) Program* [online]. Washington D.C.: US Environmental Protection Agency, 2002c. [cited 30 November 2002]. Available from the World Wide Web: http://www.epa.gov/tri/whatis.htm.

EPA (United States Environmental Protection Agency) *The Toxics Release Inventory (TRI) and Factors to Consider When Using TRI Data* [online]. Washington D.C.: US Environmental Protection Agency, 2001d. [cited 30 November 2002]. Available from the World Wide Web: http://www.epa.gov/tri/tridata/tri00/press/overview.pdf .

EPA (United States Environmental Protection Agency) *Standard Industrial Classification (SIC) Codes in TRI Reporting* [online]. Washington D.C.: US Environmental Protection Agency, 2002a. [cited 12 March 2003]. Available from the World Wide Web: http://www.epa.gov/tri/report/siccode.htm.

EPA (United States Environmental Protection Agency) *Toxic Chemical Release Inventory Reporting Forms and Instructions, Revised 2001 Version.* [online] Washington D.C.: US Environmental Protection Agency, 2002b. [cited 3 March 2003]. Available from World Wide Web:http://www.epa.gov/triinter/report/508_forms/2001_forms _and_instructions/2001_rfi_508.htm.

Ford Motor Company. *Supplier Certification.* [online] [cited 26 February 2003]. Available from World Wide Web: http://www.ford.com/en/dedication/awards/supplierCertification.htm.

Gerde, V., and Logsdon, J. *Measuring Environmental Performance: Use Of The Toxics Release Inventory (TRI) And Other US Environmental Databases.* Business Strategy and the Environment 10. 2001. 269-285.

Goetz, M.A. *Think outside the box: Analysis of Categorical Data* [online]. Quintiles Inc., Arlington, Virginia, 2002. [cited 12 March 2003]. Available from the World Wide Web: http://www.pace.edu/nesug/proceedings/nesug00/ps/Ps7008.pdf.

International Organization for Standardization. *Benefits of the ISO 14000 family of International Standards* [online]. Switzerland [cited 13 March 2003a]. http://www.iso.ch/iso/en/prods-services/otherpubs/iso14000/benefits.pdf

International Organization for Standardization. *The ISO Survey of ISO 9000 and ISO 14000 Certificates: Tenth Cycle: up to and including 31 December 2000* [online]. Switzerland [cited 13 March 2003b]. http://www.iso.org/iso/en/prods-services/otherpubs/pdf/survey10thcycle.pdf

International Organization for Standardization. *ISO and the Environment* [online]. Switzerland [cited 5 April 2003c]. http://www.iso.org/iso/en/iso9000-14000/tour/isoanden.html.

International Organization for Standardization. *About ISO* [online]. Switzerland [cited 9 December 2002a]. Available from World Wide Web http://www.iso.ch/iso/en/aboutiso/introduction/index.html.

International Organization for Standardization, *Environmental Management.* [online] [cited 5 December 2002b]. Available from World Wide Web: http://www.iso.org/iso/en/prods-services/otherpubs/iso14000/family.pdf.

King, A.A., and Lenox, M.J. *Lean and green? An empirical examination of the relationship between lean production and environmental performance.* Production and Operations Management. Fall 2001. Vol 10 Issues 3 page 244-256.

Kirkland, L., and Thompson D. *Challenges in Designing, Implementing and Operating an Environmental Management System*. Business Strategy and the Environment 8. 1993. 128-143.

North Carolina Division of Pollution Prevention and Environmental Assistance*, What are the 17 elements of the ISO 14001 Standard?* [online] [cited 5 December 2002]. Available from World Wide Web: http://www.p2pays.org/iso/faqs.htm.

Quality Network (1996a). *British Standard 7750* [online] [cited 5 December 2002]. Available from World Wide Web: http://www.quality.co.uk/bs7750.htm.

Quality Network (1996b). *EMAS* [online] [cited 5 December 2002]. Available from World Wide Web: http://www.quality.co.uk/emas.htm.

Quality Systems Update Publishing Company. *ISO 14001 Registered Company Directory – North America.* CD-ROM, Volume 3, Number 1, 2002.

Stapleton, P.J., Glover, M.A., and Davis, P.S. *Environmental Management Systems: A Guide for Small and Medium-Sized Organizations*. National Science Foundation International Publications, 2001.

Thompson, D. *Tools for Environmental Management: a Practical Introduction and Guide*. New Society Publishers, 2002.

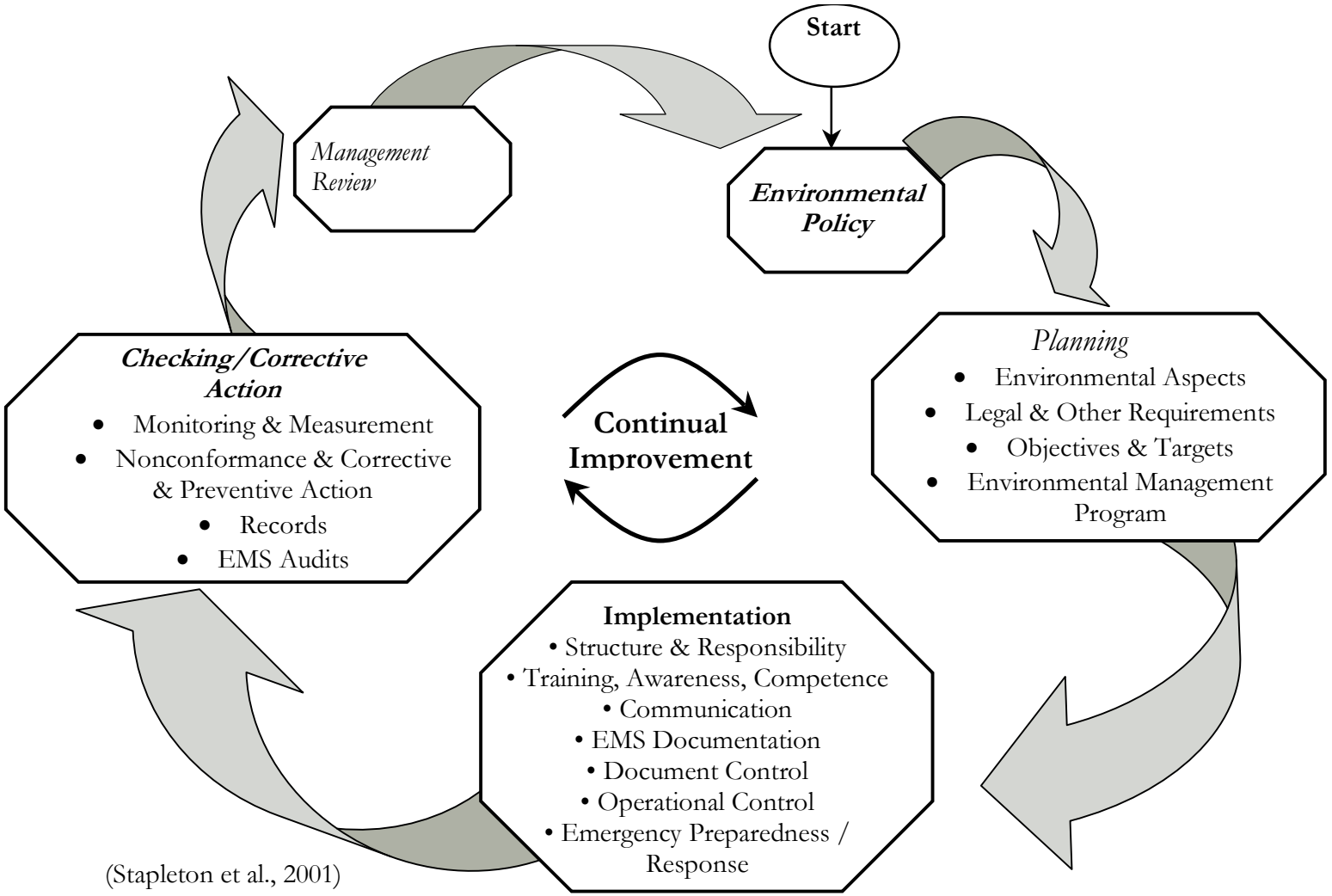
Appendix 1 EMS Elements

Key Elements of an EMS

- **Environmental Policy**- Develop a statement of your organization's commitment to the environment. Use this policy as a framework for planning and action.
- **Environmental aspects**- Identify environmental attributes of your products, activities and services. Determine those that could have significant impacts on the environment.
- **Legal and other requirements**- Identify and ensure access to relevant laws and regulations, as well as other requirements to which your organization follows.
- **Objectives and targets**- Establish environmental goals for your organization, in accordance with your policy, environmental impacts, the views of interested parties and other factors.
- **Environmental management program**- Plan actions necessary to achieve your objectives and targets.
- **Structure and responsibility**- Establish roles and responsibilities for environmental management and provide appropriate resources.
- **Training, awareness and competence**- Ensure that your employees are trained and capable of carrying out their environmental responsibilities.
- **Communication**- Establish processes for internal and external communications on environmental management issues.
- **EMS documentation**- Maintain information on your EMS and related documents.
- **Document control**- Ensure effective management of procedures and other system documents.
- **Operational control**- Identify, plan and manage your operations an activities in line with your policy, objectives, and targets.
- **Emergency preparedness and response**- Identify potential emergencies and develop procedures for preventing and responding to them.
- **Monitoring and measurement**- Monitor key activities and track performance. Conduct periodic assessments of compliance with legal requirements.
- **Nonconformance and corrective and preventative action**- Identify and correct problems and prevent their recurrence.
- **Records**- Maintain and manage records of EMS performance.
- **EMS audit**- Periodically verify that your EMS is operating as intended.

(Stapleton et al., 2001)

Appendix 2 EMS Model



(Stapleton et al., 2001)

Appendix 3 ISO Family of Standards

ISO 14000 Family of Standards		
Standard	**Date**	**Description**
ISO 14001	1996	Environmental management systems – Specifications with guidance for use
ISO 14004	1996	Environmental management systems – General guidelines on principles, systems and supporting techniques
ISO 14010	1996	Guidelines for environmental auditing – General principles
ISO 14011	1996	Guidelines for environmental auditing – Audit procedures – Auditing of environmental management systems
ISO 14012	1996	Guidelines for environmental auditing – Qualification criteria for environmental auditors
ISO 14015	2001	Environmental management – Environmental assessment of sites and organizations
ISO 14020	2000	Environmental labels and declarations – General principles
ISO 14021	1999	Environmental labels and declarations – Self-declared environmental claims (Type II environmental labeling)
ISO 14024	1999	Environmental labels and declarations – Type I environmental labeling – Principles and procedures
ISO/TR 14025	2000	Environmental labels and declarations – Type III environmental declarations
ISO 14031	1999	Environmental management – Environmental performance evaluation – Guidelines
ISO/TR 14032	1999	Environmental management – Examples of environmental performance evaluation
ISO 14040	1997	Environmental management – Life cycle assessment – Principles and framework
ISO 14041	1998	Environmental management – Life cycle assessment – Goal and scope definition and inventory analysis
ISO 14042	2000	Environmental management – Life cycle assessment – Life cycle impact assessment
ISO 14043	2000	Environmental management – Life cycle assessment – Life cycle interpretation
ISO/TR 14047	TBD	Environmental management – Life cycle assessment – Examples of application of ISO 14042
ISO/TS 14048	2002	Environmental management – Life cycle assessment – Data documentation format
ISO/TR 14049	2000	Environmental management – Life cycle assessment – Examples of application of ISO 14041 to goal and scope definition and inventory analysis
ISO 14050	2002	Environmental management – Vocabulary
ISO/TR 14061	1998	Information to assist forestry organizations in the use of the Environmental Management System standards ISO 14001 and ISO 14004
ISO/TR 14062	2002	Environmental management – Integrating environmental

		aspects into product design and development
ISO/WD 14063	TBD	Environmental management – Environmental communications – Guidelines and examples
ISO/AWI 14064	TBD	Guidelines for measuring, reporting and verifying entity project-level greenhouse gas emissions
ISO 19011	2002	Guidelines for quality and/or environmental management systems auditing (This standard replaces ISO 14010, 14011 and 14012)

(ISO, 2002b)

Appendix 4 Environmental Management Survey

UNIVERSITY OF CALIFORNIA, SANTA BARBARA

BERKELEY • DAVIS • IRVINE • LOS ANGELES • MERCED • RIVERSIDE • SAN DIEGO • SAN FRANCISCO SANTA BARBARA • SANTA CRUZ

Environmental Management Survey

This survey is being sent to environmental managers across the United States. The results will help environmental managers create more effective environmental training and management programs. It should take about 15 minutes to complete.

The survey has been designed by graduate students at the Donald Bren School at the University of California, Santa Barbara. Information you provide will be analyzed as part of a Master's thesis, the results of which will be presented at a small public workshop in the Spring of 2003. All responses are **strictly confidential**, and reported results will include only aggregate measures, general analysis and interpretation. Please let us know on the following page if you would like to be notified when the report is available online or if you would like more information about the workshop.

There are no correct or incorrect responses, so please express yourself freely. At the end of the survey you will have an opportunity to share any additional comments or to elaborate on earlier responses. Your prompt reply is important to us. It will help to provide us with an accurate representation of facilities in the United States, and will strengthen our contribution to the growing literature on environmental management.

Please return the completed survey in the pre-addressed envelope provided by November 5th.

We thank you for taking the time to complete this survey. Should you have any questions or comments, please do not hesitate to contact us at emsurvey@bren.ucsb.edu.

Ryan Harding
Brandy O'Gorman
John Onderdonk
Derek Sweatt
Greg Tamblyn

Donald Bren School
University of California, Santa Barbara

Optional Respondent Information

Would you like to be notified when the final report is available online? Yes ☐ No ☐

Would you like to receive more information about the public workshop? Yes ☐ No ☐

Email address: _____

Survey begins on the next page.

FACILITY ENVIRONMENTAL MANAGEMENT

Please answer the following questions concerning your facility or plant as opposed to your corporate headquarters or parent company.

General Facility Information

1. How many employees does your facility have? _____

2. How many of these employees have environmental responsibilities (for example, hazardous waste, air quality, scrap recycling) in their job? _____

3. Has your facility significantly changed it's operations, either by changing product lines or ceasing manufacturing, since the year 2000?

   Yes ☐ No ☐ Don't Know ☐

4. How involved is the facility manager in environmental management at your facility?

Very Involved	*Somewhat Involved*	*Not Involved*	*Don't Know*
☐	☐	☐	☐

5. Does your facility have an Environmental Manager or equivalent that is responsible for environmental issues at your facility?

   Yes ☐ No ☐ Don't Know ☐
   If you answer 'No' or 'Don't Know', go to question 7.

6. If yes, what percentage of his or her time is spent on environmental issues?_____

Facility Environmental Policy

The environmental policy is a statement or written document where the facility defines its main environmental goals and objectives.

7. Does your facility have a written environmental policy?

   Yes ☐ No ☐ Don't Know ☐
   If you answer 'No' or 'Don't Know', go to question 11.

8. Who wrote this environmental policy? *Check all that apply.*
   - ☐ Our Facility
   - ☐ Corporate Headquarters or Parent Company
   - ☐ Other: _____

9. Please indicate to which of the following areas the facility environmental policy applies.

	Yes	*No*	*Don't Know*
Facility operations	☐	☐	☐
Facility products and services	☐	☐	☐
Facility suppliers and service providers	☐	☐	☐
Other:_____	☐	☐	☐

10. How is the facility environmental policy made available to employees? *(Check all that apply)*

- ☐ Written policy is posted around the facility
- ☐ Employee receives a copy when they are hired
- ☐ Employee learns about it during environmental training
- ☐ Written policy is available on the facility website or intranet
- ☐ Supervisor informs employees about the environmental policy.
- ☐ Other:_____

Environmental Management System

An environmental management system documents the processes, practices, procedures, and resources necessary for achieving environmental goals.

11. Does your facility have a documented environmental management system (EMS)?

Yes ☐ No ☐ Don't Know ☐

If you answer 'No' or 'Don't Know', go to question 15.

12. In what year did you implement your current EMS? _____

13. To what degree were the following people involved in the design of the EMS?

	Heavily Involved	*Involved*	*Not Involved*	*Don't Know*
Facility Manager	☐	☐	☐	☐
Facility Environmental Manager	☐	☐	☐	☐
Corporate staff	☐	☐	☐	☐
Staff from other facilities	☐	☐	☐	☐
External consultant	☐	☐	☐	☐
Facility employees	☐	☐	☐	☐
Other: _____	☐	☐	☐	☐

14. How effective is your EMS at helping the facility manage the following issues?

	Effective	*Partially Effective*	*Ineffective*	*Don't Know*
Regulatory compliance	☐	☐	☐	☐
Identifying environmental impacts	☐	☐	☐	☐
Managing environmental impacts	☐	☐	☐	☐
Demonstrating environmental stewardship to the public	☐	☐	☐	☐
Promoting internal communication among managers	☐	☐	☐	☐
Fostering communication with the community	☐	☐	☐	☐
Improve Environmental Performance	☐	☐	☐	☐

ISO Certification

15. Is your facility ISO 9000 registered?

Yes ☐ No ☐ Don't Know ☐

16. Is your Environmental Management System ISO 14001 certified?

Yes ☐ No ☐ Don't Know ☐
If you answer 'No' or 'Don't Know', go to question 20.

17. How is your Environmental Management System certified for ISO 14001?

Self ☐ External ☐ Don't Know ☐

18. Check the statement that best describes the scope of your ISO 14001 certification:

Entire Facility ☐ Specific Area within your Facility ☐ Don't Know ☐

19. Which one of the following reason(s) was most important in deciding to certify your facility? *Check all that apply.*
    - ☐ Corporate mandate
    - ☐ Improve regulatory compliance
    - ☐ Improve management of environmental impacts
    - ☐ Improve communication and demonstrate environmental stewardship to the public
    - ☐ Customer request
    - ☐ Improve internal communication among managers
    - ☐ Improve business opportunities
    - ☐ Decrease insurance costs
    - ☐ Other:_____
    - ☐ Don't Know

Environmental Performance Indicators (EPIs)

Environmental Performance Indicators measure an aspect of environmental performance, such as resources use or pollution emission.

20. Does your facility use environmental performance indicators (EPI)?

Yes ☐ No ☐ Don't Know ☐

If you answer 'No' or 'Don't Know', go to question 22.

21. What type of EPI does your Facility use? *Check all that apply.*
    - ☐ Energy consumption
    - ☐ Water consumption
    - ☐ Solid waste generation
    - ☐ Hazardous waste generation
    - ☐ Air emissions
    - ☐ Other:_____

Employee Participation

22. How do individual employees at your facility receive information regarding environmental issues? *Check all that apply.*
    - ☐ Workshops / Seminars / Briefings
    - ☐ Audiovisual or computer based materials
    - ☐ Corporate environmental report
    - ☐ Procedures manual
    - ☐ Newsletters, posters and notices
    - ☐ During performance evaluations
    - ☐ Informal conversations during work with supervisor
    - ☐ Environmental Manager or equivalent
    - ☐ Co-workers
    - ☐ Other:_____

23. Does your facility have a system that allows employees to suggest ways to improve environmental practices?

    Yes ☐ No ☐ Don't Know ☐

    If 'Yes', How?_____

24. Which of the following describes your environmental training program? *Check all that apply.*
    - ☐ Training materials or summaries are available to employees at any time
    - ☐ Employee comprehension of material is tested
    - ☐ Refresher training is provided to employees as needed
    - ☐ Training is tailored to each job description
    - ☐ Other:_____
    - ☐ No Program

25. How many hours of environmental training does the average employee receive in one year? _____

26. What information do your employees receive during environmental training? *Check all that apply.*
    - ☐ Environmental policy
    - ☐ Environmental impacts of their job position
    - ☐ Training regarding their role and responsibilities in avoiding or reducing environmental impacts
    - ☐ Training to help employees creatively solve environmental problems
    - ☐ Other:_____

27. How is environmental training delivered to employees? *Check all that apply.*
    - ☐ Computer or Video
    - ☐ On the job training
    - ☐ Written Materials
    - ☐ Instruction by qualified facility employee or Consultant
    - ☐ Other:_____

28. Are environmental goals considered in **job performance reviews** for the following employees: *Check all that apply.*
    - ☐ Facility manager
    - ☐ Facility Environmental manager or equivalent
    - ☐ Non-management employees
    - ☐ Other:_____
    - ☐ None

29. Does your facility present **awards** to its employees for contributions to environmental performance?

    Yes ☐ No ☐ Don't Know ☐

    If you answer 'No' or 'Don't Know', go to question 31.

30. If yes, what type of awards? *Check all that apply.*
    - ☐ Bonus pay
    - ☐ Non-monetary award (gifts, company products, dinner, or other awards with value)
    - ☐ Public recognition (in newsletter, website, etc.)
    - ☐ Other:_____

Facility EMS Review and Internal Audits

An audit determines whether environmental practices, policies and procedures are being carried out as planned.

31. How often is your facility's overall EMS reviewed?

- ☐ Multiple reviews in a year
- ☐ Once a year
- ☐ Once every 2 years
- ☐ Once every 3 years
- ☐ Once every 4 years or more
- ☐ Never

32. Who is involved in this review? *Check all that apply.*

- ☐ Corporate Board of Directors
- ☐ Corporate Environmental Managers
- ☐ Facility Manager
- ☐ Environmental Manager or equivalent
- ☐ Non-management employees
- ☐ Other:_____

33. Does your facility have an environmental audit program?

Yes ☐ No ☐ Don't Know ☐

If you answer 'No' or 'Don't Know', go to question 38.

34. Which of the following describes your environmental auditing program? *Check all that apply.*

Internal Audit ☐ Independent / 3rd Party Audit ☐ Don't Know ☐

35. Is there a process to ensure that any observations, recommendations, or findings from internal audits are acted upon?

Yes ☐ No ☐ Don't Know ☐

36. Who participates in environmental audits at your facility? *Check all that apply.*

- ☐ Facility environmental staff
- ☐ Corporate environmental staff
- ☐ External consultant
- ☐ Employees
- ☐ Other:_____

37. How many internal environmental audits are conducted each year in the facility?

0	1	2	3	4	More than 5
☐	☐	☐	☐	☐	☐

Corporate Environmental Management

The following questions apply to your corporate headquarters or parent company. They do not apply to your individual facility.

38. Does your facility have a parent company?

Yes ☐ No ☐ Don't Know ☐

If you answer 'No' or 'Don't Know', go to question 40.

39. In what country is your parent company located?_____

40. How does your facility receive information from the parent company or corporate headquarters regarding environmental issues? *Check all that apply.*
    - ☐ Workshops or Seminars
    - ☐ Corporate Environmental Report
    - ☐ Corporate environmental procedures manual
    - ☐ Newsletters or notices
    - ☐ Company-wide emails, voicemail messages, or intranet
    - ☐ Informal conversations with Corporate Staff
    - ☐ Other:_____

41. How often does your facility communicate with the parent company or corporate headquarters regarding environmental issues?
    - ☐ Weekly or more often
    - ☐ Monthly
    - ☐ Quarterly
    - ☐ Annually
    - ☐ Once every two years
    - ☐ Other:_____

42. Does your company publish an annual corporate environmental report?

Yes ☐ No ☐ Don't Know ☐

If you answer 'No' or 'Don't Know', go to question 44.

43. Does the report include information on your facility?

Yes ☐ No ☐ Don't Know ☐

44. Does your company have a written environmental policy at the Corporate Level where its main environmental goals and objectives are defined?

Yes ☐ No ☐ Don't know ☐

45. Has the corporation defined quantifiable environmental targets for your facility?

Yes ☐ No ☐ Don't Know ☐

46. Are there company wide programs in place to formally assess and minimize the environmental impacts associated with:

	Yes	*No*	*Does Not Apply*	*Don't Know*
Company Operations	☐	☐	☐	☐
Product Packaging	☐	☐	☐	☐
Product Distribution	☐	☐	☐	☐
Product Use and Disposal	☐	☐	☐	☐
Company Services Provided	☐	☐	☐	☐
Suppliers and Service Providers	☐	☐	☐	☐

47. Please specify if your company has implemented any of these actions in the last five years:

	Implemented	*Considered, but not Implemented*	*Not Considered*	*Don't Know*
Taken environmental performance into account in selection of new suppliers	☐	☐	☐	☐
Placed demands on existing suppliers to take environmental actions	☐	☐	☐	☐
Introduced 'green products'	☐	☐	☐	☐
Implemented product life cycle analysis (LCA)	☐	☐	☐	☐

48. Does your company participate in voluntary environmental initiatives?

- ☐ Project XL
- ☐ Energy Star
- ☐ WasteWise
- ☐ Natural Step
- ☐ LEED Certification
- ☐ Environmental Performance Track
- ☐ Other:_____
- ☐ Don't Know

Please provide us with any additional comments that you feel would be useful.

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

END OF SURVEY

Please return the survey in the enclosed envelope.
Thank you very much for your time.

Appendix 5 Time Weighted Averages

Compound	CAS #	TWA (mg/m^3 air)	Source
1,1,1-TRICHLOROETHANE	71-55-6	1900	OSHA
1,1,2,2-TETRACHLOROETHANE	79-34-5	35	OSHA
1,1,2-TRICHLOROETHANE	79-00-5	45	OSHA
1,1-DICHLOROETHANE	75-34-3	400	OSHA
1,1-DIMETHYL HYDRAZINE	57-14-7	1	OSHA
1,2,3-TRICHLOROPROPANE	96-18-4	300	OSHA
1,2,4-TRICHLOROBENZENE	120-82-1	40	NIOSH
1,2,4-TRIMETHYLBENZENE	95-63-6	125	OSHA
1,2-DIBROMOETHANE	106-93-4	153.8	OSHA
1,2-DICHLOROBENZENE	95-50-1	300	OSHA
1,2-DICHLOROETHANE	107-06-2	202.5	OSHA
1,2-DICHLOROETHYLENE	540-59-0	790	OSHA
1,2-DICHLOROPROPANE	78-87-5	350	OSHA
1,3-BUTADIENE	106-99-0	2.21	NIOSH
1,3-DICHLOROPROPENE (MIXED ISOMERS)	542-75-6	5	OSHA
1,4-DICHLOROBENZENE	106-46-7	450	OSHA
1,4-DIOXANE	123-91-1	360	OSHA
1-METHYL-2-NITROBENZENE	88-72-2	30	OSHA
1-METHYL-3-NITROBENZENE	99-08-1	30	OSHA
2,4,5-T	93-76-5	10	OSHA
2,4,6-TRINITROPHENOL	88-89-1	0.1	OSHA
2,4,6-TRINITROTOLUENE	118-96-7	1.5	OSHA
2,4-D	94-75-7	10	OSHA
2-CHLOR-1,3-BUTADIENE	126-99-8	90	OSHA
2-METHYL-1-PROPANOL	78-83-1	300	OSHA
2-NITROPROPANE	79-46-9	90	OSHA
4,6-DINITRO-O-CRESOL	534-52-1	0.2	OSHA
ACETALDEHYDE	75-07-0	360	OSHA
ACETONE	67-64-1	2400	Osha
ACETONITRILE	75-05-8	70	OSHA
ACROLEIN	107-02-8	0.25	OSHA
ACRYLAMIDE	79-06-1	0.3	OSHA
ACRYLIC ACID	79-10-7	6	NIOSH

Compound	CAS #	TWA (mg/m³ air)	Source
ACRYLONITRILE	107-13-1	4.34	OSHA
ALDRIN	309-00-2	0.25	OSHA
ALLYL ALCOHOL	107-18-6	5	OSHA
ALLYL CHLORIDE	107-05-1	3	OSHA
ALUMINUM	7429-90-5	15	OSHA
AMMONIA	7664-41-7	35	OSHA
ANILINE	62-53-3	19	OSHA
ANTIMONY COMPOUNDS	ADQ500	0.5	OSHA
AROCLOR 1254	11097-69-1	0.5	OSHA
ARSENIC	7440-38-2	0.01	OSHA
ARSENIC (ORGANIC OR INORGANIC COMPOUNDS)	ARF750	0.01	OSHA
ATRAZINE	1912-24-9	5	NIOSH
AZINPHOS-METHYL	86-50-0	0.2	OSHA
BARIUM	7440-39-3	0.5	OSHA
BARIUM COMPOUNDS	BAK500	0.5	OSHA
BENOMYL	17804-35-2	15	OSHA
BENZENE	71-43-2	3.19	OSHA
BENZENETHIOL	108-98-5	0.5	NIOSH
BENZO(A)PYRENE	50-32-8	0.2	OSHA
BENZYL CHLORIDE	100-44-7	5	OSHA
BERYLLIUM	7440-41-7	0.002	OSHA
BERYLLIUM COMPOUNDS	BFQ500	0.002	OSHA
BIPHENYL	92-52-4	0.2	OSHA
BIS(2-CHLOROETHYL) ETHER	111-44-4	90	OSHA
BIS(2-ETHYLHEXYL)PHTHALATE	117-81-7	5	OSHA
CADMIUM	7440-43-9	0.005	OSHA
CADMIUM COMPOUNDS	CAE750	0.005	OSHA
CAMPHECHLOR	8001-35-2	0.5	OSHA
CAPTAFOL	191906	0.1	NIOSH
CAPTAN	133-06-2	5	NIOSH
CARBARYL	63-25-2	5	OSHA
CARBOFURAN	1563-66-2	0.1	NIOSH
CARBON DISULFIDE	75-15-0	62.2	OSHA
CARBON MONOXIDE	630-08-0	55	OSHA
CARBON TETRACHLORIDE	56-23-5	62.9	OSHA

Compound	CAS #	TWA (mg/m³ air)	Source
CATECHOL	120-80-9	20	NIOSH
CHLORDANE	57-74-9	0.5	OSHA
CHLOROBENZENE	108-90-7	350	OSHA
CHLORODIFLUOROMETHANE	75-45-6	3500	NIOSH
CHLOROETHANE	75-00-3	2600	OSHA
CHLOROFORM	67-66-3	240	OSHA
CHLOROMETHANE	74-87-3	207	OSHA
CHLORPYRIFOS	2921-88-2	0.2	NIOSH
CHROMIUM	7440-47-3	1	OSHA
CHROMIUM COMPOUNDS	CMJ500	1	OSHA
COBALT	7440-48-4	0.1	Osha
COBALT COMPOUNDS	CNB850	0.1	OSHA
COPPER	7440-50-8	1	OSHA
COPPER COMPOUNDS	CNK750	1	OSHA
CUMENE	98-82-8	245	OSHA
CYCLOHEXANE	110-82-7	1050	OSHA
CYCLOHEXANONE	108-94-1	200	OSHA
DDT	50-29-3	1	OSHA
DEMETON	8065-48-3	0.1	OSHA
DIAZINON	333-41-5	0.1	NIOSH
DIBUTYL PHTHALATE	84-74-2	5	OSHA
DICHLORODIFLUOROMETHANE	75-71-8	4950	OSHA
DICHLOROMETHANE	75-09-2	86.75	OSHA
DICHLORVOS	62-73-7	1	OSHA
DIELDRIN	60-57-1	0.25	OSHA
DIETHANOLAMINE	111-42-2	15	NIOSH
DIETHYL ETHER	60-29-7	1200	OSHA
DIETHYL PHTHALATE	84-66-2	5	OSHA
DIMETHYL PHTHALATE	131-11-3	5	OSHA
DIMETHYL SULFATE	77-78-1	5	OSHA
DIMETHYLAMINE	124-40-3	18	OSHA
DIPHENYLAMINE	122-39-4	10	NIOSH
DISULFOTON	298-04-4	0.1	OSHA
DIURON	330-54-1	10	NIOSH
ENDOSULFAN	115-29-7	0.1	NIOSH

Compound	CAS #	TWA (mg/m³ air)	Source
ENDRIN	72-20-8	0.1	OSHA
EPICHLOROHYDRIN	106-89-8	19	OSHA
ETHYL ACETATE	141-78-6	1400	OSHA
ETHYL ACRYLATE	140-88-5	100	OSHA
ETHYLBENZENE	100-41-4	435	OSHA
ETHYLENE GLYCOL MONOETHYL ETHER	110-80-5	740	OSHA
ETHYLENE GLYCOL MONOMETHYL ETHER	109-86-4	80	OSHA
ETHYLENE OXIDE	75-21-8	1.8	OSHA
FORMALDEHYDE	50-00-0	0.75	OSHA
FORMIC ACID	64-18-6	9	OSHA
FREON 113	76-13-1	7600	OSHA
GAMMA-LINDANE	58-89-9	0.5	OSHA
HEPTACHLOR	76-44-8	0.5	OSHA
HEXACHLORO-1,3-BUTADIENE	87-68-3	0.24	NIOSH
HEXACHLOROCYCLOPENTADIENE	77-47-4	0.1	NIOSH
HEXACHLOROETHANE	67-72-1	10	OSHA
HYDRAZINE	302-01-2	1.3	OSHA
HYDROCHLORIC ACID	7647-01-0	7	OSHA
HYDROFLUORIC ACID	7664-39-3	2.5	OSHA
HYDROGEN CYANIDE	74-90-8	11	OSHA
HYDROQUINONE	123-31-9	2	OSHA
ISOPHORONE	78-59-1	140	OSHA
ISOPROPYL ALCOHOL	67-63-0	980	OSHA
LEAD	7439-92-1	0.05	OSHA
LEAD COMPOUNDS	LCT000	0.05	OSHA
M-CRESOL	108-39-4	22	OSHA
M-DINITROBENZENE	99-65-0	15	OSHA
M-XYLENE	108-38-3	435	OSHA
MALATHION	121-75-5	15	OSHA
MALEIC ANHYDRIDE	108-31-6	0.25	OSHA
MANGANESE	7439-96-5	5	OSHA
MANGANESE COMPOUNDS	MAR500	5	OSHA
MERCURY	7439-97-6	0.1	OSHA
MERCURY COMPOUNDS	EDF-033	0.1	OSHA
METHACRYLONITRILE	126-98-7	3	NIOSH

Compound	CAS #	TWA (mg/m³ air)	Source
METHANOL	67-56-1	260	OSHA
METHOMYL	16752-77-5	2.5	NIOSH
METHOXYCHLOR	72-43-5	15	OSHA
METHYL ACETATE	79-20-9	610	OSHA
METHYL ACRYLATE	96-33-3	35	OSHA
METHYL BROMIDE	74-83-9	80	OSHA
METHYL ETHYL KETONE	78-93-3	590	OSHA
METHYL HYDRAZINE	60-34-4	0.35	OSHA
METHYL IODIDE	74-88-4	28	OSHA
METHYL ISOBUTYL KETONE	108-10-1	410	OSHA
METHYL METHACRYLATE	80-62-6	410	OSHA
METHYL PARATHION	298-00-0	0.2	NIOSH
METRIBUZIN	21087-64-9	5	NIOSH
MEVINPHOS	7786-34-7	0.1	OSHA
MOLYBDENUM	7439-98-7	15	OSHA
N,N-DIMETHYLANILINE	121-69-7	25	OSHA
N-BUTYL ALCOHOL	71-36-3	300	OSHA
N-HEXANE	110-54-3	1800	OSHA
NAPHTHALENE	91-20-3	50	OSHA
NICKEL	7440-02-0	1	OSHA
NICKEL COMPOUNDS	NDB000	1	OSHA
NITRIC ACID	7697-37-2	5	OSHA
NITROBENZENE	98-95-3	5	OSHA
NITROGEN DIOXIDE	10102-44-0	9	OSHA
NITROGLYCERIN	55-63-0	2	OSHA
O-ANISIDINE	90-04-0	0.5	OSHA
O-CRESOL	95-48-7	22	OSHA
O-DINITROBENZENE	528-29-0	1	OSHA
O-TOLUIDINE	95-53-4	22	OSHA
O-XYLENE	95-47-6	435	OSHA
OZONE	10028-15-6	0.2	OSHA
P-CRESOL	106-44-5	22	OSHA
P-DINITROBENZENE	100-25-4	1	OSHA
P-NITROCHLOROBENZENE	100-00-5	1	OSHA
P-PHENYLENEDIAMINE	106-50-3	0.1	OSHA

Compound	CAS #	TWA (mg/m³ air)	Source
P-XYLENE	106-42-3	435	OSHA
PARATHION	56-38-2	0.1	OSHA
PENTACHLOROPHENOL	87-86-5	0.5	OSHA
PHENOL	108-95-2	19	OSHA
PHOSPHORIC ACID	7664-38-2	1	OSHA
PHTHALIC ANHYDRIDE	85-44-9	12	OSHA
PROPOXUR	114-26-1	0.5	OSHA
PROPYLENE OXIDE	75-56-9	240	OSHA
PYRIDINE	110-86-1	15	OSHA
SEC-BUTYL ALCOHOL	78-92-2	450	OSHA
SELENIUM	7782-49-2	0.2	OSHA
SELENIUM COMPOUNDS	SBP500	0.2	OSHA
SILVER	7440-22-4	0.01	OSHA
SILVER COMPOUNDS	SDO000	0.01	OSHA
STYRENE	100-42-5	426	OSHA
TERT-BUTYL ALCOHOL	75-65-0	300	OSHA
TETRACHLOROETHYLENE	127-18-4	678	OSHA
THALLIUM	7440-28-0	0.1	OSHA
THIRAM	137-26-8	5	OSHA
TIN	7440-31-5	2	OSHA
TOLUENE	108-88-3	754	OSHA
TRIBROMOMETHANE	75-25-2	5	OSHA
TRICHLOROETHYLENE	79-01-6	537	OSHA
TRICHLOROFLUOROMETHANE	75-69-4	5600	OSHA
TRIETHYLAMINE	121-44-8	100	OSHA
TRIPHENYLTIN CHLORIDE	639-58-7	0.1	OSHA
VINYL ACETATE	108-05-4	15	NIOSH
VINYL CHLORIDE	75-01-4	2.56	OSHA
XYLENE (MIXED ISOMERS)	1330-20-7	435	OSHA
CYANIDE COMPOUNDS		11	OSHA
BENZOYL PEROXIDE	94-36-0	5	OSHA
SULFURIC ACID	7664-93-9	1	OSHA

(Center for Disease Control and Prevention, 2003)

Appendix 6 TRI Exposure Categories

The various types of releases are listed exactly as noted by the US EPA in the TRI list of field names documentation (EPA, 2002e). Additions to the field names have been provided in italics for clarification. In most cases, these fields are sums of other fields within the TRI.

Low Exposure Potential
Total Underground Injection *(onsite)*
Total Other On-Site Land Releases
Total RCRA Subtitle C Landfills
Total Other Disposal
Transfers to POTWs (Metals And Metal Compounds) *(POTWS = publicly owned treatment works)*
Underground Injection *(offsite)*
Landfills/Disposal Surface Impoundments *(offsite)*
Other Off-Site Management
Other Land Disposal
Transfers to Waste Broker for Disposal
Unknown
Total Transferred Off-Site For Further Waste Management
Other On-Site Waste Management

Medium Exposure Potential
Total Land Treatment *(onsite)*
Total Surface Impoundments
Land Treatment *(offsite)*

High Exposure Potential
Total Air Emissions
Total Surface Water Discharge

Appendix 7 Survey Results

		ISO Group	Non-ISO Group
Q1_EMP	Mean	1056.97	185.12
	Median	460	100
	Minimum	25	8
	Maximum	22000	1100
	Range	21975	1092

		ISO Group	Non-ISO Group
Q2_RESP	Mean	257.68	37.09
	Median	25	6
	Minimum	1	1
	Maximum	4600	900
	Range	4599	899

		ISO Group	Non-ISO Group
Q3_Operations	Yes	39	16
	No	87	51

		ISO Group	Non-ISO Group
Q4_FMGR	Very Involved	72	32
	Somewhat Involved	52	30
	Not Involved	1	5

		ISO Group	Non-ISO Group
Q5_ENVMG	Yes	121	58
	No	5	9

		ISO Group	Non-ISO Group
Q6_EM	Mean	0.612	0.509
	Median	0.5000	0.5000
	Minimum	0.05	0.01
	Maximum	1.00	1.00
	Range	0.95	0.99

		ISO Group	Non-ISO Group
Q7_POL	Yes	126	50
	No	0	17

		ISO Group	Non-ISO Group
Q8_FAC	Yes	103	24
	No	23	26

		ISO Group	Non-ISO Group
Q8_CORP	Yes	50	31
	No	76	19

		ISO Group	Non-ISO Group
Q8_OTHER	Yes	0	2
	No	126	48

		ISO Group	Non-ISO Group
Q9_OPS	Yes	124	50
Q9_PROD	Yes	111	36
	No	12	12
	Don't Know	1	2
Q9_SUPP	Yes	92	27
	No	31	21
	Don't Know	1	2
Q9_OTHER	Yes	10	1
	No	114	49

		ISO Group	Non-ISO Group
Q10_POST	Yes	119	24
	No	7	24
Q10_HIRE	Yes	82	7
	No	44	41
Q10_TRNG	Yes	122	33
	No	4	15
Q10_WEB	Yes	86	22
	No	40	26
Q10_SUPR	Yes	72	14
	No	54	34
Q10_OTHR	Yes	4	0
	No	122	48

		ISO Group	Non-ISO Group
Q11_DOC	Yes	126	24
	No	0	43

		ISO Group	Non-ISO Group
Q12_EMS YEAR	1980	0	1
	1984	0	1
	1990	0	1
	1991	1	0
	1992	1	1
	1994	1	1
	1995	0	2
	1996	5	3
	1997	23	1
	1998	37	2
	1999	45	3
	2000	7	2
	2001	3	2
	2002	2	0

		ISO Group	Non-ISO Group
Q13_FMGR	Heavily Involved	36	4
	Involved	77	12
	Not Involved	12	5
	Don't Know	1	2
Q13_EMGR	Heavily Involved	109	16
	Involved	11	4
	Not Involved	0	2
	Don't Know	1	1
Q13_CORP	Heavily Involved	25	5
	Involved	64	11
	Not Involved	34	3
	Don't Know	2	3
Q13_STAF	Heavily Involved	6	1
	Involved	50	5
	Not Involved	64	16
	Don't Know	1	0
Q13_CONS	Heavily Involved	15	0
	Involved	49	10
	Not Involved	57	9
	Don't Know	1	2
Q13_EMP	Heavily Involved	27	4
	Involved	92	8
	Not Involved	5	10
	Don't Know	1	1

		ISO Group	Non-ISO Group
Q14_IDEN	Effective	116	15
	Partially Effective	9	7
	Ineffective	1	0
	Don't Know	0	2
Q14_COMP	Effective	105	20
	Partially Effective	19	4
	Ineffective	2	0
Q14_MNG	Effective	108	15
	Partially Effective	17	6
	Ineffective	1	2
	Don't Know	0	1
Q14_PUB	Effective	76	9
	Partially Effective	39	10
	Ineffective	8	3
	Don't Know	3	2
Q14_COMM	Effective	69	9
	Partially Effective	49	12
	Ineffective	7	2
	Don't Know	1	1
Q14CMNTY	Effective	45	2
	Partially Effective	62	12
	Ineffective	15	5
	Don't Know	4	5
Q14_PERF	Effective	97	12
	Partially Effective	28	10
	Ineffective	1	1
	Don't Know	0	1

		ISO Group	Non-ISO Group
Q15_9000	Yes	114	25
	No	12	42

		ISO Group	Non-ISO Group
Q16_ISO	Yes	126	0
	No	0	67

		ISO Group	Non-ISO Group
Q17_CRT	Self	4	0
	External	122	0

		ISO Group	Non-ISO Group
Q18_SCP	Entire Facility	124	0
	Specific Area	2	0

		ISO Group	Non-ISO Group
Q19_MAND	Yes	97	0
	No	29	0
Q19_COMP	Yes	54	0
	No	72	0
Q19_PUB	Yes	50	0
	No	76	0
Q19_REQ	Yes	44	0
	No	82	0
Q19_COMM	Yes	29	0
	No	97	0
Q19_BUS	Yes	75	0
	No	51	0
Q19_INS	Yes	7	0
	No	119	0
Q19_OTHR	Yes	1	0
	No	125	0
Q19_DK	Yes	0	0
	No	126	0

		ISO Group	Non-ISO Group
Q20_EPI	Yes	118	33
	No	8	34

		ISO Group	Non-ISO Group
Q21_ENER	Yes	107	20
	No	11	13
Q21_HOH	Yes	102	24
	No	16	9
Q21_SOL	Yes	107	24
	No	11	9
Q21_HAZ	Yes	112	30
	No	6	3
Q21_AIR	Yes	104	26
	No	14	7
Q21_OTHR	Yes	9	1
	No	109	32

		ISO Group	Non-ISO Group
Q22_WSHP	Yes	86	40
	No	40	25
Q22_AV	Yes	64	22
	No	62	43
Q22_RPRT	Yes	46	6
	No	80	59
Q22_MANL	Yes	96	25
	No	30	40
Q22_NEWS	Yes	101	27
	No	25	38
Q22_EVAL	Yes	26	3
	No	100	62
Q22_SUPR	Yes	51	38
	No	75	27
Q22_EM	Yes	97	47
	No	29	18
Q22_OTHR	Yes	6	6
	No	120	59

		ISO Group	Non-ISO Group
Q23_SGST	Yes	121	47
	No	4	17

		ISO Group	Non-ISO Group
Q24_MTRL	Yes	90	28
	No	36	36
Q24_TEST	Yes	57	19
	No	69	45
Q24_RFRS	Yes	112	43
	No	14	21
Q24_TLRD	Yes	79	34
	No	47	30
Q24_NONE	Yes	0	4
	No	126	60

		ISO Group	Non-ISO Group
Q25_HRS	Mean	6.2	5.67
	Median	4.0	3.0
	Minimum	0.33	0
	Maximum	50	40
	Range	49.67	40

		ISO Group	Non-ISO Group
Q26_POLY	Yes	118	35
	No	8	27
Q26_IMPC	Yes	118	39
	No	8	23
Q26_ROLE	Yes	122	57
	No	4	5
Q26_CRTV	Yes	35	12
	No	91	50

		ISO Group	Non-ISO Group
Q27_VID	Yes	73	32
	No	53	31
Q27_ONJB	Yes	89	44
	No	37	19
Q27_WRTN	Yes	95	37
	No	31	26
Q27_INST	Yes	109	51
	No	17	12

		ISO Group	Non-ISO Group
Q28_FMGR	Yes	67	24
	No	57	40
Q28_EMGR	Yes	99	39
	No	25	25
Q28_NONM	Yes	38	7
	No	86	57
Q28_OTHR	Yes	5	3
	No	119	61
Q28_NONE	Yes	19	21
	No	105	43

		ISO Group	Non-ISO Group
Q29_AWRD	Yes	61	12
	No	65	53

		ISO Group	Non-ISO Group
Q30_BNUS	No	38	5
	Yes	22	7
Q30_NONM	No	15	4
	Yes	45	8
Q30_RECG	No	17	6
	Yes	43	6

	#EMS reviews per year	**ISO Group**	**Non-ISO Group**
Q31_RVW	0		8
	1		1
	2		8
	3	2	9
	4	36	29
	5	88	9

		ISO Group	**Non-ISO Group**
Q32_BRD	Yes	11	3
	No	115	53
Q32_CMGR	Yes	36	28
	No	90	28
Q32_FMGR	Yes	95	30
	No	31	26
Q32_FEMG	Yes	120	46
	No	6	10
Q32_NONM	Yes	73	12
	No	53	44
Q32_OTHR	Yes	15	3
	No	111	53

		ISO Group	**Non-ISO Group**
Q33_AUDT	Yes	126	42
	No		23

		ISO Group	**Non-ISO Group**
Q34_INT	Yes	119	34
	No	5	8
Q34_IND	Yes	104	16
	No	20	26

		ISO Group	**Non-ISO Group**
Q35_ADTF	Yes	125	41
	No		1

		ISO Group	Non-ISO Group
Q36_FENV	Yes	118	36
	No	7	6
Q36_CENV	Yes	47	25
	No	78	17
Q36_CONS	Yes	63	14
	No	62	28
Q36_EMP	Yes	103	17
	No	22	25
Q36_OTHR	Yes	4	5
	No	121	37

	# audits per year	ISO Group	Non-ISO Group
Q37_ADTS	0	1	5
	1	16	22
	2	29	4
	3	6	1
	4	12	3
	5	61	5

		ISO Group	Non-ISO Group
Q38_PRNT	Yes	120	44
	No	7	19

		ISO Group	Non-ISO Group
Q39_CTRY	Canada	2	0
	England	2	0
	France	2	0
	Germanc	4	1
	Holland	1	0
	Japan	27	0
	Korea	1	0
	Netherlands	3	0
	South Africa	1	0
	Sweden	7	0
	Switzerland	1	0
	UK	1	0
	USA	68	36
	China	0	1
	Finland	0	3
	Ireland	0	1
	Mexico	0	2

		ISO Group	Non-ISO Group
Q40_WSHP	Yes	57	27
	No	67	23
Q40_RPRT	Yes	81	14
	No	43	36
Q40_MNL	Yes	59	21
	No	65	29
Q40_NEWS	Yes	77	17
	No	47	33
Q40_EML	Yes	103	37
	No	21	13
Q40_CONV	Yes	76	33
	No	48	17
Q40_OTHR	Yes		2
	No	124	48

		ISO Group	Non-ISO Group
Q41_COMM	999		2
	98	4	2
	Never	2	4
	Every 2 Years	3	1
	Annually	17	2
	Quarterly	20	3
	Monthly	38	18
	Weekly	40	17

		ISO Group	Non-ISO Group
Q42_CORP	Don't Know	8	7
	Yes	86	14
	No	32	39

		ISO Group	Non-ISO Group
Q43_RPRT	Don't Know	2	0
	Yes	73	11
	No	9	3

		ISO Group	Non-ISO Group
Q44_POLY	Don't Know	6	1
	Yes	109	38
	No	12	19

		ISO Group	Non-ISO Group
Q45_TRGT	Yes	74	22
	No	51	33
	Don't Know	1	3

		ISO Group	Non-ISO Group
Q46_OPS	Does Not Apply	2	
	Don't Know	4	3
	Yes	107	45
	No	11	13
Q46_PACK	Does Not Apply	17	5
	Don't Know	12	9
	Yes	70	19
	No	22	24
Q46_DIST	Does Not Apply	12	3
	Don't Know	25	12
	Yes	41	15
	No	39	26
Q46_USE	Does Not Apply	9	3
	Don't Know	13	6
	Yes	73	32
	No	27	19
Q46_SRVC	Does Not Apply	28	12
	Don't Know	14	10
	Yes	49	11
	No	25	23
Q46_SUPP	Does Not Apply	8	4
	Don't Know	13	10
	Yes	71	20
	No	29	22

		ISO Group	Non-ISO Group
Q47_NSUP	Implemented	72	13
	Considered	25	11
	Not Considered	11	22
	Don't Know	17	14
Q47_ESUP	Implemented	66	10
	Considered	27	9
	Not Considered	15	26
	Don't Know	17	14
Q47_GRN	Implemented	62	21
	Considered	26	9
	Not Considered	17	16
	Don't Know	18	14
Q47_LCA	Implemented	45	4
	Considered	39	8
	Not Considered	20	24
	Don't Know	18	24

		ISO Group	Non-ISO Group
Q48_ONE	Participate	67	18
	Does Not Participate	60	49

Appendices 8 Survey Response Rates

Response Rate per Question

Question	Responses	% Responses	Missing Responses	% Missing
1	191	99%	2	1%
2	186	96%	7	4%
3	193	100%	0	0%
4	192	100%	1	1%
5	193	100%	0	0%
6	178	92%	14	7%
7	193	100%	0	0%
8	176	100%	0	0%
9	174	99%	2	1%
10	174	99%	2	1%
11	193	100%	0	0%
12	149	99%	1	1%
13	149	99%	1	1%
13	144	96%	6	4%
13	147	98%	3	2%
13	143	95%	7	5%
13	143	95%	7	5%
13	148	99%	2	1%
13	8	5%	142	95%
14	150	100%	0	0%
15	193	100%	0	0%
16	193	100%	0	0%
17	125	98%	3	2%
18	125	98%	3	2%
19	125	98%	3	2%
20	193	100%	0	0%
21	151	100%	0	0%
22	191	99%	2	1%
23	189	98%	4	2%
24	190	98%	3	2%
25	185	96%	8	4%
26	188	97%	5	3%
27	189	98%	4	2%
28	188	97%	5	3%
29	191	99%	2	1%
30	72	99%	1	1%
31	190	98%	3	2%
32	182	100%	0	0%
33	191	99%	2	1%
34	166	99%	1	1%
35	167	100%	0	0%
36	167	100%	0	0%
37	165	99%	2	1%

38	190	98%	4	2%
39	164	100%	0	0%
40	174	90%	20	10%
41	173	89%	21	11%
42	186	96%	8	4%
43	98	99%	1	1%
44	185	95%	9	5%
45	184	95%	10	5%
46	185	95%	9	5%
46	178	92%	16	8%
46	173	89%	21	11%
46	182	94%	12	6%
46	172	89%	22	11%
46	177	91%	17	9%
47	185	95%	9	5%
47	184	95%	10	5%
47	183	94%	11	6%
47	182	94%	12	6%
48	114	59%	0	0%