Mary Kay O'Connor Process Safety Center

2001 Assessment of Chemical Safety in the United States

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Texas Engineering Experiment Station
The Texas A&M University System
Chemical Engineering Department
3574 TAMU
College Station, TX 77843-3574
• • • •
http://process-safety.tamu.edu
Phone 979/845-3489

The Mary Kay O'Connor Process Safety Center was established in 1995 with a goal to improve chemical safety in the chemical process industries. The Center is associated with the Texas Engineering Experiment Station, of The Texas A&M University System, Chemical Engineering Division.

The Center provides a uniquely neutral forum to address chemical process safety for all stakeholders, industry, government, labor, and the general public.

This document represents the collective work of the Mary Kay O'Connor Process Safety Center researchers and staff in support of the National Chemical Safety goals. The ongoing research efforts of the Center will be presented in similar documents as work is continued. Each research document serves as an individual step in achieving the national safety goals.

The research presented in this report was conducted by the Mary Kay O'Connor Process Safety Center. The opinions and analysis expressed in this report are solely the responsibility of the Mary Kay O'Connor Process Safety Center.

Mary Kay O'Connor Process Safety Center

Mission

Lead the integration of process safety -
through education, research, and service -
into the education and practice of all individuals
and organizations involved in chemical operations.

Vision

Serve as the premier process safety resource
for all stakeholders so that safety becomes second nature
for managers, engineers, and workers
as progress continues toward zero injuries and lost lives.

Values

- Health and safety of the community and the workforce
- Sound scholarship and academic freedom
- Sharing of knowledge and information
- Diversity of thought and viewpoint
- Independence to practice rigorous science
- Integrity of science validated by peer review
- Freedom to evaluate and comment on public policy
- Progress without undue influence by special interests
- Individual and group achievement

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2001 Assessment Report on Chemical Safety in the United States

Foreword

Chemical Safety in the United States 2001 Assessment Report is a report on the status of chemical safety in the United States. Specifically, this report discusses:

- The feasibility of using existing federal incident databases to measure chemical safety in the United States;
- Defines indicators and metrics for measuring chemical safety;
- Reports on public trust and community interaction through a survey; and
- Provides recommendations for improving chemical safety in the United States.

This report is a product of the Mary Kay O'Connor Process Safety Center. The Center was established in 1995 to improve safety in the chemical process industry through programs, research activities, and educational outreach that are aimed at making safety second nature in the chemical and petrochemical industry. The Center is part of the Texas Engineering Experiment Station, a Texas state agency. It also is associated with the Department of Chemical Engineering at Texas A&M University.

As part of its mission, the Center created the National Chemical Safety Program and convened a diverse group of stakeholders (Roundtable) to determine national chemical safety goals. Those goals were identified as:

- ***Chemical incidents are zero;***
- ***Chemical enterprises have earned the public's trust; and***
- ***Public, government, and facility interactions improve safety and reduce risks.***

Using those goals as a starting point, the Center prepared three reports of the research conducted during 2000 and 2001. These reports are: *Feasibility of Using Federal Incident Databases to Measure and Improve Chemical Safety; Defining Indicators and Metrics for Measuring Improvements in Chemical Safety;* and *Measuring and Understanding Public Trust and Awareness to Prevent Chemical Incidents.* The *2001 Assessment Report on Chemical Safety in the United States* is a summary of the research efforts by the Center.

The process industries, governmental agencies, labor unions, and the general public should use the information in this report to gauge progress in improving chemical safety and to actively participate in the development and implementation of recommendations for improving chemical safety.

This report was prepared by the Center researchers and staff with guidance from the Roundtable and National Chemical Safety Program (NCSP) Steering Committee.

Executive Summary

During the seventeen years since the tragic accident at Bhopal, India, many organizations throughout the United States, including industry, government at all levels, trade associations, labor organizations, environmental and public interest groups, have taken major steps toward improving industrial chemical safety. These steps have included actions dealing with prevention, training, preparedness, and response. It is clear that there are a great many stakeholders concerned with chemical safety, but to date there have been no means to assess whether the myriad of activities are really improving chemical safety.

In an effort to answer this question, the Mary Kay O'Connor Process Safety Center launched a program to assess chemical safety. This program began with a Roundtable meeting of diverse stakeholders in June 1999, to identify a set of national chemical safety goals. Through collaborative efforts, the Roundtable established the National Chemical Safety Goals as:

- ***Chemical incidents are zero;***
- ***Chemical enterprises have earned the public's trust; and***
- ***Public, government, and facility interactions improve safety and reduce risk.***

The primary focus of this 2001 Assessment Report is a summary of the Center's ongoing research efforts related to reaching the National Chemical Safety Goals. Specifically, this report will:

- ***Assess the scope and usefulness of currently available, federal data sources;***
- ***Propose indicators and metrics for measuring chemical safety at fixed facilities;***
- ***Report on the survey of public trust and awareness; and***
- ***Present recommendations to improve chemical safety.***

Analysis of Existing Federal Databases

Many of the existing federal databases are online and searchable offering an ability to analyze the status of chemical safety. Seven federal databases were selected because they provided the best publicly available information that could be used to establish metrics for chemical safety at fixed facilities. They are: RMP 5-Year Accident History; Accidental Release Information Program (ARIP); Occupational Injury and Illness, Census of Fatal Occupational Injuries (OII); Wide-Ranging On-line Data for Epidemiological Reporting (WONDER); Hazardous Substances Emergency Events Surveillance (HSEES), and Incident Reporting Information System (IRIS).

Limitations in current reporting strategies stymie efforts to gain an overview of chemical incidents in the United States. Agencies can only collect information on incidents within their legal authority, which may be further limited by subsequent rulemaking. Many of the rulemaking efforts rely solely on self-reporting by companies or the parties involved. While federal law may require incident reporting, it is difficult to know how many incidents go either unreported or reported multiple times under the varying federal statutes. After reviewing the common data elements that could be normalized, the Center determined that a starting point for assessing chemical safety at fixed facilities should include as indicators: fatalities, injuries, releases, and chemicals. Agreement among the stakeholders on these indicators will be sought in 2002.

Indicators and Metrics

The information being gathered includes data on the number of chemical releases, injuries, illnesses, fatalities, and the chemicals involved. Are these accurate indicators of the status of chemical safety? The Center proposes to use deaths, injuries, releases, and chemicals as the initial set of indicators for fixed facilities. The effect of specific policy changes should be reflected in the data currently being collected, over time, using these indicators. However, it is also necessary to establish a set of metrics (questions) that can be used to evaluate the changes in the data. For fixed facilities, the Center proposes to use:

- What are the 5 most commonly produced chemicals by volume?
- What are the 5 chemicals with most money spent to prevent incidents?
- What are the 5 most released chemicals by business segment and geographic area?
- What are the 5 chemicals with the largest consequences by business segment and geographic area?

These metrics were applied to production volumes obtained from a literature search and the RMP 5-Year Accident History information. The complete results are presented in the body of this report.

Public Trust and Awareness

Community awareness and public trust are essential elements with regard to improving chemical safety. One key component to ensuring citizen awareness is the actions being taken by all stakeholders to mitigate potential exposure. The Center conducted a telephone survey of 720 randomly selected households during the Spring of 2001 to assess public trust and awareness of chemical facilities.

There is a need for stakeholder and citizen outreach and input into efforts to increase chemical safety in communities. Less then one-third of respondents were aware of companies in the community that use, manufacture, or distribute potentially hazardous chemicals. Less than half of all respondents were aware of non-governmental organizations in place to assist in improving chemical safety or of the onsite efforts by EPA and OSHA to increase chemical safety through inspections. Communities continue to turn first to television as their source of information, while the primary source of information should be the company involved.

General Observations

To achieve the National Chemical Safety Goals, stakeholders need a benchmark against which to measure improvements in chemical safety in the United States. Progress is being made in many areas, however more work needs to be done to fully understand chemical incidents. Existing federal databases provide much of the information necessary to understand the causes and consequences. Improvements to the data sources would only enhance the overall understanding. Therefore, the development of an integrated system, based on the federal data, would address many of the problems outlined in the Center’s research efforts. The work in public trust and awareness cannot be slowed or abandoned. The public must understand the hazards associated with the chemicals produced and used in their communities and the efforts being taken to mitigate the risks.

2001 Assessment of Chemical Safety in the United States

1.0 Introduction

In December 1984, the release of 40 metric tons of methyl isocyanate from a pesticide manufacturing plant in Bhopal, India caused the deaths of over 2,000 people and injuries to another 100,000. During the seventeen years that have passed since the tragic accident at Bhopal, many organizations throughout the United States, and indeed the world, have taken major steps toward improving industrial chemical safety. These steps have included actions dealing with prevention, training, preparedness, and response. It is clear that there are a great many stakeholders concerned with chemical safety – governments at all levels, research institutions, trade associations, labor organizations, colleges and universities, public interest groups, and general industry.

1.1 Legislation and Regulations

The history of safety regulations in the United States can be traced back to 1899, when the United States government issued the River and Harbor Act, which prohibited the creation of obstructions to the navigable waterways and was intended to protect the nation's waterways from excessive dumping. Since the Act's promulgation, federal, state, and local governmental organizations have promulgated numerous regulations related to chemical safety and protection of the public and the environment from chemical releases.

However, major steps in regulating industry did not occur until 1970, when the U.S. Occupational Safety and Health Administration (OSHA) and the U.S. Environmental Protection Agency (EPA) were formed. Both of these agencies play a significant role in chemical safety. Several regulations were passed during the 1970s to protect human health and the environment, including the Clean Water Act and the Toxic Substances Control Act.

During the early 1980s, the United States developed an emergency management system focusing on chemical releases, which resulted in the establishment of the National Response Center and the promulgation of EPA's Comprehensive Environmental Response Compensation and Liability Act (CERCLA). In the late 1980s, the focus shifted to preparing for releases, and saw more emphasis upon community-focused regulations like EPA's Emergency Planning and Community Right-to-Know Act.

However, in the 1990s, after witnessing the catastrophic effects of Bhopal, the direction of federal regulations was shifted towards managing hazards. Specifically, the Clean Air Act Amendments of 1990 gave additional authority to both OSHA and EPA in the area of chemical process safety. This resulted in the promulgation of OSHA's *Process Safety Management Standard of Highly Hazardous Chemicals* (PSM Standard, 29 CFR 1910.119) and EPA's *Accidental Release Prevention and Risk Management Planning* (RMP Rule, 40 CFR 68). The Amendments established the U.S. Chemical Safety and Hazard Investigation Board (CSB) as having the primary responsibility for investigating major chemical accidents at fixed facilities.

While OSHA and EPA, through their respective regulations, have the most direct effect on the chemical industry, many other Federal agencies have oversight of the chemical industry and have promulgated their own rules to regulate the industry, including:

- Consumer Product Safety Commission
- U.S. Department of Transportation
- U.S. Coast Guard
- U.S. Department of Interior's Minerals Management Service
- U.S. Department Health and Human Services' Agency for Toxic Substances and Disease Registry.

In the last three decades, these federal agencies have monitored the chemical industry and gathered large quantities of data about releases and incidents. While there has been a shift in regulations in the last decade to manage hazards, to date there has not been a diligent, broad-based approach to reduce hazards and promote inherent safety.

In addition, despite the magnitude of data, stakeholders have not been able to answer the question, "What is the status of chemical safety in the United States?"

1.2 Mary Kay O'Connor Process Safety Center

Embracing its mission and vision, the Center, working with a Roundtable consisting of key stakeholders, began a program to assess chemical safety in the nation. The Program began by analyzing the history of accident prevention activities, reviewing accident and injury statistics, and evaluating other safety programs. The intent was to establish a measurement system that not only helps identify the effectiveness of current programs and activities, but also serves as the basis for setting future goals.

Roundtable and NCSP Steering Committee members are identified in the Appendix. The Roundtable consisted of a broad range of stakeholder groups, including:

- Academicians and Researchers
- Citizen and Public Interest Groups
- Chemical Plant Insurance Representatives
- Environmental Groups
- Federal and State Government Agencies
- Industry
- Industry Associations
- Local Emergency Planning Committees
- Select Overseas Organizations

Throughout several meetings of the Roundtable, attendees unanimously adopted as a vision for chemical safety in the United States, *"To reduce chemical process accidents to zero while building public trust through community interaction"*.

With this initial agreement in hand, the project group moved forward with the guidance of a smaller NCSP Steering Committee. The Steering Committee was selected from the Roundtable with appropriate representation and participation from all stakeholder groups. Over the months following the October 1999 Roundtable meeting, the Steering Committee worked to expand and clarify the vision in an effort to advance the project.

Members of the Roundtable readily recognize the national goals to be long-term objectives and therefore did not establish a fixed timetable for achievement. All stakeholders should remember it is important to show progress towards these goals, rather than to focus solely on total achievement. To show progress, an accurate measurement of chemical safety in the United States first must be determined to provide a benchmark against which to measure progress. Once a clear understanding of the current state of chemical safety is established, then the stakeholders can work to achieve the goals.

While the members of the Roundtable have identified national goals that we can all work toward, it is not possible for the Roundtable or the Center to ensure accomplishment of those goals. Rather, the Center will publish the Chemical Safety Assessment Program results in an assessment report to educate and inform individual chemical industry stakeholders about progress towards reaching the National Chemical Safety Goals and about areas needing improvement in chemical safety.

Based on available resources, the Center began working on the first two parts of the National Goals ***(Chemical incidents are zero; and Chemical enterprises have earned the public's trust)***. Seven databases containing chemical accident data were analyzed and a survey of public trust and community interaction was conducted. The third portion of the National Goals ***(Public, government, and facility interactions improve safety and reduce risk)*** will be analyzed in the future.

2.0 Definitions

The Center needed to establish specific criteria and limitations for its scope of work if the information developed was to be useful. This section provides the required definitions, reasoning, selected indicators, and limitations needed to analyze databases to determine the status of industrial chemical safety in the United States and create a baseline from which to measure progress toward the National Goals.

Chemical safety is defined as:

> **The management principles and systems applied to the identification, understanding, and control of hazards involved in the manufacture or use of chemicals to prevent injuries and incidents.**

A **fixed facility** is defined as:

> **Any building, structure, piece of equipment, or installation involved in the manufacture or use of a hazardous substance that is located at one location or belongs to the same industrial group or under the control of a one person from which an incident could occur.**

A **chemical incident** is defined as:

> **The sudden unintended release of or exposure to a hazardous substance that results in or might reasonably have resulted in, deaths, injuries, significant property or environmental damage, evacuation or sheltering-in-place.**

A **hazardous substance** is defined as:

> **Any chemical, including a petroleum product that is toxic, reactive, flammable, asphyxiating, or that presents a potential hazard to people, the environment, or property because of pressure or temperature.**

These definitions utilize common elements from across several federal agencies, including: the EPA Chemical Emergency Preparedness and Prevention Office; OSHA; U.S. Chemical Safety and Hazard Investigation Board; U.S. Coast Guard; the U.S. Department of Transportation (DOT) Office of Hazardous Materials; the DOT Office of Pipeline Safety; the U.S. Department of Interior Minerals Management Service; the U.S. Department of Health and Human Services ATSDR; U.S. Bureau of Alcohol, Tobacco and Firearms; U.S. Mine Safety and Health Administration; and the National Response Center.

However, this report analyzes many data sources that employ other criteria in the definition of "incident." Where possible, the records are filtered to meet the presented definition. In other cases, this was not entirely possible and the information was used in an "as is" form.

Incidents involving the manufacture, processing, packaging, storage, transportation, distribution, and commercial use of hazardous substances are included. The emphasis in this report is on fixed facilities. Consumer products, drugs, alcoholic beverages, biological agents, radioactive materials, and vehicle fuel are excluded from this report.

2.1 Inclusions and Exclusions of Incidents

The definition of an incident adopted in this report is intended to be broad enough to include all significant acute incidents involving hazardous substances in commercial settings.

However, there are several reasons to limit the definition to exclude incidents with a very low probability of causing harm. The number of incidents could be endless if limitations on the types of chemicals and quantities released are not employed. In addition, to fully understand incidents, reliable data about each incident, its cause, and effects must be fully documented.

For example, the U.S. Coast Guard's data on oil spills provide a lesson on the trade off between the total number of incidents and their significance. In 1998, the U.S. Coast Guard recorded 8,315 spills, of which 7,962 (95.8 percent) were less than 100 gallons. Only 353 spills were greater than 100 gallons. Yet, these 353 spills accounted for 95.7 percent of the total volume of oil spilled. For the 7,962 spills that were less than 100 gallons, the median spill size was one gallon.

Setting limits for other chemicals is far more difficult due to wide variations in volatility, reactivity, flammability, and toxicity. For many substances, release quantities of one to 10 pounds may cause significant harm (e.g., hydrofluoric acid).

In an attempt to gather the most valuable data and limit incidents with a very low probability of causing harm or are not directly related to the purposes of this report, the Center has compiled a list of incident types that will be included and excluded. For the purposes of the report, incidents that will be ***included*** for fixed facilities are:

- Incidents that involve primarily legal activities, even if laws are violated during the activity.
- Fires and explosions involving portable liquid propane gas (LPG) tanks, if they involve a failure of the tank or integral valves;
- Drowning in water, if chemicals are the initiating cause;
- Incidents on offshore platforms in U.S. waters are included if they involve oil and gas processing;
- Incidents at government facilities;
- Hazardous waste sites;
- Fires in warehouses that contain chemicals, if the chemicals are involved in the fire or lead to evacuations or sheltering-in-place, even if the cause of the fire was not related to the chemicals;
- Sheens of oil on water, if the spill is large with known consequences or causes;
- Spills of "small" quantities of low hazard materials, such as ambient temperature and pressure hydraulic fluid, lubricants, heat transfer fluids, and antifreeze, only if there are known consequences; and
- Explosions of blasting materials and pyrotechnics during their manufacture, storage, and transportation.

In an attempt to limit the number of incidents with a low probability of causing harm or are not directly related to industrial chemical safety, the incidents that will be ***excluded*** for fixed facilities are:

- Inherently illegal activities such as illicit drug manufacturing, arson, terrorism, theft, and intentional illegal dumping of chemicals;
- Residential fires caused by natural gas, LPG distribution systems, or gas appliances;
- Fires and explosions involving LPG tanks that involve appliances and supply hoses;
- Spills of vehicle fuel and vehicle fires;
- Drug overdoses and drug poisonings;

- Intentional inhalation of chemicals (i.e., huffing);
- Poisoning due to carbon monoxide as a result of poor combustion in a residence or from a vehicle;
- Incidents at private residences involving consumer products used by the occupants;
- Mine fires and explosions involving naturally occurring gases;
- Blowouts resulting from natural pressure in an oil or gas field;
- Incidents involving radioactive materials, unless a chemical reaction caused or significantly contributed to the incident;
- Sheens of oil on water, if the source, quantity, or effects are unknown;
- Spills of “small” quantities of low hazard materials such as ambient temperature and pressure hydraulic fluid, lubricants, heat transfer fluids, and antifreeze, unless there are known consequences; and
- Damage and injuries resulting from the intentional detonation of blasting materials and pyrotechnics.

3.0 Analysis of Existing Federal Databases

To address the first national goal (***Chemical incidents are zero***), the Center reviewed several federally available databases to provide insight concerning their usefulness for establishing indicators and trends in chemical safety. The databases shown in Table 1 have the most potential for fixed facilities.

Table 1: Available Federal Databases

Agency	Databases
U.S. Environmental Protection Agency	• **Risk Management Program (RMP) 5-year Accident History** • **Accidental Release Information Program (ARIP)**
Centers for Disease Control and Prevention (CDC)	• **Wide-ranging On-line Data for Epidemiological Reporting (WONDER)**
Occupational Safety and Health Administration (OSHA)	• **Occupational Injury and Illness (OII)** • **Census of Fatal Occupational Injuries (CFOI)**
National Response Center	• **Incident Reporting Information System (IRIS)**
Agency for Toxic Substances and Disease Registry (ATSDR)	• **Hazardous Substances Emergency Events Surveillance (HSEES)**

3.1 Incident Reporting Information System (IRIS)

Covered Universe	IRIS contains data on reported releases from fixed facilities, marine/offshore facilities, pipelines, and transportation vehicles. Many federal statutes require reporting of releases to the NRC.
Time Period	1990-1999
Strengths for analytical purposes	NRC handles approximately 30,000 telephone calls each year, of which approximately 25,000 are unique incidents. The database provides an indication of the total number of incidents involving petroleum and non-petroleum products discharged into navigable waterways or onto land.

Weaknesses for analytical purposes	While reporting to the NRC is required by a number of statutes, it also receives numerous “complaints” from the public. Because this system contains initial reports, the information is many times inaccurate or incomplete. In comparing the incident counts among various databases, proper notifications to the NRC are not being made in many cases. Statistical analysis of the consequences of these releases is generally not justified due to the preliminary nature of the information. In addition, practice drills for emergency releases are captured in the database. The NRC collects non-chemical related events such as railroad crossing accidents.

3.2 RMP 5-year Accident History Database

Covered Universe	RMP-covered facilities that have released a listed substance, which is stored above a threshold quantity and results in fatalities, injuries, or significant environmental or property damage, are required to report 5-year accident histories.
Time Period	1994-1999
Strengths for analytical purposes	The reporting is from a well-defined universe of facilities and allows statistical treatment of the frequency of releases per facility or process unit that is not available from other systems. The reports do address such items as the causes and consequences of the release and steps taken to prevent or mitigate future incidents. Future data from EPA’s 5-year Accident History Database may provide more information to determine statistically significant trends and the effects of implementing EPA’s RMP Rule and OSHA’s Process Safety Management (PSM) Standard of Highly Hazardous Chemicals, which were promulgated to improve safety in the chemical industry.
Weaknesses for analytical purposes	Because of the specificity of the requirements, the reported accidents in the RMP 5-year Accident History database may be fewer than the actual number of accidents. The information available also may not be statistically significant because of the relatively short period of time and variability of the number of incidents from month to month. Because the two primary programs intended to improve chemical safety, RPM Rule and OSHA’s PSM standard, were implemented during the period covered by the database, the Center may not be able to reveal the effects of these regulations using the RMP 5-year Accident History database. The RMP Rule went into effect in June 1996 and compliance was required by June 1999. While the incidents reported in EPA’s 5-year Accident History database begin in 1994, OSHA’s PSM standard went into effect in May 1992. The RMP data are available only in 5-year cycles.

3.3 Accidental Release Information Program (ARIP)

Covered Universe	Facilities were asked by EPA to provide information to the ARIP database if the facility reported an incident to EPA’s Emergency Response Notification System and the release event met one or more criteria.

Time Period	1986-1992
Strengths for analytical purposes	ARIP is one of the larger collections of incidents with details concerning, causes, consequences, operating mode, and corrective actions. ARIP has collected over 4,800 release records since it inception. The total database is large enough to provide meaningful analysis and conclusions. ARIP will allow the Center to analyze causes and consequences for the years before the implementation of the RMP 5-year Accident History database. The data are considered accurate because reporting was done directly by facilities several months after the release occurred.
Weaknesses for analytical purposes	This program has been discontinued. No trends with regards to time can be gathered. The chemicals reported to EPA were reported under existing statutes and regulations and tend to exclude gasoline, methane, ethane, propane, and other chemicals, some of which are included in the EPA 5-year Accident History database. In September 1993, EPA took steps to streamline the database by including only releases with significant offsite consequences, such as casualties, evacuations, sheltering-in-place, or any other necessary precautions taken by individuals offs-site as a result of a release. The database questionnaire has been revised over time adding some information and deleting other information. Therefore, analysis cannot be performed on the entire database.

3.4 Occupational Injury and Illness (OII)

Covered Universe	All OSHA-covered facilities.
Time Period	1972 to 1999
Strengths for analytical purposes	These statistics are based on an annual sampling of about 250,000 companies in the United States. This system contains valuable information on chemical incidents resulting in injuries or fatalities. There are no arbitrary limitations due to type of facility, chemical lists, or threshold quantities. The data have been consistently reported since 1992, and therefore trends beginning with 1992 can be determined and compared with injury rates.
Weaknesses for analytical purposes	The BLS databases provide a statistical sample and not individual incidents. Chemical incidents are identified only for cases with days away from work. The survey was redesigned between 1987 and 1992, and therefore statistical analysis is limited for the years prior to 1992. OSHA's definition of an incident is broader than the definition adopted by the Center. OSHA's definition includes all workplace incidents that result in days away from work.

3.5 Wide-Ranging On-line Data for Epidemiological Reporting (WONDER)

Covered Universe	All fatalities in the United States
Time Period	1979-1997

Strengths for analytical purposes	The WONDER database is useful for the purpose of determining overall trends in fatalities due to chemicals. The database allows sorting by codes, which describe a class of chemicals or a type of event. It also allows sorting by the age of the deceased. This feature was used to eliminate victims less than 20 years of age, as it is unlikely these were industrial accidents. The data are available since 1979, which provides a long and statistically significant trend. Unlike most other databases, a physician, who is presumably not biased when determining the cause of death, codes the data.
Weaknesses for analytical purposes	The scope of incidents in WONDER is very broad and contains incidents such as teenager huffing butane, which resulted in a fatal incident, and incidents involving consumer products in residences. The data are not related to specific incidents. Public access to WONDER is limited. Thus it is not possible to eliminate selected types of incidents. Data can only be gathered by presenting queries by the number of fatalities due to a certain cause in a given year by age group.

3.6 Hazardous Substances Emergency Events Surveillance (HSEES)

Covered Universe	Sixteen state health departments currently have cooperative agreements with ATSDR to participate in HSEES. The state health departments report an "event" if it meets the HSEES definition, which is "any release(s) or threatened release(s) of at least one hazardous substance. A substance is considered hazardous if it might reasonably be expected to cause adverse human health effects. Releases of petroleum products are excluded from this system.
Time Period	1990-1998
Strengths for analytical purposes	HSEES captures data for more than 5,000 events annually, which provides a large base of information to analyze. Future analysis of HSEES is expected to yield favorable results.
Weaknesses for analytical purposes	The scope of the data is limited to the states that are participating in the program, which varies; therefore extrapolating the statistical analysis from these data to the rest of the nation is difficult. The HSEES program currently covers only 16 states and excludes petroleum products. The general public does not have access to the data; ATSDR provides summary reports of the data.

3.7 Center's Conclusions on the Usefulness of Federal Databases

The federal databases, most of which are online and searchable, do offer an ability to analyze the status of chemical safety. After looking at common data elements that could be normalized and provide statistically verifiable samples, the Center determined that a beginning point for assessing chemical safety could include an analysis of the number of fatalities, injuries, and releases as they relate to specific chemicals. It is important for each of the agencies to contiue their data collection efforts.

When the Center, in collaboration with the stakeholders, reaches agreement that the base indicators of performance are fatalities, injuries, and releases, then the databases reviewed in this report can provide the groundwork for measuring chemical safety for fixed facilities in the United States. The actual process for normalizing the base indicators of performance to produce a usable model will be addressed in future research efforts.

Unfortunately, there are several issues concerning the databases when attempting to present accurate analysis on chemical safety. Currently many federal, state, and local agencies are collecting and reporting chemical incidents. However, each agency can only collect information on incidents within their legislative authority. Subsequent rulemaking further limits the scope of data collection in many cases. Because of the varying focus among agencies, the data collected and the terminology employed vary widely. The agencies are generally limited to certain chemicals, at or above predetermined threshold quantities, in particular for fixed facilities or transportation modes. These limitations stymie efforts to gain an overview of all chemical incidents and chemical safety in the United States.

In addition, many of the federal systems rely solely on self-reporting of incidents by the companies or parties involved. While federal law mandates incident reporting, it is not known how many incidents each year remain unreported. A significant effort is required to identify and vet the incidents, which are reported multiple times to multiple agencies. An independent means of checking for accuracy and completeness is not conducted due to the significant manhours of contact with each reporting company by a third party. Some agencies do use proactive means of searching for incidents, which ensures a certain level of accuracy; however, their scope is limited in other ways.

Improvements made in the federal databases would result in a clearer picture of national chemical safety. Even with the improvements, information gathered from the federal databases is imperfect. The Center should continue to perform a thorough review as a part of its quality control process. Vetting, in many instances, would still be needed on the databases before useful data can be presented to demonstrate the status of chemical safety in the United States.

4.0 Defining Indicators and Metrics

4.1 Using Indicators

The information gathered includes data on the specifics and numbers of releases of chemicals, on injuries, illnesses, and deaths caused by chemicals. Do these indicators accurately depict the state or effectiveness of chemical safety efforts? Do they indicate whether chemical safety is improving? Is one process or chemical safer than another?

An indicator is generally defined as an observed variable. Essentially, an indicator is presumed to reflect through a positive correlation a single underlying variable. The underlying variable being considered here is the safety of chemical processes. It is impossible to observe or measure chemical safety as a positive measure. It can only be measured as a negative measure, or an observable variable, which is defined when safety processes fail. The number of process failures is an indicator, when taken in the context of the universe of potential failures, of chemical safety.

The indicator becomes more valuable in understanding the underlying variable when observed over a period of time, or as a trend. Trend analysis is based on values of an indicator or series of indicators over time to determine if there is a general sustained movement upward, downward, or if there is no discernible pattern. Trend lines are used to display trends in data and to analyze problems of prediction. Such analysis is also called regression analysis. By using regression analysis, one can extend a trend line in a chart beyond the actual data to predict future values. The specific techniques that are most commonly applied include a linear model, an exponential model, or a moving-averages model.

Trends analysis is commonly misapplied. For example, two or three data points do not indicate a trend, though with a simple glance it might appear so. In any trend and regression analysis, there always is the assumption that a component of the underlying variable is generated through a random or stochastic process interacting with the concrete set of data. Over a short period of time, the potential impact of this random process can be much larger then over a longer time period, where it becomes the "white noise" or part of the error term in a regression analysis.

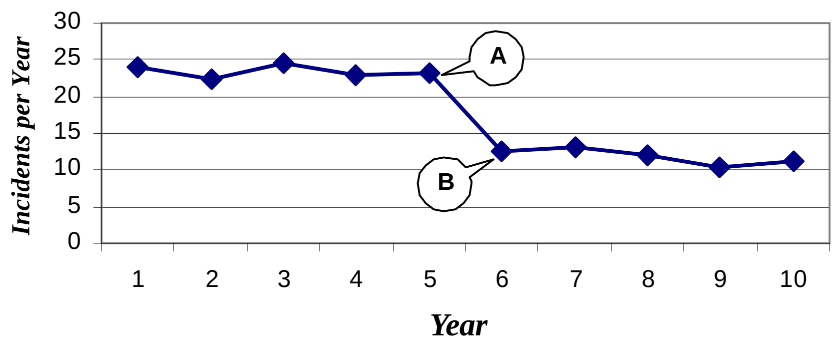
It is often better to use a variety of time periods to perform a trends analysis. For example, weekly measurements viewed over a period of a year may indicate an upward movement of the number of injuries related to chemical releases. When viewed over a five year period, the trend may be generally down, except for the current period, which could have been caused by an external variable, such as a change in the definition of an injury or a change in measuring techniques or methodologies.

On a larger perspective, to be able to compare one set of indicators, the indicators must be normalized so that a comparison is made of essentially equal sets. Normalization is a general process by which two or more indicators are divided by an equivalent denominator. For the above example, an equivalent denominator might be the amount of chemicals produced. It is unadvisable to make a comparison across indicators that have not been normalized, as there is no equivalent basis for comparison.

4.1 Policies Affecting Chemical Safety

Careful selection of indicators is just as important as the identification of information types. The effects of changes in government regulations covering the chemical industry should be identifiable in the data. If a specific policy change or new regulation has an affect on chemical safety, then graphic representations of the data recorded in the federal databases should be reflected in the metric of interest. For example, the data presented in Figure 1 might illustrate the results of a governmental policy change. The performance in years one through five is relatively constant. During the fifth year (point A on the chart), a policy change is made and the resulting performance is shown by the value in year six (point B on the chart). It could be inferred that the change resulted in about a 40 percent decrease in the number of incidents.

Figure 1: Measuring the Impact of a Policy Change



Perhaps the information presented in Figure 1 is a measure of the number of incidents at PSM-covered facilities. If the shift (A to B) occurred in 1996 when PSM programs were nearing full implementation, the shift in the curve would indicate that the PSM standard has had a positive affect on chemical safety by reducing incidents in PSM covered facilities. The amount of shift from the slope of the original curve describes the effectiveness of the PSM implementation. If the change is negative, then the result of the change can be viewed as detrimental. This type of clear indication is the ideal result of the NCSP project to measure chemical safety.

4.2 Governmental Programs

The history of safety regulations in the United States can be traced back to 1899 with the promulgation of the River and Harbor Act. Since that time federal, state, and local governmental organizations have promulgated numerous regulations related to chemical safety and protection of the public and the environment from chemical releases. Major steps in regulating the industry did not occur until 1970, when the U.S. Occupational Safety and Health Administration (OSHA) and the U.S. Environmental Protection Agency (EPA) were formed. However, in the 1990s, following the catastrophic results from Bhopal, the direction of federal regulations was shifted towards managing hazards. Specifically, the Clean Air Act Amendments of 1990 gave additional authority to both OSHA and EPA in the area of chemical process safety.

4.2.1 OSHA's PSM Standard

The Process Safety Management (PSM) standard, promulgated in 1992, is intended to prevent or minimize the consequences of a catastrophic release of toxic, reactive, flammable, or explosive chemicals from a process. A process is any activity or combination of activities including any use, storage, manufacturing, handling, or onsite movement. A process includes any group of vessels that are interconnected and separate vessels that are located such that a hazardous chemical could be involved in a potential release.

The PSM standard applies to processes that contain a threshold quantity or greater amount of a regulated toxic or reactive highly hazardous chemical. The standard applies to 10,000 pounds or greater amounts of flammable liquids and gases.

The PSM standard does not apply to retail facilities, normally unoccupied remote facilities, and oil or gas well drilling or servicing activities. Hydrocarbon fuels used solely for work place consumption as a fuel are not covered, if such fuels are not part of a process containing another highly hazardous chemical covered by the standard. Atmospheric tank storage and associated transfer of flammable liquids that are kept below their normal boiling point without benefit of chilling or refrigeration are not covered by the PSM standard.

4.2.2 EPA's RMP Rule

In 1996, EPA promulgated the RMP Rule, which was mandated by Section 112(r) of the Clean Air Act Amendments of 1990. The regulation requires regulated facilities to develop and implement appropriate risk management programs to minimize the frequency and severity of chemical plant accidents. In keeping with regulatory trends, EPA required a performance-based approach towards compliance with its risk management program regulation.

The EPA regulation requires regulated facilities to develop a Risk Management Plan (RMP). The RMP includes a description of the hazard assessment, a prevention program, and an emergency response program. Facilities submit their RMPs to the EPA, which makes them available to governmental agencies, the state emergency response commission, and local emergency planning committees.

The risk management program regulation defines the worst-case release as the release of the largest quantity of a regulated substance from a vessel or process line failure, including administrative controls and passive mitigation that limit the total quantity involved or the release rate. For alternative scenarios, facilities can take credit for both passive and active mitigation systems.

The final regulation lists endpoints for toxic substances to be used in worst-case and alternative scenario assessments. The toxic endpoints are based on ERPG-2 (Emergency Response Planning Guidelines – Level 2) or other levels of concern data compiled by EPA.

4.2.3 Other Federal Agencies

While OSHA and EPA, through their respective regulations, have the most direct effect on the chemical industry, many other Federal agencies have oversight of the chemical industry and have promulgated their own rules to regulate the industry, including:

- Consumer Product Safety Commission
- U.S. Department of Transportation
- U.S. Coast Guard
- U.S. Department of Interior Minerals Management Service
- U.S. Department Health and Human Services Agency for Toxic Substances and Disease Registry.

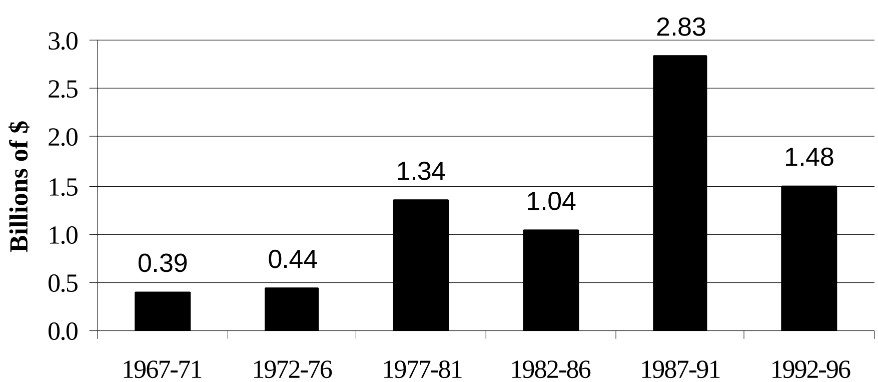
Further analysis of the data and interpretation of the results should provide a picture of regulations that are making an impact.

4.2.4 Center's Analysis of Governmental Programs

OSHA's PSM standard requires covered facilities to implement a very detailed and thorough performance-based management program that, when adhered to, will improve safety. The Center believes that the implementation of several key elements, e.g., Management of Change, Process Hazard Analysis, and Mechanical Integrity have improved safety in the covered processes. It is important to note that no one element shows a significant change; but a combination of the elements exhibits measurable results in chemical safety. Many companies view their compliance efforts not only as responsible corporate leadership but also as a competitive edge.

The eighteenth edition published in 1998, of the J&H Marsh & McLennan report of the "Large Property Damage Losses in the Hydrocarbon-Chemical Industries: A Thirty-year Review" illustrates that policy changes have had an impact on chemical safety. Changes in technology, plant size and layout, and management attitudes and programs are the primary drivers for the sharp drop in the number of losses and dollar amounts of each loss from 1992 through 1996. The implementation of Process Safety Management programs has likely contributed to the decrease in both the number and dollar amount of these losses. Using their data, Figure 2 shows a graphical representation of the losses over several 5-year periods.

Figure 2: Loss Distribution Over 5-year Periods



EPA's RMP rule requires covered facilities to implement a program similar to OSHA's PSM standard. The main focal difference between the two standards is OSHA's concentration on worker protection and EPA's focus on the environment. RMP implementation has had a positive impact on chemical safety. Many facilities have either reduced or eliminated onsite inventory of hazardous substances. The requirement to develop "worst-case" scenarios has opened the dialogue to the potential impact of a chemical release into the community.

The Center believes the information in EPA's RMP 5-Year Accident History and Accidental Release Information Program database can be used to show improvements in chemical safety. The databases represent a large and potentially useful source of information; however, because PSM and RMP went into effect while the data were being collected, the Center may not be able to demonstrate the full, independent impact of each of these regulations. Analysis of the usefulness of all databases can be found in *Feasibility of Using Federal Incident Databases to Measure and Improve Chemical Safety.*

4.3 Industry Programs

Government programs are not necessarily the only effort impacting chemical safety. Industry has taken a proactive role in safety since the 1984 incident in Bhopal, India. Several industry-led programs have been designed and launched to improve chemical safety. This section discusses those programs.

4.3.1 Responsible Care®

In 1988, the American Chemistry Council (formerly known as the Chemical Manufacturers Association) launched Responsible Care® to respond to public concerns about the manufacture and use of chemicals. The program is comprised of several guiding principles and six codes of management practice. Through Responsible Care®, member companies are committed to support a continuing effort to improve the industry's responsible management of chemicals. Specifically, member companies are required to:

- Continually improve their health, safety and environmental performance;
- Listen and respond to public concerns;
- Assist each other to achieve optimum performance; and
- Report their goals and progress to the public.

4.3.2 Environmental Stewardship

American Petroleum Institute's (API) Environmental Stewardship evolved out of what had previously been called the Strategies for Today's Environmental Partnership or STEP Program, which was phased out in June of 1999. The Environmental Stewardship Program facilitates information sharing and fosters continuous improvement. Environmental Stewardship activities can be grouped into:

- Guiding Principles
- Sharing Information & Technology Transfer
- Operating Practices
- Performance Measures
- Communications
- Public Involvement and Community Outreach
- Programs and Partnerships
- Management Support

4.3.3 Center's Analysis of Industry Programs

The Center believes that industry programs such as API's Environmental Stewardship and ACC's Responsible Care® have improved safety in the chemical process industries by responding to public concerns and by establishing guidelines for the responsible management of chemical processes. Industry programs establish a code of acceptable practice for a particular industry with adherence exhibited by membership in many cases. The benefits of participation can be found in the reduction of employee injuries, chemical releases, and public exposure. These programs center on continuous improvement in health, safety and environmental practices, listening to and responding to the concerns of the public, and openly reporting their progress.

4.4 Public Incentives

A third area affecting chemical safety results from interaction of the general public with neighboring facilities and governmental agencies. Public incentives have had an impact of their own. Many of these local committees create an expectation of industry and government working together to improve chemical safety.

4.4.1 Local Emergency Planning Committees

The Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986 required each state's governor to establish a State Emergency Response Commission (SERC). The SERC is charged with developing integrated plans for responding to chemical emergencies and making chemical information available to the public. SERCs, in turn, appoint the local emergency planning committees (LEPCs). LEPCs are to include broad-based membership whose primary work is to receive information from local facilities about chemicals in the community, use that information to develop a comprehensive emergency plan for the community, and respond to public inquiries about local chemical hazards and releases.

The initial task of a LEPC is to develop an emergency plan to prepare for and respond to chemical emergencies. The LEPC must publicize the plan through public meetings or newspaper announcements, obtain public comments, and periodically test the plan by conducting emergency drills. Beyond the emergency response plan, the LEPC receives emergency releases and hazardous chemical inventory information submitted by local facilities and makes this information available upon request to the general public.

LEPCs have improved chemical safety because of their direct interaction between facilities and the local community. As noted in a 1999 George Washington University study for the U.S. Environmental Protection Agency, over 75 percent of the "active" LEPCs reported that they completed and submitted an emergency response plan. Nearly half of the "active" LEPCs reported that they made hazard reduction, accident prevention, or pollution prevention recommendations. While over half of these indicated that they have provided assistance to local business, few LEPCs report a "high" involvement with large businesses and very few report a "high" level of involvement with small businesses.

4.4.2 Community Advisory Panels

Community Advisory Panels (CAPs) are important entities in the process of improving the dialogue between facilities and neighbors. They serve as an important link between the chemical facilities and their local communities while building mutual respect and trust.

A CAP consists of a group of individuals living near or around a facility. Members may include environmental groups, civic leaders, business leaders, homemakers, hourly workers, and individuals who represent key elements of a community such as health care providers and emergency responders. CAP members make a commitment to meet with facility management on a regular basis to discuss issues of mutual interest in a forum for open and honest dialogue.

4.4.3 Center's Analysis of Community Programs

The Center conducted a survey from mid-January through mid-February of 2001 on *Public Trust and Community Interaction in Areas Surrounding RMP Facilities*. The survey measured relevant attitudes, knowledge and experience of persons living near sites where chemical releases are possible. Nearly half of the respondents were unaware of any companies in their community that manufacture, use, or distribute chemicals that may be hazardous. When asked about LEPCs, over 50 percent were unaware of the existence of an LEPC in their community.

These percentages reveal several areas for improvement in the community programs. LEPCs and SERCs serve an important role in planning, training, and communicating information in their local communities. The Center believes that their level of activity and therefore their effectiveness is directly related to the support they receive from governmental agencies, industry, and the community. Public incentives have a place in improving chemical safety in the United States. Continued support should be a high priority among all stakeholders to ensure the continued existence of many community programs.

4.5 Proposed Indicators to Measure Chemical Safety

As described in the *Feasibility of Using Federal Incident Databases to Measure and Improve Chemical Safety*, there is a great deal of federally available information on the chemical industry. The critical component is to identify what data are useful in determining the status of chemical safety. Since current data were collected for different purposes, the Center must clearly define what information is of value as indicators and how those indicators can be used to produce the most accurate picture of chemical safety in the United States.

The Center proposes to use the following four data elements to establish a baseline from which to measure performance, because they are commonly available throughout the selected databases and are clear indicators for the purposes of the NCSP.

> **Fatalities** - represent a clear and uncontestable indication that a chemical incident has occurred. By measuring fatalities resulting from a chemical incident, a better understanding of the most significant incidents is available. Additionally, mortality information has been collected for decades by governmental agencies.
>
> **Injuries –** represent a clear indication of the significance of a chemical incident. By working to separate the onsite and off-site injuries, the Center can more fully describe the severity of the incident in terms of impact to company personnel and the general public. Measurement of injuries has been commonplace in general industry for many years.
>
> **Releases –** represent a clear indication that a chemical incident has occurred. Counting the number of releases in combination with the types and amounts of the chemicals released presents an indication of the magnitude of exposure.
>
> **Chemicals –** represent the materials involved in the chemical incident. By combining the type and amount of chemical released with the number of releases, the magnitude of the exposure can be described.

The databases reviewed contain information on many types of chemical incidents. EPA's ARIP and RMP databases concentrate on fixed facilities providing information on listed chemicals stored above a threshold quantity and releases resulting in significant consequences. NRC's IRIS database concentrates on chemicals, releases, injuries, and fatalities. It provides a listing of reported incidents from fixed facilities, marine and offshore facilities, pipelines, and transportation vehicles. Occupational fatalities and injuries from all industry are recorded in the OSHA/ BLS system. Chemical related incidents could be sorted to provide not only a business segment but also a total manufacturing viewpoint. The ATSDR and CDC databases concentrate on the human aspects of incidents. CDC's WONDER records all fatalities in the United States while ATSDR's HSEES records incidents involving hazardous substances that might reasonably result in adverse health effects. Table 2 summarizes the indicators and the databases from which they can be obtained.

By combining the information within the various data sources, a relatively complete picture of each incident can be created. Then by sorting the information based on the indicators, a baseline of performance can be established.

Table 2: Federal Databases and Potential Indicators

Agency - Databases	Chemicals Involved	Number of Incidents	Fatalities	Injuries
NRC – IRIS	Ö	Ö	Ö	Ö
EPA - ARIP	Ö	Ö	Ö	Ö
EPA - RMP	Ö	Ö	Ö	Ö
OSHA	Ö		Ö	Ö
ATSDR - HSEES	Ö	Ö	Ö	Ö
CDC - WONDER	Ö		Ö	Ö

The Center proposes initially the baseline be established for fixed facilities using EPA's RMP 5-year Accident History database. Various modes of transportation will be the second business segment reviewed. Other business segments and the capability of sorting by geographic area will be added as the data become available.

To make the measurement of chemical safety performance reproducible, two things must occur. First, the data gathering by the federal agencies must continue, and the quality of the reported data must be improved. For more information, refer to the Center report entitled: *Feasibility of Using Federal Incident Databases to Measure and Improve Chemical Safety*. Second, a series of questions should be created to which the answers can be compared to determine trends.

The following questions are proposed as a way of interpreting the data used to establish the status of chemical safety.

- What are the 5 most commonly produced chemicals by volume? (This question identifies the chemicals in commerce posing the greatest potential for exposure.)
- What are the 5 chemicals with the most money spent to prevent incidents? (This question identifies those chemicals currently receiving the most attention due to their inherent hazards and potential adverse health or environmental effects.)
- What are the 5 most released chemicals by business segment and geographic area? (This question focuses on the chemicals that traditionally present problems within a business segment or geographic region.)
- What are the 5 chemicals with the largest consequences by business segment and geographic area? (This question represents the chemicals involved in significant incidents within the business segments or geographic area.)

4.6 Preliminary Application of the Indicators

To show the potential application of the indicators for fixed facilities in measuring chemical safety, a series of simple queries were run against EPA's ARIP and the RMP 5-year Accident History databases. Tables 3 and 4 show the chemicals that are most frequently released and the resulting consequences.

Table 3: Data from the ARIP Database (1986 – 1992)

Chemical Name	Number of Releases	Deaths	Hospitalizations	Injuries	Incidents with Injury
Ammonia	880	7	203	500	108
Chlorine	648	1	454	1793	187
Sulfur dioxide	370	0	66	199	24
Sulfuric acid	326	2	24	89	31
Hydrogen sulfide	186	1	41	149	17

Ammonia, chlorine, and sulfur dioxide top the two lists as the chemicals with the most number of releases, injuries, and hospitalizations. However, the similarities in the two data sources end there.

While the different answers can generally be rationalized by the different scope of the two databases, it is essential to have an understanding of the original intent as well as the limitations of the data sources.

As shown in Table 5, the RMP 5-Year Accident History data can be further broken down into subcategories such as: worker and public deaths, worker and public injuries, and medical treatment cases. In Table 4, "Deaths" is a summation of worker death plus public death. "Injuries" are reported as a combination of worker injuries and public injuries. "Medical Treatment" as reported in Table 5, indicates the number of people off-site requiring medical treatment.

Table 4: Data from the 5-Year Accident History Database (1994 to 1999)

Chemical Name	Number of Releases	Deaths	Hospitalizations	Injuries	Incidents with Injury
Ammonia	666	7	48	688	277
Chlorine	505	0	47	623	330
Sulfur dioxide	45	1	2	26	16
Ethylene oxide	19	0	0	5	5
Hydrogen sulfide	17	0	6	33	8

The next step involves interpreting the information gained from the RMP 5-year Accident History database. The production volumes shown in Figure 3 came from the National Petroleum Refiners Association and Bureau of the Census as presented in a June 26, 2000 article entitled *Production: Gains Beat Losses*, which was published in Chemical and Engineering News.

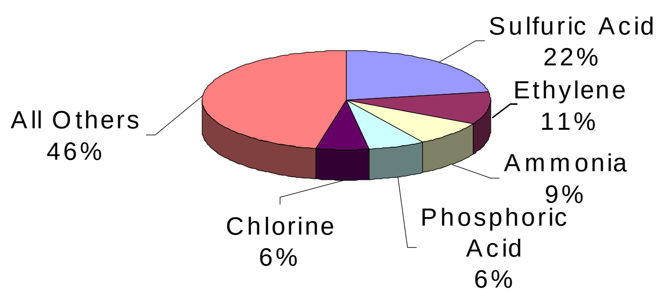
Table 5: Additional Data from the 5-Year Accident History Database (1994 – 1999)

Chemical Name	Worker Deaths	Public Deaths	Worker Injuries	Public Injuries	Offsite Deaths	Medical Treatment
Ammonia	7	0	651	37	0	374
Chlorine	0	0	531	92	0	111
Sulfur dioxide	1	0	26	0	0	89
Ethylene oxide	0	0	5	0	0	0
Hydrogen sulfide	0	0	33	0	0	80

The Center proposes to use the ten EPA regions as the geographic area breakdown. The RMP 5-Year Accident History database does not currently include the EPA regions and thus the field would need to be included in the final repository. However, the database does include a finer breakdown of information by using data fields such as City, State, and Zip. By applying the currently available information in the RMP 5-Year Accident History database to the Center's proposed questions produced the following responses. Note that geographic areas are not shown because of database limitations.

- What are the 5 most commonly produced chemicals by volume in each business segment and geographic area?

Figure 3: 1998 Production Volumes



- What are the 5 chemicals with most money spent to prevent incidents?

  Answering this question requires further research to identify an indicator and a metric. The Center believes the chemicals used to answer this question must come from commerce and not from the military. By excluding chemicals produced for military use, a better understanding of the industry's return on investment to prevent incidents can be reached.

- What are the 5 most released chemicals by business segment and geographic area?

Table 6: Summary of Chemical Releases by Pounds Released

Chemical	No. of Total Releases	Total Pounds Released	Pounds per Release
Ammonia	437	7,708,255	17,639
Flammable mixture	54	2,019,677	37,401
Formaldehyde	16	263,283	16,455
Propane	31	253,183	8,167
Chlorine	263	23,343	89

Further Analysis by Business Segment

Chemical	No. of Total Releases	Total Pounds Released	Pounds per Release	Highest No. of Total Releases	Lowest No. of Total Releases	Largest Total Quantity Released	Lowest Total Quantity Released
Chemical Manufacturing - NAICS # 325XX							
Ammonia	132	7,697,481	58,293	X		X	
Formaldehyde	16	263,283	16,455				
Nitric acid	10	144,525	14,452				
Oleum	7	66,859	9,551		X (Tie)		X
Propane	7	191,587	27,367		X (Tie)		
Food Manufacturing - NAICS # 311XX							
Ammonia	292	1,726	1,591	X		X	
Chlorine	9	119	13				X
Hydrogen fluoride	1	360	360		X (Tie)		
Propane	1	200	200		X (Tie)		
Sulfur dioxide	2	901	451				
Utilities - NAICS #221XX							
Ammonia	12	9,047	753	X			
Chlorine	205	21,803	106			X	
Isopentane	1	10	10		X (Tie)		X (Tie)
Methane	1	10	10		X (Tie)		X (Tie)
Sulfur dioxide	9	1,096	121				
Paper Manufacturing - NAICS # 322XX							
Ammonia	1	1	1		X		X
Chlorine	49	10,807	220			X	
Chlorine dioxide	54	2,354	45	X			
Sulfur dioxide	4	1,421	355				
Petroleum Refining - NAICS # 32411							
Flammable mixture	54	2,019,677	37,401	X		X	
Butane	18	174,416	9,689				
Isobutane	10	540,185	54,018				
Propane	23	61,396	2,790				
Sulfur dioxide	3	27,128	9,042		X		X

- What are the 5 chemicals with the largest consequences by business segment and geographic area?

Table 7: Summary of Chemical Releases by Consequence

Chemical	Total Property Damage (Single Release – Mixture)	Total Deaths (Single Release – Mixture)	Total Injuries (Single Release – Mixture)
Chlorine	$1,373,473 -- $202,000	9 -- 0	333 -- 1
Flammable Mixtures	$379,791,446 -- $71,058,000	7 -- 1	41 -- 29
Ammonia	$308,591,908 -- $580,000	7 -- 0	542 -- 0
Hydrogen	$4,005,000 -- $58,425,000	0 -- 2	6 -- 35
Propane	$10,999,984 -- $55,416,200	0 -- 7	10 -- 42

Further Analysis by Consequence

Chemical	Property Damage (Single Release – Mixture)	Deaths (Single Release – Mixture)	Injuries (Single Release – Mixture)
Chemical Manufacturing - NAICS # 325XX			
Ammonia	$226,474,259 -- $580,000	4 -- 0	75 -- 0
Isobutane	$25,000 -- $38,000,000	0 -- 0	0 -- 12
Flammable mixtures	$168,598,500 -- $1,925,000	0 -- 1	18 -- 0
Hydrogen	$4,005,000 -- $58,425,000	0 -- 2	6 -- 35
Propane	$752,500 -- $40,850,100	0 -- 0	0 -- 30
Food Manufacturing - NAICS # 311XX			
Ammonia	$82,117,649 -- $0	3 -- 0	456 -- 0
Chlorine	$500 -- $0	0 -- 0	6 -- 0
Hydrogen fluoride	$1,585 -- $0	0 -- 0	0 -- 0
Sulfur dioxide	$0 -- $0	0 -- 0	1 -- 0
Propane	$0 -- $0	0 -- 0	0 -- 0
Utilities - NAICS #221XX			
Ammonia	$0 -- $0	0 -- 0	11 -- 0
Chlorine	$1,372,923 -- $0	9 -- 0	249 -- 0
Sulfur dioxide	$75,000 -- $0	0 -- 0	4 -- 0
Methane	$50,000 -- $0	0 -- 0	0 -- 0
Isopentane	$0 -- $0	0 -- 0	1 -- 0
Paper Manufacturing - NAICS # 322XX			
Chlorine	$50 - $202,000	0 -- 0	78 -- 1
Chlorine dioxide	$50 - $202,000	0 -- 0	93 -- 1
Sulfur dioxide	$0	0 -- 0	4 -- 0
Ammonia	$0	0 -- 0	0 -- 0
Petroleum Refining - NAICS # 32411			
Flammable mixtures	$211,192,946 -- $69,133,000	7 -- 0	23 -- 29
Butane	$61,750 -- $29,266,100	0 -- 6	2 -- 2
Propane	$10,247,484 -- $14,566,100	0 -- 7	10 -- 12
Methane	$2,600,000 -- $14,000,100	0 -- 7	0 -- 9
Isobutane	$1,048,000 -- $20,050,100	0 -- 0	0 -- 3

"Single Release" denotes release of a single chemical in one event.
"Mixture" denotes release of multiple chemicals in one event.

5.0 Public Trust and Awareness

Community awareness and public trust are very important elements of chemical safety improvements. A key part is ensuring citizen awareness of both the potential dangers and actions that have been taken to mitigate those dangers. As part of this project, the Center sought to develop a methodology to analyze the impact of various programs for the prevention of accidental releases of reactive, flammable, and toxic chemicals during manufacture, processing, packaging, storage, transportation, distribution, and commercial use.

A primary component of the development of this methodology was an assessment of progress made by chemical enterprises to increase community awareness and gain and maintain the public's trust. To establish a baseline metric to measure progress toward improved community awareness and public trust, the Center conducted a telephone survey to measure the level of public knowledge and trust of chemical operations near their homes.

5.1 Survey Instrument

The survey instrument included a total of 15 primary questions and 19 secondary questions based upon the response to the primary question. The questions were divided into the three categories of general information, community awareness, and public trust. The questions on awareness were used to determine the level of public awareness about the number and types of chemical facilities located in their community, and the efforts made by the facilities and the community to protect the community from a chemical incident. The trust questions focused on the public's perception and belief that these efforts were adequate to protect public safety and health.

5.2 Sampling Methodology

In determining who to survey, the Center used the U.S. Environmental Protection Agency's (EPA) Risk Management Program (RMP) 5-year accident history database to identify suitable chemical facilities. The Center then identified the homes within a one mile radius of each of the facilities selected and collected the telephone numbers. The Center interviewed 720 randomly selected households from across the United States, that are located near facilities that use, manufacture, or distribute chemicals.

The sampling approach involved the use of a multistage cluster sample of sites and households within a mile radius of each site. The sample was stratified into two groups: (1) those living within a mile of sites of industries with a high probability of a chemical release, as regulated by EPA's RMP rule; and (2) those living near industries that have a low probability of a release. The EPA RMP 5-year Accident History Database was used to determine "high" versus "low" probability of a release. It is assumed that based upon the number of frequency of incidents, communities with a high frequency of incidents are more likely to have a higher community awareness and a lower level of public trust. An arbitrary cutoff of 0.08 incidents per process unit was used to distinguish between the high frequency and low frequency strata.

In each group, 60 facility sites were randomly selected. An average of six households per site were surveyed for a total of approximately 360 households within each stratum. The actual number sampled from each site is proportional to the number of households within a one-mile radius of the site. The households were identified through listed phone numbers.

5.3 Limitations of Survey Methodology

The 95 percent confidence interval would be approximately ± 4 percent for a sample of 720 households, assuming a simple random sample. The cluster sample potentially increases the error, and the amount of the increase is a function of the variability across clusters. The estimated error for each stratum would be within ± 6 percent. This range could be smaller for estimates in which the two strata are combined, because stratification along a variable providing homogeneity within a stratum tends to increase the precision of the estimates. Under this complex sample design, each sampled household receives a sampling weight through which the sample based results are generalized to the entire population of interest.

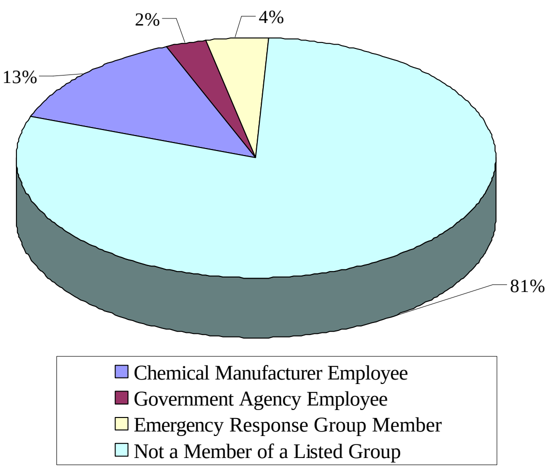
5.4 Community Awareness

The community awareness questions are within three general categories. The first, **Perspective**, is designed to determine if there is a biased perspective from a respondent. For example, a member of a first responder group or someone who is an employee of a chemical manufacturing entity would be more likely to have a more informed and higher level of community awareness then someone who is not. The second category, **Level of Awareness**, provides a differentiation tool to gauge how well informed and aware members are of activities taking place in their community. The final category, **Outreach Efforts**, gauges if a community member has been affected by an outreach effort from the chemical industry, government, or other groups concerning chemical safety.

5.4.1 Perspective

The questions in this section focused on whether respondents might have an unusual level of knowledge concerning chemical safety and chemical incidents. Question 1 specifically focuses on whether a respondent or a member of that household is an employee of a company that manufactures, uses, or distributes chemicals, an employee of a government regulatory agency, or a member of a first responder group. In the high frequency strata, less then 15% of the respondents worked for a chemical company, less then 2.5% were employed by a government regulatory agency, and less then 5% were members of a first responder group or agency. In the low frequency strata, less then 9% of the respondents worked for a chemical company, less then 5% were employed by a government regulatory agency, and less then 5% were members of a first responder group or agency. Figure 4 provides a graphical representation of the combined responses to questions 1 from the high and low frequency strata.

Figure 4: Survey Question 1
Are you or anyone in your household any of the following?
SELECT ALL THAT APPLY
(Figure shows overall data for both high and low frequency strata)

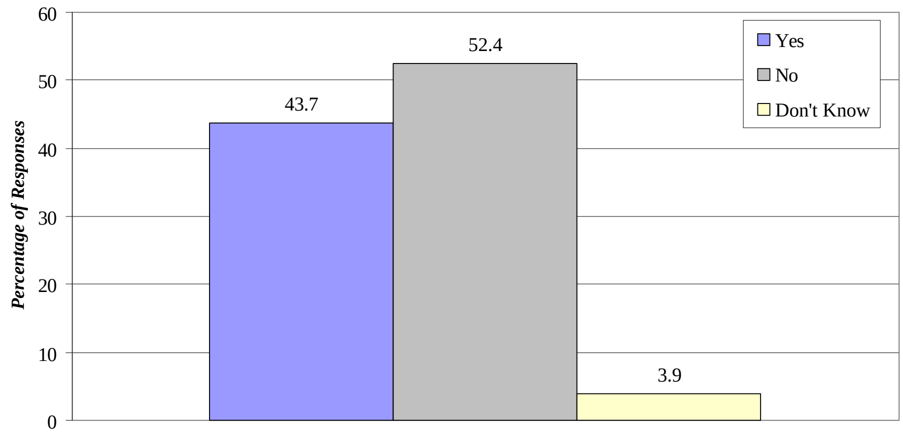


5.4.2 Level of Awareness

The questions in this section focus on the base level of awareness of respondents concerning chemical safety and chemical incidents in their community. This category encompasses eight questions including awareness of any companies in the community that use, manufacture, or distribute potentially hazardous chemicals, the types of actions that one would take during an incident, the perceived level of awareness, the efforts of external non-regulatory groups and regulatory agencies, past incidents, and potential levels of danger.

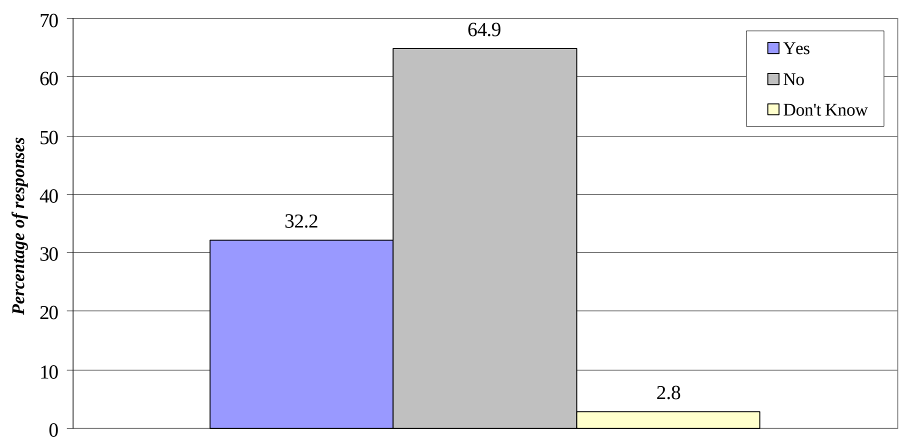
Question 2 focuses on the awareness of any companies in the community that use, manufacture, or distribute potentially hazardous chemicals. In the high frequency strata, 25.2% and in the low frequency strata, 31% of the respondents were aware of such companies. In a separate question, in the high strata, 29% and in the low strata, 24.5% of the respondents thought that other members of the community were very well informed or adequately informed about where to acquire information during an emergency.

Figure 5: Survey Question 2
Are you aware of any companies in your community that manufacture, use or distribute chemicals that may be hazardous?
(Figure shows overall data for both high and low frequency strata)



Question 11 considers the level of knowledge of any chemical incidents that have occurred in the community in the last five years. In the high frequency strata, 33.7% of the respondents knew of a chemical incident that had taken place in the community during the past five years.

Figure 6: Survey Question 11
Are you aware of any chemical accidents that have occurred in your community during the past five years?
(Figure shows overall data for both high and low frequency strata)



5.4.3 Outreach Efforts

The questions in this section focus on outreach efforts concerning to the community. This category encompasses different types of outreach efforts, including if the respondents have received information concerning potential accidents, where the information came from, what other information is needed, and who is responsible for providing it.

Question 3 presents the general question of whether or not the respondent had received information on what to do in case of an incident in the community involving the release of chemicals. In the high frequency strata, 25%

of the respondents received such information, with 77% of those receiving it believing that the information would enable them to know what to do in the event of such an accident. In the low frequency strata, 17% of the respondents received such information, with 87% of those receiving it believing that the information would enable them to know what to do in the event of such an incident. As might be expected, there was a statistically significant difference between the responses of the low frequency strata and the high frequency strata groups.

5.5 Public Trust

The public trust questions are within three general categories. The first, **Information**, is designed to determine where the community relies on to obtain information and where their preferences lie. The second category, **Effects of Efforts**, measures how well the efforts of various groups concerning chemical safety are perceived. The final category, **Ability to Respond**, gauges the perception of the ability of a community to respond appropriately to a chemical incident.

5.5.1 Information

A series of five questions consider aspects of communication regarding a chemical incident, including the method of communicating information, preferred sources of information, the ability of the information to assist in safety, and timeliness of information.

Prior to an incident, the sources for information on chemical safety were the chemical company, a government agency, an LEPC, a CAP, a health professional, and other citizen groups. In the high frequency strata, the most common source was the company. 19.8% of received information came from the company, 15.5% received information came from a government agency, 13.2% from a LEPC, 5.5% from a CAP, 15.6% from a health professional, and 9.5% from another citizens group. In the low frequency strata, the most common source was also the company. 16.0% of received information came from the company, 14.4% received information came from a government agency, 11.4% from a LEPC, 5.0% from a CAP, 14.3% from a health professional, and 6.1% from another citizens group.

The preferred source for such information by the respondents is primarily television. 39% of the respondents said the best way to get the needed information was television. This was followed by brochures (25.3%), newspapers (14%), radio (11.5%), and the internet (8.7%). In general, over 25% of the respondents did not know where to acquire up-to-date information during an incident that involved a release of chemicals in the community.

5.5.2 Effects of Efforts

There are numerous groups making efforts to improve chemical safety in the communities. These groups can generally be divided into government and non-government entities. There are other groups, such as the company whose efforts can also affect the level of perceived safety and trust. However, these indicators were not measured as a part of this survey. The effects of these efforts were measured through four questions.

EPA and OSHA were used to represent all government agencies and may not accurately reflect efforts of state and local agencies. For the government, almost 85% of the high frequency strata respondents and almost 88% of low frequency strata respondents would feel safer if EPA provided accident prevention and hazard reduction assistance to a chemical firm. Similarly, almost 81% of the high strata respondents and almost 84% of low strata respondents would feel safer if OSHA provided accident prevention and hazard reduction assistance to a chemical firm.

The second group is composed of non-government entities and is represented by LEPCs and CAPs. Almost 65% of the high strata respondents and almost 67% of low strata respondents felt that the presence of an LEPC makes a community safer. Almost 56% of the high strata respondents and almost 57% of low strata respondents felt that the presence of a CAP makes a community safer.

5.5.3 Ability to Respond

Lastly, the ability of the community to respond is a key component in the level of public trust. If there is the perception that the community, governmental agencies, and other groups are unable to respond appropriately, there will be a correspondingly lower level of trust. Almost 62% of the high frequency strata respondents and almost 57% of low frequency strata respondents felt that the community could respond to a chemical accident adequately or very well. However, almost 63% of the high strata respondents and almost 57% of low strata respondents felt that their families would be in some danger or in great danger should a chemical incident occur.

5.6 Conclusions on Public Trust and Awareness

A need exists for stakeholder and citizen outreach to increase chemical safety awareness in communities to reduce the number of incidents, reduce the magnitude of an incident, and to inform the public before, during, and after. Less then one-third of respondents were aware of companies in the community that use, manufacture, or distribute potentially hazardous chemicals. Less then half of all respondents were aware of non-governmental organizations to assist in improving chemical safety and of the onsite efforts by EPA and OSHA to increase chemical safety through inspections.

There also seems to be a defined need for additional efforts in earning the public's trust. Communities turn to television for their information with the company as the primary source of that information. Lastly, a majority of the respondents felt that even though their community may be able to respond well to a chemical incident, a majority still felt that their families were exposed to some danger.

6.0 Conclusions and Recommendations

To achieve the national goals, stakeholders need a benchmark against which they can measure progress. The Center began the work to identify and to establish an accurate assessment of chemical safety in the United States. As a reminder, the National Chemical Safety Goals are

- **Chemical incidents are zero;**
- **Chemical enterprises have earned the public's trust; and**
- **Public, government, and facility interactions improve safety and reduce risks.**

Progress is being made in many areas with regard to chemical safety. However, work must continue to fully analyze chemical incidents in the United States. Without a complete picture, it is difficult to develop effective improvement programs. The existing federal databases can and do provide much of the information necessary to understand the causes and consequences of these incidents.

While researching data for this report, the Center identified several limitations with the existing databases. The data are not easily accessible, nor is there a common language among databases. As the system currently exists, chemical industry stakeholders and the public face a challenge to find data that they can use to facilitate improvements in chemical safety. An important component of improving the data collection process is providing information that is useful to stakeholders and that facilitates progress towards reducing the number of incidents.

While an argument can be made that a completely new system of reporting is required to compile chemical incident information, it is not clear that such a step would necessarily lead to a complete and accurate picture of chemical safety. In addition to requiring costly new programs for both the government agencies involved and industry, such new reporting requirements may not yield the desired benefits.

Therefore, the development of an integrated system, based on existing federally developed databases, would address many of the problems facing the stakeholders in assessing chemical safety. A web-based, user-friendly interface would allow for easy retrieval of the data contained in the existing federal databases.

Regarding handling of the databases, the Center intends to:

- Determine the indicators and metrics for measuring chemical safety.
- Improve existing federal databases.
- Apply the vetting processes discussed in this report to the existing federal databases.
- Track the indicators and metrics by business segments and geographic areas.
- Request business segments, public agencies (LEPCs), and responders provide metric information.

Based on the analysis of the seven federal databases, the Center recommends as indicators and metrics for fixed facilities the following:

Indicators

- Chemicals involved
- Number of incidents
- Fatalities
- Injuries

Metrics

- What are the 5 most commonly used chemicals by volume?
- What are the 5 chemicals with the most money spent to prevent incidents?
- What are the 5 most released chemicals by business segment and geographic area?
- What are the 5 chemicals with the largest consequences by business segment and geographic area?

To date, preliminary application of the proposed indicators and metrics shows that ammonia was released over 400 times during the period 1994-1999. During this same period, chlorine was the second most released chemical and was responsible for nine fatalities and 333 injuries. Flammable mixtures, hydrogen, propane, and formaldehyde complete the top five most released chemicals and with the most severe consequences.

The Center will continue to measure chemical safety by:

- Seeking stakeholder approval for the proposed indicators and metrics for fixed facilities.
- Establishing a frequency for performing the trend analysis work.
- Working to improve data quality throughout the seven federal databases.

Stakeholder and citizen outreach efforts must increase chemical safety awareness in communities to reduce the number and magnitude of incidents and to keep the public informed. Less then one-third of respondents to the survey were aware of companies in the community that use, manufacture, or distribute potentially hazardous chemicals. Less then half of the respondents were aware of the non-governmental organizations to assist in improving chemical safety or of efforts by EPA and OSHA to increase chemical safety through inspections. There is a need for additional efforts from industry to earn the public trust. Communities rely on television news reporters for their information when the primary source of that information should be company officials. A majority of the respondents felt that even though their community may be able to respond well to a chemical incident, a majority still felt that their families were exposed to some danger.

The Center calls all stakeholders to:

- Influence the database owners to act upon the presented recommendations.
- Seek ways to gain standardization of the key data elements, e.g., definition of an incident.
- Take an active role in promoting chemical process safety through local organizations, e.g., LEPCs.
- Work to establish and institutionalize the indicators and metrics used to measure chemical safety in the United States.
- Openly support all stakeholders showing progress towards meeting the national chemical safety goals.

Appendix

National Chemical Safety Program Roundtable

- William Allmond, National Association of Chemical Distributors
- Ramon Alvarez, Environmental Defense
- Nicholas Ashford, Massachusetts Institute of Technology
- Kari Barrett, American Chemistry Council
- Bob Barrish, State of Delaware - DNREC
- Jeremiah Baumann, US PIRG
- Paul Beswick, Metropolitan Water District of Southern California
- Wayne Bissett, Environmental Emergencies
- Bruce Blankenship, Sterling Chemicals, Inc.
- Matthew Borkovic, Synthetic Organic Chemical Manufacturers Association
- Jerry Bradshaw, Texas A&M University
- Kennith Brock, GE Industrial Risk Insurers
- Nancy Brodbeck, Tosco Refining Co.
- Steve Brouillard, Conoco, Inc.
- Neil Carman, Lone Star Chapter of Sierra Club
- Martina Cartwright
- Bob Chipkevich, National Transportation Safety Board
- Phil Cogan, CSB
- Donald Connolley, Akzo-Nobel
- Elaine Davies, EPA
- Richard Duffy, International Association of Firefighters
- Anthony Earl, Quarles & Brady
- Neil Elliott, Rohm and Haas
- Buddy Elmore, Huntsman Corp.
- Lois Epstein, Environmental Defense Fund
- Gregory L. Keeports, Rohm & Haas Co.
- Christian Kirchsteiger, European Commission
- Myron Knudson, EPA’s Region VI
- Howard Kunreuther, Wharton Risk Management and Decision Processes Center
- Thomas Lawrence, American Society of Safety Engineers
- Jim Lester, Environmental Institute of Houston
- Paula Littles, Paper and Allied Industrial, Chemical and Energy Workers
- Jim Makris, U. S. EPA CEPPO
- Mike Marshall, OSHA
- Steve Mason, U. S. EPA
- Jack McCavit, Celanese Chemicals
- Mike McHale, Air Products & Chemicals
- Pat McNulty, Wharton School of Business
- Benjamin Milk, Association of Refrigerated Warehouses
- Fred Millar
- Kenneth Murphy, U.S. Department of Energy
- Mike O’Connor, Mary Kay O’Connor Process Safety Center
- Erik Olson, Natural Resources Defense Council
- Paul Orum, Working Group on Community Right-to-Know
- Tim Overton, Dow Chemical Co.
- Dennis Parker, Conoco, Inc.
- Tim Pizatella, National Institute of Occupational Safety & Health
- Jerry Poje, CSB
- Ortwin Renn, Center for Technology Assessment
- William Rogers, Mary Kay O’Connor Process Safety Center

- Bill Erny, American Petroleum Institute
- Lee Feldstein, National Safety Council
- Tim Fisher, American Society of Safety Engineers
- Frank Frodyma, U.S. Department of Labor
- Tim Gablehouse, Colorado Emergency Planning Commission
- Michela Gentile, Mary Kay O'Connor Process Safety Center
- Keith Goddard, Occupational Safety & Health
- Melanie Granberg, Colorado Emergency Planning Commission
- Richard W. Harris, Texas Department of Health - Bureau of EPI
- Stan Hearn, Pioneer Americas, Inc.
- Daniel Horowitz, CSB
- Charles Isdale, Texas A&M University
- Kim Jennings, U. S. EPA CEPPO
- Irene Jones, Huntsman Corp.
- Kathy Jones, U. S. EPA CEPPO
- Pam Kaster, Citizens for a Clean Environment
- Peter Kearns, Organization for Economic Cooperation and Development
- Irv Rosenthal, CSB
- Russ Salter, Federal Emergency Management Agency
- Ray Skinner, OSHA's Houston South Office
- Robert Smerko, Chlorine Institute
- Jim Solyst, Chemical Manufacturers Association
- Jerry Speir, Tulane Law School
- James Staves, EPA
- Paris Stavrianidis, Factory Mutual Research Corp.
- Doug Stephens, Paper & Allied Industrial, Chemical & Energy Workers
- Angela Summers, SIS-TECH Solutions, LLC
- Bruce Swiecicki, National Propane Gas Association
- Syl Turicchi, AICHE's Center for Chemical Process Safety
- Mark Tweeddale, HM Tweeddale Pty Ltd.
- Suzanne Wallace
- Harry West, Shawnee Engineers, Inc.
- David White, Industrial Fire World
- Maureen Wood
- Johnny Wright, Amoco Corp.

National Chemical Safety Program Steering Committee

- Kari Barrett, American Chemistry Council
- Bruce Blankenship, Sterling Chemicals, Inc.
- Bill Effron, Mary Kay O'Connor Process Safety Center
- Lois Epstein, Environmental Defense
- Tim Gablehouse, Colorado Emergency Planning Commission
- Daniel Horowitz, CSB
- Kim Jennings, EPA's CEPPO
- Irene Jones, Huntsman Corp.
- Kathy Jones, EPA's CEPPO
- Pam Kaster, Citizens for a Cleaner Environment
- Sam Mannan, Mary Kay O'Connor Process Safety Center
- Mike O'Connor, Mary Kay O'Connor Process Safety Center
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- Irv Rosenthal, CSB
- Raymond Skinner, OSHA's Houston South Office
- Bob Smerko, The Chlorine Institute
- Jim Staves, EPA's Region VI