Demonstrating the Business Value of Industrial Hygiene

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Methods and Findings from the Value of the Industrial Hygiene Profession Study

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Demonstrating the Business Value of Industrial Hygiene

Executive Summary

Introduction

The American Industrial Hygiene Association’s (AIHA) mission is “to promote healthy and safe environments by advancing the science, principles, practice, and value of industrial hygiene and occupational and environmental health.” (See the AIHA Website at: http://www.aiha.org/Content/AboutAIHA/strategicplan.htm.)

To achieve its mission and to effectively communicate the value that the industrial hygiene/occupational health profession brings to business, AIHA awarded a contract to EG&G Technical Services, Inc., a Division of URS, who engaged ORC Worldwide to conduct original research that would identify and quantify links between industrial hygiene investment and business value. ORC Worldwide developed and tested a strategy, the Strategy for Demonstrating the Value of Industrial Hygiene (IH Value Strategy) that enables industrial hygiene (IH) managers and professionals to conduct practical and credible business case analyses that demonstrate the value IH programs and activities bring to business at the facility, business unit, and enterprise levels. In addition, EG&G conducted a survey to identify components of management systems that have demonstrated the value that Industrial Hygiene and Occupational Health (IH/OH) program practices can bring to an organization’s business results. This report presents the IH Value Strategy and documents the project’s multi-phase approach to its development.

The Value of the Industrial Hygiene Profession Study was a multi-phase effort that resulted in a number of findings about IH and its relationship to the business process. Among the most significant was that many business leaders do not fully understand the value that IH brings to the business, and, conversely, that many industrial hygienists do not understand the company’s business and how their work adds value. With the IH Value Strategy, industrial hygienists can correct these deficiencies and increase the perception that their skills are an integral part of business success.

Background

The value of anything is determined by how well it performs its function in relation to its cost. In a free market economy, creating and demonstrating value is increasingly a key factor in success; with rare exception, organizations must produce and demonstrate value to survive. CEOs of publicly held businesses are required by their stockholders and Boards of Directors to demonstrate value; corporate officers must demonstrate value to company leadership; managers to company executives; and so on. In business, the value proposition describes the tangible results that investing in a given product or service will yield.

In the current highly competitive and globalized economy, success depends on getting the attention of value-oriented, yet overburdened, decision makers. Investments may not be made in programs that do not clearly and immediately add value. Under these conditions, a strong value proposition can make the difference between survival and obsolescence. A financially-oriented value proposition that speaks to critical business issues and that includes specific numbers or percentages is now almost a requirement for obtaining funding for many projects and programs. Those who lack such a business case will
quickly lose ground to those who have one. Making the value proposition for IH strengthens the moral argument for protecting workers. Demonstrating value is important for IH because it empowers industrial hygienists to be effective in fulfilling their mission.

Three deficiencies have contributed to the professions’ inability to effectively demonstrate value.

First, there is a lack of understanding. As previously mentioned, business leaders do not fully understand the value that industrial hygiene adds to the business, and many industrial hygienists do not understand the business and how IH adds value.

Second, there is a lack of know-how and tools needed to make the business case. Industrial hygienists tend to lack understanding of the strategic and operational objectives, and do not fully understand how value is demonstrated by other parts of the business. This “gap” is compounded by the fact that user-friendly tools focused on the IH contribution have not been available to help them.

Third, there is a general lack of data. Critical data streams for making the value case do not exist in many companies. Where they do exist, the industrial hygienists often have difficulty accessing them.

The cumulative effect of these deficiencies is significant; the combined lack of understanding, tools, and data has resulted in many industrial hygienists lacking the motivation even to attempt the value case. Even when data are available, making the value case can be daunting. Direct safety and health (S&H) costs can be quantified in many instances, but identifying and tracking costs is complex and time consuming. There is no real handle on indirect S&H costs, and soft numbers have discouraged their use over the years. Health benefits are hard to measure due to latency issues for some health conditions and the difficulty of assessing long-term ill-health effects. Measuring impacts on existing revenue streams, new revenue, and/or improvements to business processes requires that one isolate the IH influence, establish the cause and effect, and identify and extract other factors that could have produced the same result. Under most circumstances this is a complex and difficult process.

It is time to make a better business case both for IH and S&H practice in general. In the past it may have been sufficient simply to provide a description of an IH project or program’s ability to meet regulatory requirements or to prevent occupational illnesses and injuries, with a good measure of “it’s the right thing to do” thrown in. This approach, though perhaps still effective in some organizations, is generally a weak value proposition because it offers no description of the return on the investments required to implement the project or program. Nor does it describe how the IH initiative is connected to other realizable business benefits.

Making a value proposition based primarily on how IH programs or activities have reduced incident-related and workers’ compensation costs ignores other potential benefits that individually or together may outweigh the value of such reductions. This approach can also fail to show an adequate return to justify the investment in prevention programs. IH practitioners who rely solely on cost reduction to make their value propositions are taking the risk of losing support and being seen as irrelevant to the business.

Without compelling business value information, management is likely to look at IH projects and programs as efforts that, while in some cases necessary, can afford to wait for additional resources while projects with a clearer connection to the bottom line are given higher priority. Projects that are not regulatory-driven may suffer a worse fate and
be vetoed completely. Thus, in today’s business environment it is becoming increasingly critical to the survival of IH and IH practitioners that a strong value proposition for their programs be made, so that they can compete successfully for limited resources with other business functions.

However, industrial hygienists and other safety and health professionals struggle with the task. As a group, the comfort zone has traditionally been around the technical aspects of the job—identifying, controlling and/or eliminating risk, and training others on those skills—rather than with understanding the operational or strategic aspects of the business. Safety and health (including IH) work is important, and S&H professionals work hard to do the right things and do them well. Since measuring performance and demonstrating value have not always been a priority for the profession, S&H programs are sometimes undervalued by corporate leadership and even viewed as overhead instead of as an integral part of the business. When that happens, existing programs are more likely to come under intense budget scrutiny, and support for new initiatives is harder and harder to obtain.

There is growing recognition that we all have to become more business savvy to survive in an increasingly complex and competitive business world. Most IH practitioners can make much stronger value propositions than they typically do. Strong value propositions demonstrate the delivery of increased revenues, decreased costs, faster time to market, improved operational efficiency, increased capacity, increased employee morale, decreased employee absenteeism and turnover, higher quality, increased market share, and improved customer retention, among other tangible results. In addition, they connect the value of the project or program with organizational strategy and objectives, showing how the investment will help the company achieve them.

Strong value propositions for IH programs, projects, or interventions can be made nearly everywhere industrial hygienists practice. IH issues are an inherent part of business operations and therefore IH-related investments often have an impact on many aspects of a process or service. They can therefore return tremendous benefits that extend downstream, well beyond the scope of the immediate application. IH practitioners must not limit their value propositions to the local area of IH interventions, but must look at the entire process surrounding them in all directions to find their full impact.

Documented success stories are key components of the value proposition—one business case is complete without them. Using success stories to “sell” IH interventions lends believability by demonstrating that the proposition is real. In the case of IH, such stories may be contrary to the assumptions of management and thus generate excitement when the returns on the costs of an intervention are fully understood.

During the course of the Value of the Industrial Hygiene Profession study, a wide range of IH interventions were found that made substantial business contributions far beyond the immediate area of application. Nearly all of the interventions examined had a strong value proposition. Eliminating lead from a raw material stream saved tens of thousands of dollars and kept a facility from closing. Substituting a less toxic material for a chromate primer saved an aircraft company nearly half a million dollars in processing costs and significantly improved productive capacity. Installing engineering controls to control exposure to nano particles at a small company resulted in a ten-fold increase in production capacity.

The value proposition for IH practitioners themselves is strong. Their education and experience bring a unique type of intellectual capital to the business that contributes value in a number of critical ways.
The *IH Value Strategy* fills a critical need by providing value analysis approaches and tools to enable industrial hygienists, other S&H professionals, and other interested individuals to link IH investments to business value. The information contained in this report lays the foundation for the overarching value strategy and for the quantitative and qualitative strategy sub components. It is important to note at the outset that many of the findings here are the result of study, observation, experience, and anecdotal information, and do not reflect statistically reliable survey results.

**Study Methods**

Significant knowledge was gained from the iterative and interrelated study process. Lessons emerged in testing the Quantitative Approach that also applied to the Qualitative Approach and vice versa.

*Participants:*

ORC Worldwide (ORC) is an international management consulting firm offering professional assistance in human resources management for industrial, nonprofit, and public organizations. Its Occupational Safety and Health Group, composed of senior corporate managers of occupational safety and health, promotes effective programs and practices in business, and facilitates industry understanding of and input into occupational safety and health policy and program decision making globally.

ORC has unmatched access to and prior experience with over 130 large and well-respected member companies, many of which are among the Fortune 100. This provided researchers with a large base of participants with well-developed IH programs. Many of these companies were able to share the appropriate data in the quantities necessary to conduct the study.

*Data Collection:*

Three surveys were conducted to select study participants and collect data electronically. Companies selected for participation provided case study data through a detailed questionnaire as well as facility visits and face-to-face interviews.

*Adaptation of the ROHSEI Tool:*

As previously suggested, for years business support for S&H programs was largely driven by the need for regulatory compliance. In those days, interest in capturing the value of the S&H contribution to the business was tepid at best. Within ORC, the discussion of metrics for measuring the business value of S&H activities intensified in the mid-to-late 1990’s. During that period, a group of ORC member companies formed a partnership to fund the development of a tool to capture the financial implications of S&H initiatives.

The tool, then labeled Return on Health and Safety Investments (ROHSI), enabled users to calculate individual business financial measures that were recognized by other parts of the business—such as Return on Investment (ROI) and Net Present Value (NPV)—for select S&H interventions. Interest in the tool grew, and several years later the ROHSEI approach (which now includes “environmental” parameters—hence the “E” in “ROHSEI”) became a recognized benchmark for business case development for health, safety, and environmental (HSE) programs. In the course of the present study, a number
of methods and tools for performing value-oriented calculations and estimations were examined. The ROHSEI tool emerged as an appropriate basis for the development of the IH Value Strategy.

Data Analysis and Strategy Development.

A change from the original plan of the study should be mentioned at the outset: we changed our approach from the “macro” versus “micro” dichotomy mentioned in the Proposal and the Statement of Work to take more flexible “quantitative” and “qualitative” approaches that use varying techniques to demonstrate value based on the availability of data, time, resources, the target audience, etc. The original plan was based on a concept that the level of organization at which the study was focused determined the degree of detail to be examined. At this point it only needs to be noted that our approach has changed from one with rigid boundaries driven by the level of the organization to one that is flexible and driven by functional considerations.

The IH Value Strategy is composed of two sub-approaches. The Quantitative Approach allows the user to calculate generally-accepted financial business metrics by capturing detailed business data that demonstrate the IH impact on cost avoidance, cost savings, revenue generation, and other strategic aspects of a business. The Qualitative Approach allows the user to estimate the value of the IH contribution by evaluating its impact on health, risk, and the business process through an evidentiary cause and effect chain that relates intermediate outcomes to the value streams listed above and concurrently isolates confounding factors that could have produced the same effects. (The original ROHSEI tool described above was modified to create this approach.) The Qualitative Approach will generate the business values for individual IH risk abatement projects and single issue programs.

Project Phases: This study was accomplished in five phases:

Phase I: Gather and Analyze Data

The Value of Industrial Hygiene Programs Survey I (Appendix A) was developed as a means to gather and analyze general data from ORC Worldwide member companies as well as more specific information about their IH programs and practices. The survey was designed to identify ORC member companies that could provide the types of data needed to design, develop, and test the IH Value Strategy and its components, as well as be representative of the wide range of sizes and industry categories in which the Strategy ultimately would be used.

Companies were asked to provide responses for two levels of their programs: for the corporation as a whole and for the facility that represented their “best” IH program. Identifying the best facility was an approach intended to increase the probability of locating programs and projects that would be comprehensive and that would have the highest quality IH information.

The survey polled members regarding company demographics, organization, industry sector, IH management systems and program elements, IH-related costs and outcome data, and interest in participating in Phase II of the study. In all, 46 ORC member companies responded. The survey results and the process of selecting companies to participate in subsequent phases of the study are described in the Phase I section of this report.
The responding companies represented a cross-section of industry, including the following:

- Aerospace and defense equipment manufacturing
- Automobile manufacturing
- Chemical manufacturing
- Electric power generation
- Electronic products manufacturing
- Food processing
- Glass packaging manufacturing
- Industrial gases production
- Industrial parts distribution
- Industrial products manufacturing
- Medical device manufacturing
- Mining
- Paper manufacturing
- Pharmaceutical preparation manufacturing
- Petroleum processing, research laboratories
- Semiconductor manufacturing

**Phase II: Identify and Evaluate Strategy Components**

The purpose of Phase II of the project was to identify and evaluate possible elements of the *IH Value Strategy*. This was critical if the *Strategy* was to have credibility and be effective in capturing and demonstrating the value that IH adds to a company’s business. In completing Phase II, key concepts and terms were defined, a comprehensive literature search was conducted, and existing models were explored that are relevant to making the value case for industrial hygiene. Once strategy elements were identified, the inter-relationships were examined between strategy components using the ROHSEI Causal Loop Diagram that has been in use for more than a decade. The potential strategy elements were evaluated by examining cases in the ROHSEI User’s Library.

After reviewing the literature, analyzing existing models, and re-examining our own experience in demonstrating value, we came to the conclusion that the best way to capture the value that IH brings to the business is to start with the IH risk reduction process and track its impact on employee health, the IH risk management process, and the business process in general. Impacts can be quantifiable in terms of reduced cost or even added revenue, or they may be more general contributions to key business objectives.

Strategy sub-elements and parameters can be imported from the existing ROHSEI tool and from other models and sources. These elements are listed in Phases II, IV, and V. They were tested during this phase of the work with respect to reasonableness, clarity of definition, and accuracy and consistency of results.

**Phase III: Develop and Assess Qualitative Approach**

A qualitative method of determining and illustrating the IH contribution to business value was developed and assessed as an approach of the *IH Value Strategy*. The concepts behind the Qualitative Approach are not new. They have been used by ROHSEI users, legal professionals, and others for years. What may be new is the organization of the thought process. The approach enables the industrial hygienist to look at value in a broad context, and provides techniques for capturing value when data are not available to
support a quantitative analysis. It is also a comprehensive integrated approach to value analysis where a wide range of benefits are captured by using multiple approaches—qualitative and quantitative—custom tailored to each individual situation.

The real value of the *Qualitative Approach* is that it can be used to estimate value where detailed costs and benefits are hard to obtain or where there isn’t the time or resources to do a quantitative analysis.

**Phase IV: Develop and Assess Quantitative Approach**

A quantitative method of determining and illustrating the IH contribution to business value was developed and assessed as an approach of the *IH Value Strategy*. The team projected that the ROHSEI instrument could serve as the starting point for the *Quantitative Approach*. From it, the elements of an IH program or activity could be identified, and IH project intervention data collected and analyzed. Customizing the ROHSEI model specifically to evaluate IH applications required modification of the existing global parameter definitions to apply uniquely to IH value proposition analysis. One hundred fifty-three (153) user-defined parameters specific to IH were created to reflect the range of data that could be collected for value propositions that assess the value of moving the level of employee protection up the IH hierarchy of controls. The parameters were aligned with the steps in the IH Value Equation, and a method and tools were developed to collect data for IH interventions at the process, facility, and program levels.

**Phase V: Develop and Assess Overarching Strategy**

The data, information, products, and knowledge gained through previous phases of the study were used to build the *Overarching IH Value Strategy*. The *Overarching IH Value Strategy*, which links the two approaches (qualitative and quantitative), was assessed by using data and case examples from participating companies.

The *Overarching IH Value Strategy* has three categories of activity: preliminary investigation and study prioritization; value assessment; and value presentation. The categories include eight specific model components, and each component includes specific steps and approaches in a sequential construct. The overarching strategy represents a flexible approach that allows users multiple entry points and allows them to substitute their own existing information whenever possible.

The *Overarching IH Value Strategy* consists of eight steps:

1. Understand Business Objectives and IH Hazards
2. Identify and Prioritize Value Opportunities
3. Assess Risk Reduction
4. Determine Value Approach: Qualitative or Quantitative
5. Determine Changes
6. Determine Impacts
7. Determine Value
8. Present Value Proposition.

**Study Findings**

The findings that are listed below are not based on statistically reliable data. This study was not designed or funded to support that kind of analysis. Rather the findings reflect
lessons learned from more than a decade of experience with the ROHSEI effort, observations from site visits that were conducted as part of this study, and discussions and dealings over the years with colleagues from some of the world’s leading corporations.

Although the findings reflect the experience of larger companies, the insights (and resulting strategy elements) are, in many cases, applicable to smaller companies.

Finding #1 IH professionals who were eager to contribute to the project generally knew very little about cost and business data or how to access them. A major effort needs to be undertaken to educate industrial hygienists on how they can better understand their companies’ business strategies and business processes.

Finding #2 Making a credible value proposition cannot be done by the industrial hygienist in isolation; it requires a team approach with contributors from operations and other business functions.

Value demonstration requires comparison: either of a target in “before and after” conditions; or, of a program to like programs of competitors or to some control group. Users need to be able to evaluate prospective, retrospective, and current applications. To do this they must understand the business and business “drivers,” and they must understand the intersection between IH risk and the business. They must also understand the business process and the relationship between IH activity and downstream benefits.

Finding #3 The most significant IH impacts on the business were not those that have traditionally been tracked by safety and health professionals. Usually those trying to measure the value of S&H to the business track impact on workers’ compensation premiums and reduced fines and penalties. Why? Because they are the obvious connections and they seem to be the easiest to quantify. However several site visits indicated that these savings may be the “tip of the iceberg” in many situations.

At one site, substitution of a carcinogenic process chemical with a less toxic one improved the quality of the product, required less re-work to produce quality products, and thereby freed up resources that resulted in increased production capacity. The increased capacity resulted in additional sales since the plant was already working at full capacity and their output was already “sold out” for the next several years. The changes made in order to reduce health risk at that facility will produce a continuing revenue stream of several million dollars each year for years to come.

Industrial hygienists contributed substantial value by enabling a process that was key to maintaining critical production capacity to keep running. The ability of the site industrial hygienists to develop a heat stress protection program for workers conducting repairs on a critical piece of equipment ensured that there was no shutdown of the process, which would have caused a multi-million dollar loss. Had the unit shutdown, other units would have been shutdown as well. A total shutdown for 10 days would have cost approximately $15 million.

In still another example, IH involvement was critical to a key process for an entire industry that allows oil refineries to process lower grade crude oil, and subsequently results in millions of dollars of profit each year. By providing an essential function to a highly profitable process, industrial hygienists contributed tremendous value. Without their expertise in managing the radiation detector program, the delayed coking process could not have happened, and the company would have lost $81,250,000 of annual profit. Again, the business impact of industrial hygiene was significant.
**Finding #4** The traditional strategy for capturing IH value has to be broadened. Traditional S&H strategies and approaches focus on cost. That is not without reason; other disciplines, such as quality, also look to cost when measuring value.

Phil Crosby, a well-respected thought leader in the quality movement, defined the cost of quality as the “cost of conformance” (i.e., the cost of a company’s quality assurance program) plus the “cost of nonconformance” (the cost of quality defects). The IH corollary is that the cost of IH is the cost of IH-related loss plus the cost of IH programs and activities. Gross cost savings from IH programs or activities would be the cost of IH-related loss before the program or activity minus the cost of IH-related loss after the IH program or activity. That was depicted in ROHSEI as:

\[
\text{Incident Benefit:}
\]

\[
= \text{Total Annual Incident costs in current situation} - \text{Total Annual Incident costs in Scenario}
\]

\[
= \left( \frac{\text{Current Number of Incidents Per year} \times \text{Current Cost per Incident}}{\text{Scenario Number of Incidents Per year} \times \text{Scenario Cost Per Incident}} \right)
\]

Figure E-1. ROHSEI Gross Cost Savings Equation.

Net cost savings would be gross IH–related cost savings, minus the cost of the IH program or activity.

This formula still works. However, in addition to tracking cost savings and cost avoidance, two new categories should be added to the framework for capturing value. First, there are situations where IH programs and activities result in **new revenue** for the business. So there must be a mechanism to capture revenue generation. Second, there must be a means for capturing key impacts on the business process. The cost-based approach in ROHSEI should be expanded to a new framework as follows:
Finding #5 A highly effective approach to capturing business benefits (other than by measuring cost reduction and new revenue generation) is to identify the relationship of IH programs and activities to key business objectives. All organizations have objectives. Objectives are the means that organizations use to make their vision and value statements actionable. Corporate leadership uses business objectives to set priorities, guide operations, and drive accountability. As such, business objectives provide a “universal” framework for capturing the “other” business benefits contributed by IH programs and/or activities.

Finding #6 Ironically, the largest, most significant value contributions often were the most difficult to isolate and precisely quantify. Lack of precise quantification should not result in loss of the value contribution. Industrial hygienists need to be able to capture this value even though some of it may be difficult to quantify. This phase of the report contains an approach that will assist the industrial hygienist in providing credible estimates of the business value generated by industrial hygiene in these situations.

Finding #7 Making a qualitative case for IH value added will be easier in situations where the industrial hygienist presenting the information already has credibility in the organization. The technique for using cause and effect analysis will withstand scrutiny if the industrial hygienist can obtain leadership attention and focus.

Finding #8 Value assessments can be made for individual IH activities and programs. Programs can be measured at the facility, business unit, and enterprise levels. However, the precision of the assessments will vary. Project assessments provide the greatest degree of accuracy; program assessments will be less precise. The more aggregate the data the less accurate it gets. Methods used to assess value at the project level are significantly different (and more granular) than strategies needed to assess IH programs at the facility, business unit, and enterprise levels.

Finding #9 The hierarchy of controls generally applies for financial and economic reasons as well as IH reasons, although it is not a one-to-one relationship. The financial aspects vary with the industry and the type and magnitude of risk.

The greatest cost savings and other benefits tended to be associated with hazard elimination and the elimination of PPE usage. Material substitution can have very large pay-offs because the change often has impacts that create efficiencies throughout the business process. Containment projects can result in improvements in employee health exposures and significant savings in labor and waste disposal costs with little incremental capital investment.
Engineering controls are most often, but not always, better financially than PPE. In cases where financial benefit cannot be shown for engineering controls, there are often other benefits that make them preferable. The use of PPE versus engineering controls or containment is usually the least effective and most costly way to protect people. The economic circumstances of PPE programs support the IH hierarchy of controls. However:

- PPE can be a cost-effective measure to protect employees in high noise areas
- Relying on PPE as the primary means of protection requires extraordinary measures to ensure that expected levels of protection are validated in actual field operations
- Even in highly responsible organizations management may delay taking action if they have the perception that employees are adequately protected by PPE.

Management Practices Demonstrating the Value of the Profession

A survey instrument was developed based on the Malcolm Baldrige Award Criteria for Performance Excellence, and administered to participating companies in order to demonstrate the value that IH program practices can have on an organization’s business results. The survey was administered by ORC to its member companies, resulting in 24 responses. Preliminary analysis by EG&G indicates that the most significant factor affecting business results regarding IH programs is a pronounced focus on the workforce. The second most significant factor appears to be a focus on the customer. These two areas account for the majority of the variation in the responses in the Business Results category. Further analysis is under way to make more definitive statements with statistical confidence.

Opportunities for Further Research

Opportunities for further research were identified at the end of the project. They include testing and further strategy refinement, development of representative values, further study of the relationship between the hierarchy of controls and financial returns, and statistical validation and expansion to safety.

The following report details the purpose, methods, and findings of each of these study components.
Phase I: Gather and Analyze Data

Introduction

Business, financial, and IH data from ORC member companies was gathered and analyzed during Phase I of the Value of the Industrial Hygiene Profession project. Companies were selected that met criteria for participation in subsequent study phases. Although the survey responses do not represent a statistically significant sample, analyses of a number of program issues are included where the data were thought to be useful.

Those companies providing positive responses to the greatest number of questions and having the most comprehensive programs were included in the group from which participating companies were to be selected. Of particular interest were those that had performed business case analyses or conducted cost or improvement studies of various elements of their IH programs, that had implemented a comprehensive IH exposure monitoring strategy, and that maintained a health monitoring system database that had been used to conduct health studies.

Companies that had performed business case analyses or conducted cost or improvement studies were thought likely to be able to support the development and testing of the Quantitative and Qualitative Approaches, either by applying the proposed approaches and determining their ability to return meaningful analyses, or by providing insight into the elements that should be included in each strategy.

Those companies that had implemented a comprehensive IH exposure monitoring strategy and maintained a health monitoring system database were thought to be potentially able to provide data to link employee exposure history with health outcomes and ultimately to business impacts.

In providing examples for use in the quantitative strategy portion of this project, companies were asked to use cases of individual IH interventions that could be classified according to type of IH hazard (i.e., biological, chemical, ergonomic, noise, other physical, or radiation), and the level along the hierarchy of controls of the approach that was used to abate the hazard (i.e., administrative/PPE, engineering, or elimination). (See Figure I-1.) This allowed testing on a nearly full range of possible IH exposure scenarios, and added criteria for the ultimate selection of participants. The results of this testing are discussed in the Phase IV section of this report.

Few companies had all of the types of data sought through the surveys. However, in the search for companies to participate, a great deal was learned about the status of IH programs in some of the world’s best companies. The data gathered were useful for building the IH Value Strategy and for gaining insights into good IH management practice.

Ultimately, the key determining factors in the selection of participants were a company’s ability and willingness to share data, to participate in the on-site surveys, to develop case studies of IH risk mitigation projects, and to host subsequent site visits. As a consequence of these factors, the list of companies that initially expressed interest in participating and that met many of the criteria differs somewhat from those that actually contributed case studies.
Figure I-1. Project Matrix for Quantitative Analysis.

Phase I Survey Results

Survey I for the Value of the Industrial Hygiene Profession project was developed to gather and analyze general data on ORC Worldwide member companies as well as more specific information about their IH programs and practices. Companies were asked to provide responses for two levels of their programs: for the corporation as a whole and for the site that represented their “best” IH program. Identifying the best site was an approach intended to increase the probability of locating programs and projects that would be comprehensive and that would have the highest quality of IH information.

Companies identified their best sites in terms of the quality of IH-related management systems, compliance, and innovation, and the likelihood of having data that could be used to understand how employee health status and business outcomes have been influenced by IH programs.

Survey I was designed to identify ORC member companies that could 1) provide the types of data needed to design, develop, and test the IH Value Strategy and its components, and 2) be representative of the wide range of sizes and industry categories in which the IH Value Strategy ultimately would be used. The survey polled members regarding company demographics, organization, and industry sector; IH management systems and program elements; IH-related costs and outcome data; and interest in participating in Phase II of the study (see Appendix A: Survey I). In all, 46 ORC member companies responded. (See Appendix B for a list of survey respondents).
Section I—Site Identification, Demographics and Organization

Demographics

Although ORC Worldwide member companies tend to be large, the 46 responding companies exhibited a range of global employee populations from smaller (775 employees), to moderate (4,000 to 10,000 employees), to large (11,250 to 88,853 employees), to very large (219,400 to 259,263 employees) (see Figure I-2). This wide range of company sizes provided the opportunity to see how the IH Value Strategy could be applied in small as well as very large organizations. In addition, information about site-level programs and projects allowed the study team to isolate smaller projects that were similar to the conditions likely to be found in smaller companies.

Figure I-2. Range of Employee Populations of Responding Companies.

Companies also were asked to indicate the numbers of employees globally in each functional area of their businesses, according to whether they worked in manufacturing/operations, sales and/or service, corporate or division staff, or research and development (Figure I-3). The large majority of employees fell into the manufacturing/operations group, with an average population across reporting companies of approximately 28,000.

Further categorization of employees by primary North American Industry Classification System (NAICS) code(s) and the NAICS code(s) for the best IH program sites, formed a set of information about the type of exposure to potential risk that employees in each company may have experienced (Figure I-4). This was additional information for identifying companies that may have had examples meeting the criteria for participation discussed earlier, and provided data for further analysis of survey responses.

Within these companies a range of operations exists that includes service functions that are representative of the many types of businesses and activities in which industrial hygienists may find themselves engaged. Warehousing, transportation of goods, and maintenance and repair of equipment and facilities, are a few examples. Laboratory and other research settings are also represented. Missing are major service businesses such as hotel- and restaurant-related industries, package handling and delivery services, construction contractors, and transportation companies.
The responding companies represented the following primary industries:

- Aerospace and defense equipment manufacturing
- Automobile manufacturing
- Chemical manufacturing
- Electric power generation
- Electronic products manufacturing
- Food processing
- Glass packaging manufacturing
- Industrial gases production
- Industrial parts distribution
- Industrial products manufacturing
- Medical device manufacturing
- Mining
- Paper manufacturing
- Pharmaceutical preparation manufacturing
- Petroleum processing, research laboratories
- Semiconductor manufacturing
- Specialty glass and ceramic components manufacturing
- Tobacco products manufacturing.

Figure I-3: Number of Employees by Functional Area.
A more in-depth look at the distribution of employees across specific industries within the manufacturing sector revealed that a large majority of the total number of global employees is in automobile manufacturing (635,704), followed by aerospace and defense (158,100), pharmaceutical preparation manufacturing (74,329), chemical manufacturing (71,551), industrial products manufacturing (49,000), food processing (40,000), electric power generation (21,734), petroleum processing (13,885), medical device manufacturing (11,559), and tobacco products manufacturing (6,840).

The majority of manufacturing companies that responded to the survey were smaller to medium size in global employee population (Figure I-5).

**Organization**

In order to understand how companies allocate their IH expertise, and if the level of staffing should be considered as a criterion in the selection of participating companies, the survey asked them to indicate the number of Industrial Hygienists and Certified Industrial Hygienists (CIHs) throughout the corporation and at the best IH program sites. (Certification was defined as being certified in the country of employment and not necessarily by ABIH.) IH staffing was not seen as a significant factor in selection of participants.
Companies were asked to describe the IH reporting structure within their corporate and best IH program site organizations up to three reporting levels. This information was used to determine the relative status of IH throughout each company and at its best IH program site. In addition, information about where IH was placed in an organization gave an indication of how it functioned and how leadership regarded the role of IH in the company. Ideally, companies with a strong reporting relationship to company leadership would be selected because of the support that would likely be given to the IH program for participation and follow-through.

Corporate

At the highest level, the IH function typically reports to a Vice President of Environment, Health and Safety (EHS, or some similar letter combination representing those functions), as was the case with 9 of the 42 companies that answered this question. Also common is to have the highest level into which the IH function reports be a director rather than a vice president. Seven companies reported having this relationship. This position may be a Director or Senior Director of EHS or a Director of Safety and Health (S&H). Other titles included Director, Safety & Workers’ Compensation; Director, Chemical Risk Management; and Associate Director, Safety and Environmental Protection.

Three companies indicated that the IH function reported to the Chief Executive Officer (CEO). In these cases, reporting was through a Vice President, either of Human Resources, or Operations. The remaining companies indicated a variety of reporting relationships, including Vice President of Legal, and Vice President of Human Resources.

Best IH Program Site

Most of the 31 companies that responded to this part of the question described three levels of reporting structure for their best IH program sites. Reporting at the site level was typically to the plant manager or a general manager. Seven companies reported this relationship. Equally common is reporting to the operations or manufacturing function through a Vice
President or Director at the site. Other positions included Business Unit or Regional Director or Manager of EHS; Associate Director, Safety and Environmental Protection; and Director, Chemical Risk Management.

The survey asked whether a functional or reporting relationship existed between IH resources at the site level and IH resources at the corporate level. Eighteen member companies maintained they had a functional relationship, three member companies maintained they had a direct reporting relationship, and seventeen member companies stated they had both relationships.

Section II—IH Management Systems and Program Elements

IH Management Systems

To identify well-managed IH programs and to understand the characteristics of IH programs in companies selected to participate in the project, the survey asked about the specific elements of the management systems in use by both the corporation and the best IH program site. The program elements mirrored those outlined in the ANSI Z-10 Occupational Health and Safety Management Systems (OHSMS) Standard:

- IH Policy
- Leadership responsibility and authority
- Employee participation
- Planning
- Hazard identification, assessment, and control
- Incident investigation
- Design review and management of change
- Purchasing review
- Contractor IH policy
- Emergency preparedness
- Education, training, awareness, and competence
- Communication
- Records management
- Auditing
- Management review.

Ten companies reported that they had implemented all 15 OHSMS elements at both the corporation and site levels. Five of these companies were full participants in the project, providing case studies in addition to hosting site visits and responding to both questionnaires. This was extremely helpful because this level of management system implementation indicates that IH programs are likely to be strong, have reliable data upon which to base conclusions, and to have taken appropriate steps to identify and control IH risks.

Member companies generally used more industrial hygiene/occupational health management system elements at the corporation level than at their best IH program sites. The program element used most at the best IH program sites was incident investigation. Of the 39 member companies that used the incident investigation element, 34 of those companies also used the element at the corporation level. The program element used the most at the corporation level was leadership responsibility and authority. Of the 41 companies that used the leadership responsibility and authority element, 33 of those companies also used the element at their best IH program sites.
The program elements used least at the best IH program sites were purchasing review and contractor IH policy (equal numbers of companies used these elements). Of the 28 companies that used the purchasing review policy, only 18 used the element at the corporation level. Of the 28 companies that used the contractor IH policy at their best IH program sites, only 24 used the element at the corporation level. The program element least used at the corporation level was purchasing review. Of the 25 companies that used the purchasing review policy at the corporation level, only 18 used the element at their best IH program sites.

In addition to information about implementation of the management system elements listed previously, the survey collected data regarding the use of recognized management systems and/or processes such as Six Sigma, Lean, Malcolm Baldrige Award, ANSI Z-10, ISO 9000, ISO 14001, OHSAS 18001, OSHA VPP and others. Companies that used these systems, particularly Six Sigma and Lean, were thought likely to have done the kind of systematic analysis of their processes to develop data on IH risks and their possible economic impact.

Of the 42 companies that responded to this question, 24 were engaged in the Six Sigma management system. Of those 24, 19 were engaged in Lean, 7 in Malcolm Baldrige, 15 in ISO 9000, 14 in ISO 14001, 9 in OHSAS 18001, 5 in ANSI-Z-10, 12 in OSHA VPP, and 6 in other management systems. Results show that companies that used Six Sigma also used Lean more than any other approach (Table I-1).

**IH Program Element Evaluation**

The survey examined how companies address certain specific IH program elements, including risk assessment, risk prioritization, risk control, and others. These elements were then analyzed independently by sub-category. Areas of interest within risk assessment were chemical exposure monitoring, noise assessment, ergonomics, and ionizing and/or non-ionizing radiation. Areas of interest within risk control included risk elimination; substitution of less hazardous materials, operations, processes, or equipment; engineering controls; warnings; administrative controls; respiratory protection; and other personal protective equipment (PPE). We asked member companies what percentage of total program time they spent in these specific areas (Figure I-6).

On average, about 37% of total program time was spent on risk assessment. Twelve percent of total program time was spent on IH risk prioritization. About 42% of total program time was spent on IH risk control. On average, 9% of total program time was spent on other areas.

Through analysis of the time that company IH programs spend on specific risk assessment and control activities, potential areas for improving effectiveness of IH programs were identified (Figure I-7, Figure I-8). In conducting risk assessment, companies indicated that they spent 42% of their IH program time on chemical exposure assessment, 28% on ergonomics, 21% on noise assessment, and 9% on ionizing and non-ionizing radiation. On the risk control side, 24% of IH risk control time was spent on engineering controls, while another 26% was spent on protective equipment and respiratory protection. Twelve percent was given to administrative controls. Only 15% was spent on elimination of risk. Substitution of hazardous materials was given 15%, which, together with risk elimination, is an indication of focus toward more effective programs. Opportunity lies in the area of reducing the amount of time spent on PPE, respiratory protection, and administrative controls applied, and increasing the proportion spent on elimination and substitution. Indeed, these areas have been shown in previous analyses of IH interventions to have great potential to reduce operating costs and increase productivity.
### Table I-1: Use of Recognized Management Systems and/or Processes

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<th>Malcolm Baldrige Award</th>
<th>ISO 9000</th>
<th>ISO 14001</th>
<th>OHSAS 18001</th>
<th>ANSI Z-10</th>
<th>OSHA VPP</th>
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<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>We have a MS that is a consolidation of ISO, RC, etc.</td>
</tr>
<tr>
<td>27</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td></td>
</tr>
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<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>OHSAS is part of MS, not going for external cert</td>
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</table>

21
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<th>Company ID Number</th>
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<th>Malcolm Baldrige Award</th>
<th>ISO 9000</th>
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<th>OHSAS 18001</th>
<th>ANSI Z-10</th>
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<th>Others</th>
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<td>20</td>
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<td>N</td>
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<td>N</td>
<td>N</td>
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</tr>
</tbody>
</table>

Figure I-6. Total IH Program Time Spent on Risk (Average percentage of all companies)

- **Risk Assessment**: 37%
- **Risk Prioritization**: 12%
- **Other**: 9%
- **Risk Control**: 42%

Figure I-7. Percentage of Total Program Time Spent on Specific Risk Assessment Activities

- **Chemical Exposure Monitoring**: 42%
- **Noise Assessment**: 21%
- **Ergonomics**: 28%
- **Ionizing and/or non-ionizing radiation**: 9%
Selecting companies that spent more time on proactive activities was thought to increase the likelihood of finding cost-effective, more protective IH programs. It was also thought that these companies would have good test examples and case studies for the *IH Value Strategy*.

Part of this question focused on cost-benefit and process improvement studies, and asked about which IH program elements had undergone them. Eleven companies conducted these studies on risk assessment (Table I-2). Four of the 11 companies also conducted studies on risk prioritization and seven also conducted studies on risk control. Of the 11 companies, ten had conducted cost-benefit and/or process improvement studies on ergonomic risks, eight had conducted studies on chemical exposure monitoring, seven had conducted studies on noise assessment, and five had conducted studies on ionizing and/or non-ionizing radiation. These results suggest that cost or improvement studies on ergonomic risks are completed more often than other type of study.

Cost-benefit or process improvement studies for risk control were conducted by 10 member companies out of the 31 that responded to this question. Of those 10 companies, eight had risk elimination studies; eight had engineering controls studies; six had substitution of less hazardous materials, operations, processes, or equipment studies; four had respiratory protection studies; three had warning studies; three had other PPE studies; and two had administrative control studies.

The following tables illustrate the distribution of cost or improvement studies conducted on various aspects of IH risk assessment and control programs.
Table I-2: Number of Companies with IH Program Cost or Improvement Studies.

<table>
<thead>
<tr>
<th>IH Sectors</th>
<th>Number of Companies</th>
</tr>
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<td><strong>Risk Assessment</strong></td>
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<td>Chemical Exposure Monitoring</td>
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</tr>
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<td>Noise Assessment</td>
<td>9</td>
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<tr>
<td>Ergonomics</td>
<td>13</td>
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<tr>
<td>Ionizing and/or Non-ionizing Radiation</td>
<td>5</td>
</tr>
<tr>
<td><strong>Risk Prioritization</strong></td>
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<td><strong>Risk Control</strong></td>
<td>10</td>
</tr>
<tr>
<td>Risk Elimination</td>
<td>9</td>
</tr>
<tr>
<td>Substitution of Less Hazardous Materials, Operations, Processes, or Equipment</td>
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</tr>
<tr>
<td>Engineering Controls</td>
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<td>Warnings</td>
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<td>Administrative Controls</td>
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<td>Respiratory Protection</td>
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</tr>
<tr>
<td>Other Personal Protective Equipment</td>
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</tr>
<tr>
<td><strong>Other</strong></td>
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</table>

The companies shown in Tables I-3 and I-4 are those that had conducted studies in the greatest number of IH program areas. These companies represented the greatest opportunity for identifying potential projects for development of the micro strategy.

Table I-3: Cost or Improvement Studies on IH Risk Assessment and Control Programs.

<table>
<thead>
<tr>
<th>Companies Conducting Studies on RISK ASSESSMENT also conducted:</th>
<th>Studies on Chemical Exposure Monitoring</th>
<th>Studies on Noise Assessment</th>
<th>Studies on Ergonomics</th>
<th>Studies on Ionizing and/or Non-ionizing Radiation</th>
<th>Studies on Risk Prioritization</th>
<th>Studies on Risk Control</th>
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<tbody>
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</table>
Table I-4: Cost or Improvement Studies in Specific Risk Control Areas.

<table>
<thead>
<tr>
<th>Cost or Improvement Studies for RISK CONTROL (By Company ID)</th>
<th>Also Conducted Risk Elimination Studies</th>
<th>Substitution of Less Hazardous Materials, Operations, Processes, or Equipment Studies</th>
<th>Engineering Controls Studies</th>
<th>Warning Studies</th>
<th>Administrative Controls Studies</th>
<th>Respiratory Protection Studies</th>
<th>Other Personal Protective Equipment Studies</th>
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</tr>
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<td>28</td>
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<td>✓</td>
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<td></td>
</tr>
</tbody>
</table>

Program Goals

Companies were asked to describe what they believed to be the ultimate goals driving each aspect of their IH program implementation. Those that indicated excellence were regarded as having higher quality IH program implementation overall. It is notable that more companies identified compliance as a program goal than identified excellence (Table I-5). Loss avoidance was less commonly identified than compliance, but was more often cited than excellence.

Table I-5. IH Program Goals.

<table>
<thead>
<tr>
<th>IH Sector</th>
<th>Number of Companies</th>
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</thead>
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<tr>
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<td>Compliance</td>
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<td>Risk Assessment</td>
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<td>Noise Assessment</td>
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<tr>
<td>Ergonomics</td>
<td>24</td>
</tr>
<tr>
<td>Ionizing and/or non-ionizing radiation</td>
<td>28</td>
</tr>
<tr>
<td>Risk Prioritization</td>
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</tr>
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<td>Risk Control</td>
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<tr>
<td>Risk Elimination</td>
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<td>Substitution of Less Hazardous Materials, Operations, Processes, or Equipment</td>
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<td>Respiratory Protection</td>
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<td>Other Personal Protective Equipment</td>
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<tr>
<td>Other</td>
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</table>
A key element of an IH program is a comprehensive IH exposure monitoring strategy. For the purposes of Survey I, companies that had comprehensive IH exposure monitoring strategies would be able to provide detailed information about IH risk in specific processes, which would enable them to describe the effectiveness of interventions in reducing those risks. Of the 45 companies who responded, 28 (61%) had implemented a comprehensive IH exposure monitoring strategy.

If a company maintains a health monitoring system database that collects comprehensive health surveillance data, IH exposure data, and employee personal information, and that can generate specific data elements on specific employee groups, IH exposure groups, and medical surveillance outcomes, it has a powerful tool for linking IH risk with health outcomes. Even more useful would be studies that had been conducted to identify the health outcomes among specific exposed groups of employees. In designing the survey, the study team hoped to identify companies that could provide this type of information, for use in developing both the Quantitative and Qualitative Approaches of the IH Value Strategy.

Results show that the majority of member companies that had implemented a comprehensive IH exposure monitoring strategy also maintained a health monitoring system database with the capability of linking to comprehensive IH exposure data for all employee exposure groups. These 28 companies also maintained less comprehensive health surveillance data on all employees.

Of the 28 companies that implemented a comprehensive IH monitoring strategy, 18 maintained a health monitoring system database with the capability of comprehensive health surveillance data on exposed employees (Figure I-9). Four companies maintained a health monitoring system database with the capability of comprehensive health surveillance data on all employees. Twenty-two companies maintained a health monitoring system database with the capability of tracking comprehensive IH exposure data for all employee exposure groups. Nine companies maintained a health monitoring system database with the capability of linking complete employee personal information. Thirteen companies maintained a health monitoring system database with the capability of generating specific data elements on specific employee groups. Nineteen companies maintained a health monitoring system database with the capability of generating specific data elements on IH exposure groups. Thirteen companies maintained a health monitoring system database with the capability of generating specific data elements on medical surveillance outcomes.

The survey asked member companies whether their companies had conducted health studies using a health monitoring system. Of the 42 companies that responded to the question, 10 companies conducted the health studies and all 10 had comprehensive IH exposure monitoring strategies (Figure I-9). Eight of the ten companies had comprehensive health surveillance data on exposed employees, two had comprehensive health surveillance data on all employees, eight had comprehensive industrial hygiene exposure data for all employee exposure groups, seven had links to complete employee personal information, six were capable of generating specific data elements on specific employee groups, eight were capable of generating specific data elements on IH exposure groups, and eight were capable of generating specific data elements on medical surveillance outcomes (Table I-6).
The relative scarcity of the type of information discussed in the survey indicates that not many companies will be able to make data-driven connections between health outcomes and exposure. In fact, only one company that responded to the survey indicated that it has a fully functional health monitoring system. While it is interesting that there are some companies that currently have the capability to conduct studies based on this type of information, it is unlikely that many, especially smaller organizations, will acquire this resource in the near future. This information has implications for development of the *Qualitative Approach*, since the scope of a health monitoring database is at the enterprise level and can provide insights into company experience with IH risk. The companies that have these systems can serve as resources for learning where to find links between risk and outcome, and provide the guidance for researching them. It also means that in conducting value analyses, companies will have comprehensive IH exposure and health risk data available for determining the impact of IH programs and activities.
Table I-6: Specific Capabilities of Companies that Conduct Health Studies

<table>
<thead>
<tr>
<th>Comprehensive Industrial Hygiene Monitoring Strategies (By Company ID)</th>
<th>Comprehensive Health Surveillance Data on Exposed Employees</th>
<th>Comprehensive Health Surveillance Data on All Employees</th>
<th>Comprehensive industrial hygiene exposure data for all employee exposure groups</th>
<th>Linking complete employee personal information</th>
<th>Can Generate specific data elements on specific employee groups</th>
<th>Can Generate specific data elements on IH exposure groups</th>
<th>Can Generate specific data elements on medical surveillance outcomes</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>

*Metrics*

Understanding the ways in which companies measure progress in key IH program areas is important to making a case for value, because these metrics are often the means of recognizing the impacts of IH on the rest of the business. Survey I asked companies to describe both leading and trailing metrics used to track performance in risk assessment and the IH risk assessment program sub-elements, in risk prioritization, in risk control, in risk elimination and the IH risk elimination program sub-elements, and in other areas at the best IH program site and at the corporate level. This resulted in a range of different responses, and some trends were identified. In addition, a number of useful metrics that can be recommended for adoption by other IH programs were found. (See Appendix D).

There was not much difference between the metrics used at the site and corporate levels. By far the most overused metric was OSHA recordable incident rates, which was seen in nearly every category and used as both a leading and trailing indicator by at least one company. It is intriguing that so many companies are dependent on this very limited metric, given that occupational illnesses are more often than not left off the OSHA logs due to long latency and a failure to recognize work-relatedness of disease. In addition, the metric is often used for program areas that it is not sensitive enough to track. An example is use of respiratory protection.

The examples provided in this report may serve to encourage industrial hygienists to experiment with new metrics that can drive continuous improvement in risk-related IH programs more effectively.
Risk Assessment

Frequently-used leading IH metrics for risk assessment at the best IH program sites included percent of IH exposure assessments completed, percent of the IH sampling plan completed, and percent of job and project hazard assessments completed. Leading IH metrics at the corporate level were very similar to those reported at the best sites, adding audit scores to the list. Common trailing IH metrics for risk assessment at the best IH program sites included OSHA injury and illness rates and the number of health-related incidents. Trailling IH metrics at the corporate level were very similar to those reported at the best IH program sites.

Percent of exposure assessments and sampling plans completed is a frequently-used leading metric for chemical exposure monitoring at best IH program sites and at the corporate level. Trailling IH metrics at the best sites and at the corporate level for this program element included illness and injury reporting and the number of samples taken that were within specified limits.

For noise assessment, leading IH metrics at both the best IH program sites and the corporate level included percent of noise surveys completed and the number of people exposed above the 85 and 90 decibel levels. Common trailing IH metrics at best sites and at the corporate level included number of incidents and cases, OSHA recordables, and the number of threshold shifts.

Leading IH metrics for ergonomics at best IH program sites and at the corporate level included assessments/evaluations and reviews of workstations completed. Injury and illness rates and reduction in ergonomically-related incidents were the trailing IH metrics most often cited for ergonomics both at best sites and at the corporate level.

The most frequently cited leading IH metrics for ionizing and/or non-ionizing radiation at best IH program sites and at the corporate level included number of audit findings and planned assessments completed. At best IH program sites and at the corporate level, trailing metrics for ionizing and/or non-ionizing radiation included OSHA injury and illness recordkeeping, results of exposure assessments, and reviews of exposure or release incidents.

Risk Prioritization

Leading IH risk prioritization metrics addressed hazard and risk exposure assessments. Trailing IH metrics for this program element included OSHA injury/illness rates and the results of risk assessments.

Risk Control

Leading risk control metrics focused on completion of plans to minimize risk, and training and communications. Trailing risk control metrics at best IH program sites and at the corporate level included OSHA injury/illness rates and performance on audits.

Risk Elimination

Leading IH risk elimination metrics addressed planning, job hazard analysis, and reviews. A common trailing IH metric at best sites and at the corporate level for risk elimination included OSHA injury/illness rates and results of risk and exposure assessments.

Leading IH metrics to track substitution of less hazardous materials, operations, processes or equipment encouraged analysis and review of processes. Examples included efficiency of
process development routes, hazardous material control program implementation, and workplace exposure improvement score (WEIS). Trailing IH metrics for this program element relied heavily on OSHA injury/illness rates, but some companies focused on reducing the purchase of hazardous materials and the number of chemicals in use.

Leading metrics to track use and effectiveness of engineering controls varied among companies. Measures cited range from percent of recommended controls completed to reduction in exposure potential, to number of design reviews conducted, and ventilation surveys completed. Companies continued to cite OSHA recordable incidents as the main trailing metric, but also mentioned time to complete resolution of hazards, actions taken based on incidents, and number of follow-ups after the fact.

Leading warnings metrics at best IH program sites and at the corporate level measured training implementation and audits. OSHA injury/illness rates were used as the dominant trailing metric, but some companies also used actions based on incident reviews and time to complete resolutions.

Although many companies did not report metrics for administrative controls, a few were cited. Leading indicators included design reviews conducted, preplanning of hazardous operations, and reduction in exposure potential. Besides OSHA recordable rates, some companies used time to complete resolution of hazards, controls implemented due to exposure, and incident review performance.

Respiratory protection leading metrics included percent of fit tests performed versus required, elimination of the need for respiratory protection, and hazardous material control program implementation. Trailing IH metrics at best sites and at the corporate level for respiratory protection included OSHA injury/illness rates, incident reviews to determine program effectiveness, and number of employees wearing respiratory protection.

Some companies listed PPE elimination, tracking of significant threshold shifts (STS), implementation of hazardous material control programs, workplace exposure improvement score, and percent observations of use for leading metrics for other personal protective equipment. Again, for trailing metrics, companies commonly listed OSHA recordable rates, hearing and fall protection monitoring, and hazardous material control program implementation.

In addition to metrics for the risk assessment, prioritization, control, and elimination categories, companies were asked to indicate other metrics they had found useful for managing IH programs. Leading metrics included wellness interventions and health risk assessments (HRAs), management involvement meetings, management systems audit scores, and closure of audit findings. Trailing metrics resembled those mentioned previously.
Section III—IH-Related Cost and Outcome Data

Central to the ability to develop a value case for IH, or any other program for that matter, is the availability and accessibility of data concerning the costs and outcomes of that program’s activities. One of the main goals of the Phase I survey was to establish the existence and accessibility of the available data with regards to costs and outcomes of various aspects of IH Programs among participating companies. Existence of health- and exposure-related outcome data also was important to understand the relationship between IH risk and health consequences, to the extent that link could be established. It also was necessary to learn the extent to which companies had this information available to their internal IH organizations for conducting future value studies based on the strategy.

Accessibility of the data under specific terms of release was important to ORC so that a realistic IH Value Strategy could be constructed based on the information that a majority of companies had on hand or could collect. This information would allow better understanding of the existing empirical resources available for use in building the strategy. A total of 44 companies responded to this set of questions.

In addition to health outcome data, the survey asked the same existence and availability questions about human resources outcome data and costs, and legal metrics and costs. These two areas can provide information for developing the business case because the “downstream” consequences of IH risk are often seen in the form of absenteeism, workers hired to replace ill or injured employees, and legal fines and penalties.

It was also important to determine companies’ experience with business case analysis for IH projects and/or programs. The survey gathered information about the effectiveness of IH business cases as a means to develop guidance for users of the strategy, and with the intent of finding examples for inclusion in the study. As was mentioned earlier, companies’ ultimate interest in participating in the subsequent stages of the study was the defining factor in selecting participants.

Many companies regard such data as confidential and are willing to release them only under restricted circumstances, so it was important to determine whether the data existed and were releasable for study with strict confidentiality and blinded, if they existed and were not releasable for study, or if they did not exist. Companies were asked these questions for both the corporate level and for their best IH program sites.

If data regarding IH-related outcomes and costs existed, they were most likely not available for an outside study. However, these numbers varied substantially by a particular question as well as by company. Therefore, it was necessary to examine each question separately in order to compare the availability of different forms of IH-related costs and outcomes data.

Across all categories of questions on IH-related cost and outcome data, the most common answer indicated that, while the data existed, they were not available for release. In other words, approximately 44% and 42% of all answers to the questions about IH-related costs and outcomes (at the corporate level and the best IH program sites respectively) fell into the “data exist and are not releasable for study” category. At the same time, approximately 18% of the answers at the corporate level and 19% answers at the level of the best IH site indicated that the data “exist and are releasable for study with strict confidentiality and blinded.”

Twenty-four percent and 23%, respectively, of the answers at corporate and best IH site levels indicated that data did not exist, while 14% and 16% of answers (corporate and best IH
site respectively) were left blank. The existence and availability of data were slightly more common at the best IH site level (average of 19% vs. 18%). The same held for the missing answers (16% vs. 14%). The existence and non-availability, and non-existence of data were more common at the corporate level (44% vs. 42% and, 24% vs. 23% respectively), reflecting a more guarded approach to data at the corporate level (Figures I-11 and I-12).

Figure I-11. Availability of Data at the Best IH Site Level

Figure I-12. Availability of Data at the Corporate Level
Cost-Related Outcome Data

Survey respondents were asked about data existence and availability in seven areas related to IH: annual IH program costs, costs by IH program element, workers’ compensation loss data, other occupational health-related losses (skin diseases, respiratory diseases, diseases from toxic exposures, diseases from physical agents), non-occupational health-related losses, health and environmental remediation costs, and long-term occupational health liability costs (see Figures I-13 and I-14).

The most common answer across all seven categories was that the data existed but were not releasable for study. Annual IH program costs and costs by IH program element were the exceptions. In these two categories, a majority of the respondents said the data did not exist. With respect to annual IH program costs, 25 companies indicated that such data did not exist at their best IH program sites, while 26 companies indicated that the data did not exist at the corporate level.

Compared to the other four categories, a larger number of companies had cost and outcome data that were available and releasable (when compared among all seven categories) for annual IH program costs (this category was nearly evenly divided between data existed, releasable and data did not exist; 13 and 12 companies had the data at the best IH site and corporate levels respectively); workers’ compensation loss data (15 companies at both best IH site and corporate levels); and health and environmental remediation costs (15 at the best IH site level and 11 at the corporate level).

Figure I-13. Cost-related Outcome Data for Best IH Program Sites.
The questions on health and exposure-related outcome data asked survey respondents about employee exposure monitoring data, medical surveillance data, health monitoring data and workplace injury and illness data. Once again, the answer “data exist and are not releasable for study” was the most common for the categories employee exposure monitoring data (22 companies for both best IH site and corporate levels), medical surveillance data (26 companies), and health monitoring data (21 companies at the best IH site and 23 companies at corporate level).

The single exception was workplace injury and illness data, kept according to OSHA recordkeeping rules. Twenty-six companies had these data available and releasable for study at their best IH sites, and 27 at the corporate level. (Two companies said their OSHA data did not exist!) The category with the next most existing and available data was employee exposure.

Categories for which a larger number of companies had available and releasable data were annual IH program costs (13 and 12 companies had the data at their best IH sites and corporate levels, respectively); workers’ compensation loss data (15 companies at both best IH site and corporate levels); and health and environmental remediation costs (15 at the best IH site level and 11 at the corporate level).
Questions about human resources outcome data and costs focused on absenteeism data, hiring costs (full-time and replacement workers as well as part-time and temporary replacement workers), and several business and financial metrics including production and material costs, payroll and labor costs, cost of poor quality and other quality metrics, value of process improvements associated with IH programs, and productivity improvements associated with improving IH processes (Figures I-17 to I-20).
Across all questions in this section, absenteeism was the category for which the highest number of companies had existing and available data at their best IH program sites (9 companies). Data for value of process improvements associated with IH programs and productivity improvements associated with improving IH processes did not appear to exist among the majority of companies. Twenty-five and 28 companies chose that answer for value of process improvements (best IH site and corporate level respectively), and 24 and 27 chose the answer for the productivity improvements associated with improving IH processes.

Figure I-17. Human Resources Outcome Data and Costs for Best IH Sites.

Figure I-18. Human Resources Outcome Data and Costs, Including Business and Financial Metrics, at Best IH Program Sites
Legal Metrics and Costs Data

Member companies responded to questions about the availability of data on compliance citations, cost of legal judgments, cost of legal settlements and IH-related Sarbanes-Oxley disclosures (See Figures I-21 and I-22). At the level of the best IH sites, 20 companies said that data on compliance citations existed but were unavailable. In contrast, only 14 companies said that such data existed and were available. While eight companies had existing and available data regarding costs of legal judgments, 25 companies said that such data were not releasable for study. Similarly, while the same eight companies had existing and available data on the costs of legal settlements, 24 companies said that such data were not releasable.
At the corporate level, the result was very similar. Fifteen companies had existing and releasable data on compliance citations, nine companies had existing and releasable data on cost of legal judgments, and nine companies had existing and releasable data on costs of legal settlements. On the other hand, 21 companies had non-releasable data on compliance citations, 26 companies had non-releasable data on costs of legal judgments, and 26 companies had non-releasable data on costs of legal settlements.

The IH-related Sarbanes-Oxley disclosures category was different in that the most common answer was that the data did not exist (19 companies at the best IH program site level, and 24 companies at the corporate level). Only five survey respondents said they had such data available for release, and ten companies said that while such data existed, they were non-releasable. The sensitivity of data in this question certainly drove the results.

Figure I-21. Legal Metrics and Costs Data at Best IH Sites.

Figure I-22. Legal Metrics and Costs Data at the Corporate Level.
**IH Business Case Analysis**

Twelve companies indicated that they had conducted business case analyses on IH projects and/or programs; 32 companies answered that they had not (Figure I-23). Companies responding positively were then asked to provide substantive information regarding the types of projects or programs they had analyzed, the financial metrics used in the analysis, the levels of management to whom the analysis was presented, and the degree of effectiveness of the analysis in producing the expected results.

Of this group of 12 companies, three were participants in the latter phases of the study.

One company stated that all of its IH projects were subjected to business case analysis. Types of projects/programs for which the responding companies had conducted business case analyses included:

- In-house medical
- Engineering controls
- Types of PPE
- Handling equipment
- Best waste disposal methods
- Exposure reductions
- Internal environmental services
- Lab services
- Asbestos management and abatement
- Lead management and abatement
- Implementation of a new electronic Data Management System
- Post exposure medical surveillance
- Value of internal lab accreditation versus outsourcing to external lab
- Cost to purchase services vs. Internal cost
- Leveraging IH resources across sites/businesses

*Figure I-23. Business Case Analysis for IH Projects and/or Programs*

*Note: 45 companies responded*
Potent drug containment
Overall value of IH program in order to justify headcount
Business case justification for engineering controls
Monitoring equipment upgrades
Capital requests for ergonomics
Noise and chemical exposure reductions
Chromium compliance program element reductions
IH software
New product pipeline support/business gains.

Some of the financial metrics that were employed in these business case analyses included:

Productivity
Capital costs
Tax rate
Reduction per unit cost
Labor time and level of effort
Capital and expense dollars
Cost benefit
ROI
Internal Rate of Return (IRR)
NPV.

All of the companies had presented their business case analyses to the management (Figure I-24), but at different levels (Figure I-25):

1 company presented at the Board of Directors level
8 companies presented at the Senior Executive management (corporate) level
10 companies presented at the middle management (business unit) level
5 companies presented at the first-line management (plant or field) level
4 companies presented at the supervisory level.

*Note: 45 companies responded

Figure I-24. Business Case Presented to Management.
Individual company comments regarding the effectiveness of the business case in producing the expected results were as follows:

Very effective, they were receptive and interested in the process and appreciative that we would put HSE in monetary terms
Successful
Excellent
It was convincing enough that the project was approved and implemented successfully
This was just developed and is still a 'work in progress'
Providing the business case was successful in gaining management support.
Highly effective
High level of effectiveness due to the importance placed on employee safety
Business case is successful in attaining funding
Marginally effective, need to change culture in order to effect substantial change to company
Little impact.

**Interest in Further Participation**

Twenty-two out of the 44 companies that completed Section III of the Phase I Survey expressed interest in further participation in the study (Figure I-26). The negative responses to this question (“Company is not interested in further participation in Phase II of the Value of the IH Profession Study”) may have been driven by the unavailability of costs and outcomes data in these companies, as well as the high demands that were placed on the time of the individuals who were to provide responses. However, an affirmative answer to the question about interest in further participation did not signify the existence and/or presence of the costs and outcomes data.
Among the companies interested in participating in subsequent stages of the project, the existence and availability of data at the level of the best IH program site were more common than at the level of corporation. Therefore, for the future phases of the Value of the Industrial Hygiene Profession project, a focus on the best IH program sites appeared to be more promising in terms of the amount of available data.

The categories for which the greatest number of companies has existing and available data (at the level of the best IH program site) were:

1. Annual IH program costs (10 companies)
2. Workers’ compensation loss data (10 companies)
3. Health and environmental remediation costs (8 companies)
4. Workplace injury and illness data (17 companies)
5. Absenteeism data (9 companies)
6. OSHA compliance citations (12 companies).

The categories for which the fewest number of companies had existing and available data (at the level of the best IH program site) were:

1. Costs by IH program element (4 companies)
2. Other occupational health related losses (skin diseases, respiratory diseases, diseases from toxic exposures, diseases from physical agents) (4 companies)
3. Long-term occupational health liability costs (4 companies)
4. Health monitoring data (4 companies)
5. Business and financial metrics—Costs of poor quality/other quality metrics (3 companies)
6. Business and financial metrics—Value of process improvements associated with IH Programs (3 companies)
7. Business and financial metrics—Productivity improvements associated with improving IH processes (2 companies)
8. IH-related Sarbanes-Oxley disclosures (4 companies).
Conclusions

Phase I of the project identified companies that met many of the criteria that made them appropriate for further study. The real challenge in selecting companies to participate, however, was the existence of the data and companies’ willingness to release it. In addition, many companies found that the time required to answer questionnaires and provide case studies was more than they could spare. A combination of lean staffing and increased scope of coverage has contributed to a decrease in the time that corporate HSE staffs have for activities external to their companies. Therefore, the initial list of companies that responded to Survey I (Appendix B) differs significantly from the final list of participating companies (Appendix C).

Nonetheless, Survey I provided data and information that were useful to the study phases that followed, as well as providing a better understanding of how IH is staffed, managed, and practiced in a number of large, well-respected companies. The distribution of CIHs at the corporate vs. best IH program sites; the implementation of management systems for IH programs; the proportion of time spent on IH program activities; the extent to which companies have completed IH program cost or process improvement studies in specific program areas; the extent to which companies use IH exposure assessment strategies and health monitoring systems; and the metrics industrial hygienists use in managing their risk assessment, prioritization, elimination, and control programs all provided valuable learning that presented opportunities for improvement of IH programs generally.

A second survey was developed to gather further detail regarding program cost-benefit data, which is related to development of both the Quantitative and Qualitative Approaches. This information is presented in detail in the Phase IV section of this report.
Phase II: Develop and Test General Strategy Components

Introduction

The purpose of Phase II of the Value of the Industrial Hygiene Profession project was to identify and evaluate possible elements of the IH Value Strategy. This was considered critical if the Strategy was to be credible and effective in capturing and demonstrating the value that IH adds to the business.

The information contained herein lays the foundation for the Overarching IH Value Strategy described in the Phase V section of this report, and for the Qualitative and Quantitative Approaches described in the Phase III and IV sections of this report, respectively. Most of the key findings are captured here, but some are more appropriately discussed in Phases III, IV, and V. Also, it is important to note at the outset that many of the findings herein resulted from study, observation, experience, and anecdotal information, and do not reflect statistically reliable survey results.

Fundamental Concepts Incorporated into the IH Value Strategy

Definitions

The IH Value Strategy is based on existing concepts and models. In general, a model is an abstraction of a real-life system with the purpose of increasing understanding of that system. It is also a representation of a system, which provides a means for investigating the components of the system. Of import to this endeavor is a specific type of model—the business model—which has been described in varied ways.

Peter Drucker, the father of modern management, suggests that the business model must identify the customer, what the customer values, and how the firm makes money in the business. In other words, what is the underlying logic that explains how value can be delivered to the customer? Business models have been promoted as a way to explain how a firm or enterprise works—i.e., how the individual pieces of the business fit together. Business modeling has also been characterized as the managerial equivalent of the scientific method; it starts with a hypothesis, tests that hypothesis, and revises actions as needed. (Magretta, 2002).

Models can be presented in physical, graphical, or mathematical terms. Graphical models consist of lines, symbols, shapes, or charts and include Pareto Diagrams, Ishikawa Diagrams, and break-even charts. Formulas and equations are the mainstay of mathematical models and are frequently used in business to aid in decision making or planning activities. Examples include linear programming, cost benefit analysis, and return on investment calculations.

A strategy is a method or plan that combines a set or series of activities to accomplish a specific predetermined goal or result. Armed with a business model that accurately describes the operation of the business process and how various components of the business interact (including IH programs, projects, and interventions) as a foundation, a strategy can be developed that enables IH practitioners to identify and present the value of IH within the context of the business operation. This is the gist of the current project.
Beyond the specific definitions and the presentation format, a successful business strategy must create a heuristic reason that connects technical potential with the attainment of value. To accommodate this need, this project has provided both mathematical and graphical models that define the principal customer as the business enterprise and examine the relationship between the technical role of the industrial hygienist and the economic (tangible and intangible) value of their contributions. The method for this project, as is the case for any scientific method, was to hypothesize the most appropriate elements of the **Strategy**, test them under real world conditions, and revise them as necessary to ensure accurate and effective demonstration of the value of the IH profession.

**The Fundamental Role of Risk**

Risk is one of the first components necessary to derive the value of the industrial hygiene profession. The focus of the industrial hygienist is on the reduction of risk to worker health from hazards found in the work environment. Uncontrolled or insufficiently controlled hazards associated with materials and processes may create dangerous conditions to which workers should not be exposed. Industrial hygiene is the discipline of anticipating, detecting, recognizing, evaluating, and controlling such occupational health risks. Through education, training, and experience, an industrial hygienist learns what hazards can be expected from specific types of operations and how to determine if they are present, understand the likely impact of those hazards, evaluate the degree of the risk to worker health, and recommend measures to control or eliminate the risks.

Through prescribed actions to manage occupational health risk, the IH program will protect workers from biological, chemical, and physical hazards, which include ergonomic, noise, and radiation hazards. This action, which can take the form of a single focused intervention or an entire IH program, becomes another major component of the overall strategy to demonstrate the value of the profession. These two areas, risk reduction and IH activities and/or programs, will drive the value proposition.

**What We Mean By “Value”**

With a clear idea of the type strategy that this project will provide and the role of the IH profession, the next challenge is to define value. Value is a relative term, with meanings grounded in multiple disciplines. For the purposes of this discussion, the definition of value will be limited to those found in economics, accounting, and general business.

In economics it is traditional to separate the concept of value into value that expresses the inherent usefulness of an object and value associated with the power of purchasing other goods. The first is called *value in use*, the latter *value in exchange*. Value in use is not an intrinsic quality of a commodity, but its capacity to satisfy, directly or indirectly, needs or desires. Value in exchange is the worth of commodity in terms of its capacity to be exchanged for another commodity, which is usually money. This concept is referred to as market value. In classical economics the existence of use value was a prerequisite for commodities to have value in exchange.

In accounting, value has been defined as the monetary worth of services provided, a specific asset, group of assets, or the business as a whole (Barron’s, 2005). The framework for measuring value in the United States can be found in General Accepted Accounting Principles (GAAP). GAAP include the standards, conventions, and rules that accountants follow when recording and summarizing transactions and when preparing financial information. Included in the GAAP are a series of Principles to help guide the
recording and reporting functions to best ensure the transparency, comparability, reality, and acceptability of the financial results.

In management, business value is often an informal term that includes all forms of value that determine the health and well-being of the firm. Business value expands beyond economic value to include other types of value. For example, employee value, customer value, supplier value, channel partner value, alliance partner value, managerial value, and societal value. Many of these are not directly calculated in monetary terms nor are all these examples pertinent to this work.

Customer value is one of the more important business values for consideration in determining the value of the IH contribution. In this context it would be defined as the value received by the end-customer of the IH action to control risk. The end customer can include the organization’s external clients or individuals within the organization in the business process. The benefit is envisioned as utility, quality, benefits, and customer satisfaction.

The organization can also be viewed as a network of internal and external relationships. Value in this context is described as value networks or value chains. Each point in the network has an interest in the business process, such as a stakeholder group, a resource, end-consumers, interest groups, regulators, or the environment itself. To create value for the organization, there is a collaborative, creative, and synergistic process among the groups. If the organization is viewed as a network of value creating entities (in this case, the industrial hygienist) then the question becomes how each point in the network contributes to overall firm performance. While it would be beneficial if this value could be monetized into a single measure, it is clearly not feasible.

As a final note, Warren Buffet provides a most insightful definition: “Price is what you pay. Value is what you get.” Whether value is measured in accounting, economic, or business terms, the value of the IH profession is determined by what the organization gets from the work of industrial hygienists; it is this impact or the effect they have on the organization.

The next components of the strategy can be formulated using these definitions and answering one question—what is affected as a result of the industrial hygiene action? By reducing risk, the health of the employees will change, the business process will change, and the work of the industrial hygienist will change.

**How can value be evaluated?**

Understanding the IH function and the effect within the organization provides useful information but does not provide a thorough accounting of the value or worth of that function. The definition of value provides some insight, but the method of estimating that value remains to be determined. One method to measure that value is through evaluation studies focused on the specific projects or programs undertaken by the profession. In broad terms, an evaluation can focus on the strategic, technical, economic or financial aspects of a project. Technical evaluations determine the technical appropriateness of equipment, material, or the entire system. While this is a necessary evaluation, it is not sufficient to determine the contribution of IH work to the enterprise.

Economic evaluations are systematic appraisals of both the costs and consequences of an action implemented at the worksite. These are normally conducted to determine the relative economic efficiency, either allocative or technical efficiency, of specific actions. The National Institutes of Health (NIH, 2007) states the aim of economic evaluations is...
to ensure that the benefits from a program or action are greater than the opportunity costs of that program. Allocative efficiency assesses competing programs and judges the extent to which they meet objectives, and technical efficiency assesses the best way to achieve a given objective.

A full economic evaluation compares the costs and consequences of two or more actions. A full economic evaluation is required to gain valid information on efficiency—that is making the best use of the available resources of the employer. The methods to conduct a full economic evaluation include cost-benefit analysis, cost-utility analysis, cost-effectiveness analysis, or cost-minimization analysis. Cost-benefit analysis is the most commonly used method from an employer perspective and determines allocative efficiency. This method expresses all costs and consequences in the same unit, which is usually money. Cost-effectiveness analysis expresses the costs and consequences in different units; for example, cost per health outcome. However, the denominator can be other units as well, such as cost per employee or cost per unit of production. With this flexibility, the method can be used to determine technical efficiency.

In addition to a full economic evaluation, a partial evaluation study can also be conducted. This method still considers both costs and consequences, but does not compare alternative interventions, relate costs to benefits, or allow for determination of efficiency when using a single method. The five types of partial evaluations are: cost comparison or cost analysis, cost outcome description, cost description, outcome description, and cost of illness studies. Any of these types can be used as input for a full economic evaluation.

Evaluation techniques can also be categorized as using either positive or normative methods. Positive methods are based on measurable factors, while normative methods are based on factors more difficult to measure. Positive evaluation methods are grounded in positive economics, which is based on measurable factors such as costs, efficiency, or prices. Normative evaluation methods are concerned with issues of welfare, ethics, value judgment, business values, and equity. Consideration of full economic evaluation suggests that these studies can be positive evaluations. However, the consequences should be sufficiently robust—including the effect on business values and goals—to accommodate normative studies as well.

These techniques involve making quantitative evaluation of three key considerations: profitability, sustainability of operations, and the opportunity cost of not investing elsewhere (Brannock, 2004). In broad terms, profitability assumes that expected benefits exceed costs. Sustainability addresses the need for the productive process remaining competitive. Finally, it is assumed that investments in internal operations will create a larger rate of return than outside investing. It is at this point that the importance of financial measures becomes apparent. According to Brannock, economic evaluation provides “fundamental quantitative tools for financial evaluations of business case alternatives.”

Each evaluation perspective can be independently employed. However, the true power is a combination of technical, economic, and financial analysis. The technical feasibility of an IH action will be determined in the early stages of controlling risk and it is assumed that if it is not technically feasible, it will be excluded from further consideration. A strategic evaluation ensures that the project is consistent with the output objectives of the firm. The economic evaluation will explore the costs and benefits of the action and the outputs from that evaluation are often presented as financial measures. A financial analysis will help determine if the goal of maximizing value has been met.
Understanding Financial Measures

The following are common financial measures used to evaluate business investments within a corporate or commercial enterprise, including short- and long-term investments. Within this context, IH activities or programs are the investments being evaluated, whether they affect capital investment or working capital management. These measures describe the effect that an investment has on the financial condition of a company and the impact on profit. They are tools used to assist management in the allocation of limited resources between competing opportunities.

**Cash Flow**

*Cash flow* is the basis for deriving the majority of financial measures for the business case and is often the most challenging. Calculating the cash flow involves not only estimating the amount of expected benefit or cost, but also projecting when the benefit or cost will be incurred. Translating benefits and costs into cash flow statements can be challenging. Each benefit or cost identified from the previous sections leads to either an expected cash flow result, or will be assigned a value in cash flow terms. Cash flow entries should include non-cash charges such as depreciation and reflect after-tax values.

The cash flow statement provides a list of the investment outflows (costs and expenses) that will be required, the inflows (monetized benefits) the project will produce, and the time those inflows will occur during the analysis period. The following two tables provide an example of a cash flow statement associated with a “status quo” option and another one for a proposed option (Tables II-1 and II-2). These examples provide the net cash flow for each period considered as they generally serve as the starting point for budgeting and business planning activities. Estimations may be influenced by a number of factors, such as inflation, changes in tax rate, the strategic plans of the firm, and the overall economic environment.

Table II-1. Example Cash Flow Statement Associated with a “Status Quo” Scenario.

<table>
<thead>
<tr>
<th>Status Quo Scenario</th>
<th>Cash Inflows / Benefits and Gains</th>
<th>Cash Outflows / Costs &amp; Expenses</th>
<th>Cash Flow Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Year 1</td>
<td>Year 2</td>
<td>Year 3</td>
</tr>
<tr>
<td>Benefit item 1</td>
<td>45</td>
<td>66</td>
<td>165</td>
</tr>
<tr>
<td>Benefit item 2</td>
<td>428</td>
<td>588</td>
<td>641</td>
</tr>
<tr>
<td>Benefit item 3</td>
<td>781</td>
<td>677</td>
<td>620</td>
</tr>
<tr>
<td>Total cash inflows</td>
<td>1,254</td>
<td>1,331</td>
<td>1,426</td>
</tr>
<tr>
<td>Benefit item 1</td>
<td>(90)</td>
<td>(87)</td>
<td>(87)</td>
</tr>
<tr>
<td>Benefit item 2</td>
<td>(165)</td>
<td>(165)</td>
<td>(255)</td>
</tr>
<tr>
<td>Benefit item 3</td>
<td>(975)</td>
<td>(777)</td>
<td>(645)</td>
</tr>
<tr>
<td>Total cash outflows</td>
<td>(1,230)</td>
<td>(1,029)</td>
<td>(987)</td>
</tr>
<tr>
<td>Net cash flow</td>
<td>24</td>
<td>302</td>
<td>439</td>
</tr>
</tbody>
</table>
Incremental cash flow shows the difference between the status quo cash flow and the cash flow associated with implementing a new program or intervention. Simple cash flow does not consider uncertainty and the value of time.

Discounted Cash Flow (DCF) accommodates for uncertainty and the value of time by discounting the cash flow stream. Discounting adjusts the value of future cash flows by giving more “value” or weight to the near term cash flows and less “value” to those in the more distant future. It is important to know when you should include a discounted cash flow in your business case presentation. If the intervention or programs being considered cover long periods of time or if the magnitude of the inflows and outflows are different within each time period, a DCF should be presented. A DCF should also be presented if the timing of the cash flow from each intervention or program differs substantially within the analysis period.

Net Present Value (NPV) is the sum of the discounted values of a cash flow stream of net benefits (benefits – costs) over time. Mathematically it is represented as

\[ \sum_{t=0}^{n} A_t (1 + i)^{-t} \]

where \(A_t\) represents the annual net discounted cash flow of program or intervention and \(i\) represents the designated discount rate. NPV is a direct measure of the size of the benefits net of costs at the end of the analytic horizon that the business would have gained by undertaking the program or implementing the intervention, accounting for the time value of money. The discount rate for NPV and other measures calculated from the business perspective is usually the opportunity cost of capital for the business that is affected. The opportunity cost, also known as the minimum attractive rate of return (MARR) or hurdle
rate, is the market interest rate for lending and borrowing, and the risks associated with the investment opportunities. At the discretion of the analyst, discounting can be performed as though the cash flow occurred at either the beginning or end of a period. Again, because this may be a difficult rate to measure or obtain, it is important to conduct sensitivity analysis around this variable.

The NPV is a preferred merit measure because it is not affected by the planning horizon as long as the planning horizon is greater than or equal to the useful life of the program or intervention. The following table demonstrates the NPV calculation associated with a hypothetical program or intervention proposal.

Table II-3. Net Present Value Calculation.

<table>
<thead>
<tr>
<th>Time Period</th>
<th>$A_t$</th>
<th>Discount Factor for 8% interest</th>
<th>Annual Discounted Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-315.2</td>
<td>1.0000</td>
<td>-315.200</td>
</tr>
<tr>
<td>1</td>
<td>295.5</td>
<td>0.9225</td>
<td>272.599</td>
</tr>
<tr>
<td>2</td>
<td>248.2</td>
<td>0.8573</td>
<td>212.782</td>
</tr>
<tr>
<td>3</td>
<td>245</td>
<td>0.7938</td>
<td>194.481</td>
</tr>
<tr>
<td>4</td>
<td>475.2</td>
<td>0.7350</td>
<td>349.272</td>
</tr>
<tr>
<td>5</td>
<td>591.3</td>
<td>0.6806</td>
<td>402.439</td>
</tr>
</tbody>
</table>

NPV = 1116.372

Payback Period is length of time needed to recoup an investment through the expected cash flows from the investment and is generally expressed in years. In other words, how long does it take for the intervention to pay for itself? The simple payback period is the smallest positive integer $p$ such that

$$\sum_{t=0}^{p} A_{t,x} \geq 0$$

where $A_{t,x}$ represents the annual net cash flow of a program or intervention. The simple payback period does not consider the value of time; the cash flow entries are not discounted. The discounted payback period uses cash flow entries which have been discounted.

Using the cash flow example presented previously, the annual net cash flows have been derived and are shown in the top row of the table below (Table II-4). The payback period for this proposal occurs in year 2 because the sum of annual net cash flows for the project is <0 until year 2. Similarly, the payback period for maintaining status quo from an earlier table (Table II-1), is during the first year as the annual net cash flows are never <0. Alternatively, the payback period can be calculated to reflect portions of a year. Using the following example, the payback period is 1.09 years.
Table II-4. Sample Payback Period Calculation.

<table>
<thead>
<tr>
<th>For the year ending September 30</th>
<th>$ in 1,000s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Cash Flow (CF)</td>
<td>Year 0: -317.2, Year 1: 295.5, Year 2: 248.2, Year 3: 245.0, Year 4: 475.2, Year 5: 591.3, Total: 1,537.9</td>
</tr>
<tr>
<td>Cumulative Net CF</td>
<td>Year 0: -317.2, Year 1: -21.7, Year 2: 226.5, Year 3: 417.5, Year 4: 946.7, Year 5: 1,537.9</td>
</tr>
</tbody>
</table>

By inspection, the cumulative net cash flows are negative until sometime during year 2. Payback = 1.0 + (21.7 / 248.2) or 1.09.

Payback period is generally both simple to calculate and easy to understand. As a result, this merit measure is routinely used by companies and is sometimes used as a crude measure of risk. The alternative with the shorter payback period is considered less risky. Despite these attributes, the payback period remains a rough estimate and even if all the assumptions and data are precise, the exact payback day is rarely known. If the net cash flow is not positive through the time horizon, then the payback cannot be calculated. Any changes in cash flow (negative or positive) beyond the payback date are not accounted for in this merit measure.

Return on Investment is a widely used term with multiple definitions in the field of accounting. Examples of the various types of returns on investments include Return on Invested Capital, Return on Capital Employed, Return on Total Assets, and Return on Net Worth. Therefore, it is important that the methods for calculating the measure are clearly explained in the business case report. For the purposes of this effort, the Simple ROI is less of an accounting term than a generalized term for the expected value of an investment in terms of added revenue or profits, or averted expenses.

\[
\text{Simple ROI} = \frac{(P_b - P_c)}{P_c}
\]

where \( P_b \) represents the gains or benefits from the program or intervention and \( P_c \) represents the cost of that program or intervention. ROI can be presented as a ratio or as a percentage. As a ratio, it measures the effectiveness of the investment by calculating how many times the net benefits (benefits from investment minus initial and ongoing costs) recover the original investment. ROI is used to understand, evaluate and compare the value of different investment options. Although simple to define, identifying the costs and benefits necessary for calculation can be demanding. For example, an equipment redesign project is undertaken, at a cost of $1.25 million. It is expected to be in place for at least 10 years. During that time it is expected to generate a savings of $1 million in averted medical costs and lost productivity. Additional revenue streams from commercializing the technology are expected to produce $3 million. The Simple ROI is \((4\text{ million}-1.25\text{ million}) / 1.25 = 2.2\), which is generally expressed as a percentage, 220%, or ratio, 2.2:1.

Internal Rate of Return (IRR) is the discount rate at which the NPV is zero and is generally considered a simplified alternative to NPV. IRR takes into account the time value of money by considering the cash flows over the lifetime of a program or
intervention. However unlike the NPV, the Internal Rate of Return is an indirect measure of the value of the program or intervention, but nonetheless is a useful measure if a unique value exists. Mathematically, the IRR is represented as

$$\sum_{i=0}^{n} \frac{A_i}{(1+i)^t} = 0$$

where $A$ represents the annual net discounted cash flow of program or intervention and $i$ represents the interest rate. Notice that the IRR formula is merely the NPV formula set equal to zero, with cash flows known. Although the measure is conceptually simple, solving for the IRR can be more complex. Three basic methods are used to solve for the unknown interest value: trial and error, graphic representation, and financial calculator or computer solution.

Programs or interventions that have large cash outflow sometime during or at the end of its time horizon (as opposed to the normal case of one or more cash outflows followed by a series of cash inflows) can pose difficulties when employing the IRR as a merit measure. These type projects can have no solution, multiple solutions, or the solution can lead to an improper decision. To illustrate the latter assume two programs with the following cash flows (Table II-5).

Table II-5. Comparison of IRR and NPV as Merit Measures in a Large Cash Outflow Scenario.

<table>
<thead>
<tr>
<th>Project</th>
<th>Expected Net Cash Flow</th>
<th>Merit Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Year 0</td>
<td>End of Year 1</td>
</tr>
<tr>
<td>A</td>
<td>-$100,000</td>
<td>$120,000</td>
</tr>
<tr>
<td>B</td>
<td>$83,333</td>
<td>-$100,000</td>
</tr>
</tbody>
</table>

Using the IRR as the merit measure and assuming a minimum attractive rate of return (MARR) or hurdle rate of 10%, both projects would be desirable. However, the NPV suggests that Project B may not constitute an acceptable funding opportunity.

**Comparison of Merit Measures**

Each merit measure has value and presents different information for consideration by the decision maker. The following example should make clear the differences in these merit measures. In this example, the analyst assesses two proposed options to a problem identified in the early stages of a business case. Each proposal has a cost of $10,000, and the MARR for both is 12 percent. The net cash flows for each proposal are presented in Table II-6 below.
Table II-6. Assessing Proposed Options with Net Cash Flow Measures.

<table>
<thead>
<tr>
<th>Year</th>
<th>Proposal A</th>
<th>Net Cash Flow</th>
<th>Proposal B</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>(10,000)</td>
<td>(10,000)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>6,500</td>
<td>3,500</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>3,000</td>
<td>3,500</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3,000</td>
<td>3,500</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1,000</td>
<td>3,500</td>
<td></td>
</tr>
</tbody>
</table>

Table II-7 presents the cumulative cash flows for each proposal, which are necessary to calculate the payback periods.

In addition to helping decision makers select a final program or intervention, these results could also be used as a filter to reduce the number of viable proposals for the decision maker to consider. This example is simplistic in that both proposals have equal timelines and each merit measures suggest that Proposal A is the better selection. If there are proposals that are not mutually exclusive or have differing timelines, more complex analysis will be required. A full discussion of more complex computational situations or conditions is beyond the scope of this report, but can be readily found in financial management, project evaluation, or managerial accounting texts.

The “best” financial measure to be used when conducting a business case will depend on a number of factors. For example the analyst could calculate and present all measures or only the customary measure used by the organization or industry in the analysis. Alternatively, experts have stated that the accuracy of a merit measure depends on the timing and magnitude of the cash flows. Regardless, for the measure to lead to consistently accurate decisions, it must exhibit the following three properties:

- The method must consider all cash flows throughout the entire life of a project.
- The method must consider the time value of money; that is, it must reflect the fact that dollars which come in sooner are more valuable than distant dollars.
- When the method is used to select from a set of mutually exclusive projects, it must choose that project which maximizes the firm’s financial performance.
Table II-7. Assessing Proposed Options with Cumulative Cash Flow Measures.

<table>
<thead>
<tr>
<th>Year</th>
<th>Proposal A</th>
<th></th>
<th>Proposal B</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>(10,000)</td>
<td></td>
<td>(10,000)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>(3,500)</td>
<td></td>
<td>(6,500)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>(500)</td>
<td></td>
<td>(3,000)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>2,500</td>
<td></td>
<td>500</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>3,500</td>
<td></td>
<td>4,000</td>
<td></td>
</tr>
</tbody>
</table>

Payback \(_A\) = 2 + \(\frac{500}{3000}\) = 2.17 years.
Payback \(_B\) = 2 + \(\frac{3000}{3500}\) = 2.86 years.

\[
\text{NPV}_A = -10,000 + \frac{6,500}{(1.12)^1} + \frac{3,000}{(1.12)^2} + \frac{3,000}{(1.12)^3} + \frac{1,000}{(1.12)^4} = 966.01
\]

\[
\text{NPV}_B = -10,000 + \frac{3,500}{(1.12)^1} + \frac{3,500}{(1.12)^2} + \frac{3,500}{(1.12)^3} + \frac{3,500}{(1.12)^4} = 630.72
\]

\[
\text{IRR}_A = 0 = -10,000 + \frac{6,500}{(r)^1} + \frac{3,000}{(r)^2} + \frac{3,000}{(r)^3} + \frac{1,000}{(r)^4} = 18.0\%
\]

\[
\text{IRR}_B = 0 = -10,000 + \frac{3,500}{(r)^1} + \frac{3,500}{(r)^2} + \frac{3,500}{(r)^3} + \frac{3,500}{(r)^4} = 15.0\%
\]

\[
\text{ROI}_A = \frac{\text{PV benefits-costs}}{\text{PV costs}} = \frac{966.01}{10,000} = 9.7\%
\]

\[
\text{ROI}_B = \frac{\text{PV benefits-costs}}{\text{PV costs}} = \frac{630.72}{10,000} = 6.3\%
\]

As mentioned earlier, changes in cash flow beyond the payback date are not included in the calculations and therefore violate the first property. Undiscounted payback period violates the second property. However, many firms use this merit measure when the initial investment is small. The NPV, IRR, and ROI methods all satisfy the first and second properties. All three financial measures lead to identical and correct accept/reject decisions for independent projects. However, only the NPV method satisfies the third property under all conditions. If two programs or interventions are independent, NPV and IRR measures lead to the same conclusion. However, if both are mutually exclusive and not independent, the resulting measures may not lead to the same conclusions. Exclusive events are when if event \(A\) happens, then event \(B\) cannot, or vice-versa. Independent events are when the outcome of event \(A\) has no effect on the outcome of event \(B\). So, if \(A\) and \(B\) are mutually exclusive, they cannot be independent. If \(A\) and \(B\) are independent, they cannot be mutually exclusive.

**Conclusions**

The evaluation process involves a study of the key factors that result from the IH action. Evaluation of an IH action includes strategic evaluation, economic evaluation, and financial impact evaluation. While the economic and financial evaluation of a project aims at determining the most efficient strategy for delivering the desired outcome, the strategic evaluation ensures that the project is consistent with the objectives of the organization. The financial appraisal may be the most important part of the evaluation.
because the project cannot be successful if it is financially unviable, even though it may be otherwise feasible.

From this discussion of evaluation techniques and financial measures, a clear picture of the framework for the Qualitative and Quantitative Approaches developed.

The traditional strategy for capturing IH value has to be broadened. Traditional S&H strategies and approaches focus on cost. That is not without reason; other disciplines also look to cost when measuring value. Phil Crosby, a well respected thought-leader in the quality movement defined the cost of quality as the “cost of conformance” (i.e., the cost of a company’s quality assurance program) plus the “cost of nonconformance” (the cost of quality defects). The IH corollary is that the cost of industrial hygiene is the cost of IH related loss plus the cost of IH programs and activities. Gross cost savings from IH programs or activities would be the cost of IH-related loss before the program or activity minus the cost of IH-related loss after the IH program or activity. Net cost savings would be gross IH-related cost savings minus the cost of the IH program or activity.

This formula still works. However, in addition to tracking cost savings and cost avoidance, two new categories need to be added to the framework for capturing value. First, there are situations where IH programs and activities result in new revenue for the business. So a mechanism is needed to capture revenue generation. Second, a means for capturing key impacts on the business process is needed.

In short, the cost-based approach that has been used in S&H and other disciplines should be expanded to a new framework as follows:

![Figure II-1. New Framework for Cost-based Valuation.](image)

**Review of Relevant Existing Models and Approaches**

*Full Models*

Generic systems or full models (models, data collection instruments, and instructional documentation) to capture the benefits to an enterprise of implementing occupational safety and health interventions are limited in number. The following examples are the most widely used models or methods found in the literature. The elements used in these
models provide candidate key program elements for inclusion in a strategy to fully derive
the value of the IH profession.

Model A: The Productivity Assessment Tool

One of the earliest specific models, the Productivity Assessment Tool, is an economic
analysis tool designed to show that productivity and profit for an enterprise are
compatible with safe and healthful working conditions for its employees. This tool,
developed by Maurice Oxenburg, provides a framework to calculate the costs and
benefits of occupational safety and health interventions. This computerized strategy
emphasizes the costs and benefits that the employees bring to the organization. More
specifically, the tool evaluates the potential costs and benefits of specific changes in
working conditions by exploring the changes in the employee productivity. By far,
ergonomic interventions have constituted the largest share of the analyses using the
Productivity Assessment Tool.

Oxenburg has provided detailed instructions and explanations for the following four parts
of the tool:

Table II-8. The Four Parts of the Productivity Assessment Tool.

<table>
<thead>
<tr>
<th>Data concerning the employees</th>
<th>Initial Case Enter data on:</th>
<th>Test Case(s) Enter expected changes for:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data concerning the workplace</td>
<td>Recruitment</td>
<td>Recruitments</td>
</tr>
<tr>
<td></td>
<td>insurance</td>
<td>energy use</td>
</tr>
<tr>
<td></td>
<td>reduction in waste</td>
<td>other overheads</td>
</tr>
<tr>
<td></td>
<td>productive hours</td>
<td>productive hours</td>
</tr>
<tr>
<td></td>
<td>wage costs</td>
<td>wage costs</td>
</tr>
<tr>
<td></td>
<td>overtime</td>
<td>overtime</td>
</tr>
<tr>
<td></td>
<td>reduced productivity</td>
<td>reduced productivity</td>
</tr>
<tr>
<td></td>
<td>costs, or estimated costs, for the intervention</td>
<td></td>
</tr>
<tr>
<td>The reports</td>
<td>Cost-benefit analysis calculations and reports of the workplace and the employees</td>
<td></td>
</tr>
</tbody>
</table>

Source: Oxenburg, Marlow and Oxenburgh, 2004, Figure 4.1

This model measures productivity changes against what is termed the “ideal state.”
Simply put, this is the production level if all resources were operating at full capacity.
The model captures the annual hours paid by the employer, minus the hours that the
employee is not actively producing. Losses of productive time include absences from
injury, illness, training, vacation and holidays, or other absences such as maternity or
military service leave. The hours of productive time are multiplied by the wage of the
worker. This is not an individual wage for each employee, but rather an average for an
employee category or occupation. The most robust of the available programs will allow
up to five employee categories to be considered. Any additional wages, such as
overtime, are added to finalize the annual productive value.

The program offers a series of screens to capture the necessary data for calculations.
Data concerning the employee uses three screens with sections for the initial and test
cases. The first screen in this series asks for data on the number of employees, hours per week, and the absences associated with the individual employee or employee group.

Employer costs, administrative, managerial, and supervisory costs, are captured in the next screen. Employee supervisory costs include first line, middle, and senior level management. Administrative costs include the following categories:

- Administrative costs
- Pension fund
- Workers’ compensation premiums
- Taxes on wages paid by the employer
- Personnel/human resources department
- Medical and direct injury costs
- Head office allocation.

The final screen for capturing employee data requests a percentage of reduced productivity. This information is also used to identify the need for intervening or modifying the working conditions for the group of employees being examined. The following table is the overview of that data screen.

Table II-9. The Productivity Assessment Tool: Potential Interventions for Reduced Productivity.

<table>
<thead>
<tr>
<th>Reason for reduced productivity</th>
<th>Typical interventions that would lead from these factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low skill</td>
<td>Improve or increase training</td>
</tr>
<tr>
<td>Hand tools</td>
<td>Replace or improve hand tools with a design better suited to the work tasks</td>
</tr>
<tr>
<td>Capital</td>
<td>Improve maintenance, replace machinery.</td>
</tr>
<tr>
<td>Other</td>
<td>Factors not covered above</td>
</tr>
</tbody>
</table>

Source: Oxenburg, Marlow and Oxenburgh, 2004, Figure 4.4

Capturing workplace data is completed through two screens. The first collects information on allocated costs. This section considers overhead costs that should be proportioned to the employee group being analyzed. This can include workers’ compensation premiums, organizational administrative functions, equipment running costs, and maintenance costs. Warning is provided not to double count the costs already entered under the employee data. The second screen captures recruitment costs, which are associated with hiring new employees and the skill loss when employees leave.

Intervention costs are entered in the allocated costs screens under the test case column and include capital costs, management, and consultant time and costs. The effects of the intervention are entered on the remaining screens as appropriate. Following these entries, three report screens are generated: Workplace Summary, Employee Summary, and Workplace Report.

In summary, this model presents estimated productivity changes and health effects of a proposed action and produces savings per year and payback periods for use in creating other financial metrics.
Model B: The Net Cost Strategy

In 2005, Lahiri et al. published an accounting framework to derive the net costs for employers of implementing workplace interventions. Although the strategy can be applied to multiple interventions, the initial application of the strategy was focused on low back pain interventions. They defined net costs as the “investment cost for intervention equipment plus labor costs involved in implementing the intervention minus avoidable health care costs of illness and injury, productivity losses due to loss in efficiency and absenteeism, and other benefits related to productivity enhancement of all workers subjected to the intervention.” This research team developed both a graphical and mathematical model to demonstrate the worth of an occupational safety and health intervention. Figure II-2 below presents the graphical Net-Cost model.
Figure II-2. A Strategy Overview: Annualized Net Cost of Interventions for Preventing Occupational Low Back Pain (LBP)
The following excerpt (Lahiri, 2005), including explanatory footnotes, presents the specific elements and their definitions which are included in the Net-Cost Model:

Annualized Net Economic Costs Of Safety Interventions For Preventing Occupational Low Back Pain (LBP) = Annualized Additional Direct Investment Costs On Equipment For Interventions + Annual Labor Costs For Implementing The Intervention - Avoided Annual Economic Costs Of LBP - Annual Value Of Increase In Productivity For All Workers Subjected To The Intervention

Avoided Annual Economic Costs Of LBP = Avoided Medical Care Costs + Avoided Reduction In The Value Of Lost Work Time Due To LBP Sick Leave + Avoided Reduction In Productivity Losses Due To LBP When Not On Sick Leave

Annualized Net Economic Costs Of Safety Interventions For Preventing Occupational LBP Per Worker = Annualized Net Economic Costs Of Safety Interventions / (Total Workforce In The Organization)

Direct Costs on Equipment

Total Additional Direct Investment Cost Of Each Equipment = Total Direct Current Costs Of Investments In Each New Equipment After Intervention - Total Direct Costs Of Investments In Each Similar Type Of Equipment Prior To Intervention 1

Total Direct Current Costs Of Investments In Each New Equipment = Price Of Each New Equipment In 2002 Dollars * Quantity Of Each New Equipment

Total Direct Prior Costs Of Investments In Each Similar Type Of Equipment = Price Of Each Prior Equipment In 2002 Dollars * Quantity Of Each Equipment Prior To Intervention

Capital Recovery Factor For Each Equipment = Market Rate Of Interest + Rate Of Depreciation For Each Equipment 2


Total Annualized Additional Direct Investment Cost Of All Equipment = Sum Of Annualized Additional Direct Investment Cost Of All Equipments Used the Interventions

---

1 For example, we should take the price of an ergonomically approved adjustable chair and deduct from that the price of a traditional chair that was used originally. It is this additional cost of an adjustable chair that should be treated as equipment cost.

2 The depreciation for each type of equipment has been calculated by taking into account the life of the equipment and their salvage value by using the depreciation formula explained in the text.
Annualized Additional Direct Costs Of Interventions = Total Annualized Additional Direct Investment Cost Of All Equipment + Annual Labor Costs For Intervention Implementation³

Avoided Medical Care Costs

Total Annual Avoided Medical Care Costs = [Medical Care Costs Before Intervention (Acute Cases) - Medical Care Costs After Intervention (Acute Cases)] + [Medical Care Costs Before Intervention (Chronic Cases) - Medical Care Costs After Intervention (Chronic Cases)]

Medical Care Costs Before Intervention (Acute) = Average Medical Care Cost Per Acute Case In 2002 Dollars * Number Of Employees Suffering From Acute LBP Before Intervention⁴

Medical Care Costs Before Intervention (Chronic) = Average Medical Care Cost Per Chronic Case In 2002 Dollars * Number Of Employees Suffering From Chronic LBP Before Intervention

Medical Care Costs After Intervention (Acute) = Medical Care Cost Per Case In 2002 Dollars * Number Of Employees Suffering From Acute LBP After Intervention

Medical Care Costs After Intervention (Chronic) = Medical Care Cost Per Case In 2002 * Number Of Employees Suffering From Chronic LBP After Intervention

Loss In Productivity Due To LBP

Avoided Productivity Losses Due To LBP = Reduction In The Value Of Lost Work Time Due To LBP + Reduction In Efficiency Due To LBP When Not On Leave

Reduction In The Value Of Lost Work Time Due To LBP = Value Of Lost Work Time Due To Sick Leave Before Intervention - Value Of Lost Work Time Due To Sick Leave After Intervention

Value Of Lost Work Time Due To Sick Leave Before Intervention = Number Of Missed Days Of Work Before Intervention * Wage Per Hour In $ Paid During Sick Leave Due To Back Pain * Number Of Work Hours Per Day

Value Of Lost Work Time Due To Sick Leave After Intervention = Average Number Of Missed Days Of Work After Intervention * Wage Per Hour In $ Paid During Sick Leave Due To Back Pain * Number Of Work Hours Per Day

Reduction In Efficiency Due To LBP When Not On Leave = Total Number Of Employees Suffering From LBP Without Leave * Number Of Days Of Duration Of LBP For Each Employee * Coefficient Of Loss In Productivity

Coefficient Of Loss In Productivity In Dollars = Average Wage Rate – Adjusted Average Wage Rate Taking Into Account The Percentage Loss In Productivity

³ For example this cost included all costs involved in training workers to use ergonomically designed equipments.

⁴ Medical care cost per case in 2002 dollars obtained from Spine Vol. (median value)
**Enhancement In Productivity**

Annual Value Of Increase In Productivity Due To The Intervention = Number Of Workers Subjected To Intervention * Number Of Work Hours Per Week * Number Of Weeks Worked Per Year * Coefficient Of Productivity Gain Due To The Intervention

Coefficient Of Gain In Productivity In Dollars = Adjusted Average Wage Rate Taking Into Account The Percentage Gain In Productivity - Average Wage Rate

This complex model includes two general elements: the impact on changes in health and productivity. Despite the complexity of the model, the elements critical to normative evaluations that demonstrate qualitative benefits have not been included. Furthermore, there is no method of determining the effectiveness of the intervention in reducing or eliminating the identified hazard or risk.

**Model C: CERSSO Tool Kit**

The Regional Center for Occupational Safety and Health (CERSSO) developed the Tool Kit as an “instrument designed for you to test it within the confidentiality of your business and which through a simple manner can help show you how much money you are losing by not investing in the Safety and Health of your employees” (Biddle, 2004). This six-step model begins with defining the magnitude of the problem and ends with an analysis of the costs and benefits of an occupational safety and health investment. The following table presents a summary of the steps to complete the CERSSO strategy entitled “Self Evaluation of the Cost-Benefit on the Investments in Occupational Safety and Health in the Textile Factory.”

**Table II-10. The Six Steps of the CERSSO Strategy.**

<table>
<thead>
<tr>
<th>PARTS</th>
<th>MEASURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.1.a. Description of Operations</td>
</tr>
<tr>
<td></td>
<td>Prioritizing the causes (risks and demands)</td>
</tr>
<tr>
<td></td>
<td>Description of the male and female employees in their operations</td>
</tr>
<tr>
<td></td>
<td>Description of the CAUSES (risks and demands) by their Operations.</td>
</tr>
<tr>
<td></td>
<td>Description of EFFECTS and their relationship with the causes</td>
</tr>
<tr>
<td>2</td>
<td>Appraisal of the probability of the effect</td>
</tr>
<tr>
<td></td>
<td>2.2 Appraisal of the severity of the effect</td>
</tr>
<tr>
<td></td>
<td>2.3. Appraisal of the risk</td>
</tr>
<tr>
<td>3</td>
<td>Definition of the preventive measures to be undertaken.</td>
</tr>
</tbody>
</table>

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This strategy presents a more complete picture of the safety and health process by identifying and evaluating the working conditions and risk factors followed by a risk appraisal. The strategy provides the following list of risk categories (a-d) and demands categories (e-h) for reference:

a. Work environment:
   Physical: Noise, vibrations, heat, humidity, radiation, light

b. Work objects:
   Organic or inorganic dust
   Synthetic chemical substances
   Live biological (plants, microorganisms, rodents, insects) or derivatives (animals, vegetables)

c. Risks the work environments present by themselves:
   Tools
   Machines
   Work center facilities

d. Risks derived from the environmental conditions:
   Natural environment

e. Physical, static and postural loads

f. Uncomfortable and/or forced positions
g. Dynamic physical activity:

Physical exertion
Movement
Repetitive movements

h. Organization and division of work:

Long shifts
Remuneration system: by time, by work done
Type of job agreement
Work content

The risk appraisal determines the probability, consequences, and severity of the health effect. The model also employs the Johansen and Johren “Ball Model” to graph the impact of the intervention.

The evaluation of the effects of the prevention effort are determined by assigning costs to the specific interventions, which can be implemented at the source of the hazard, for use by the worker, or as medical measures. The prevention effort can include multiple interventions or what is more commonly thought of as a program. Although the link between risk and the effect of the intervention is discussed, there is no accompanying discussion of the value of the risk reduction. Table II-11 illustrates the method for calculation of prevention effort costs.

The model next provides a procedure to estimate the “costs caused by the effects” by looking at direct and indirect cost categories. These categories capture the costs associated with an incident and represent avoided costs that result from implementing the prevention efforts. The direct costs consist primarily of medical expenses and the indirect costs are associated with lost productivity. The forms and examples did not provide a mechanism to capture any additional benefits resulting from the prevention activity. However, it is worth noting that the model documentation presented the following list of benefits that follow implementing an occupational safety and health program.

For employers:

- Reduction of operating costs
- Increase of productivity levels
- Creation of a great public image
- Satisfaction in the deliveries
- Development of a niche in the market with recurrent clients
- Reduction of incident costs
- Reduction of absences due to illnesses

<table>
<thead>
<tr>
<th>Intervention Carried Out</th>
<th>Cost Unit for Estimate</th>
<th>Measurement Unit</th>
<th>Number of Units per Operation</th>
<th>Units’ Requirements</th>
<th>Monthly Unit Cost in US $</th>
<th>Estimate of Total Monthly Costs Per Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting System Maintenance</td>
<td>Technical or Professional</td>
<td>Lamps</td>
<td>Number of Lamps</td>
<td>Maintenance every six months</td>
<td>(0.50 each lamp)/6 months</td>
<td>D * F</td>
</tr>
<tr>
<td>FOR INDIVIDUAL WORKERS</td>
<td></td>
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</tr>
<tr>
<td>Ocular Protectors when applying laser (to block radiation)</td>
<td>Eyeglasses</td>
<td>Eyeglasses</td>
<td>Number of Workers</td>
<td>Change every 6 months</td>
<td>3.62 /6 months</td>
<td>D * F</td>
</tr>
<tr>
<td>MEDICAL MEASURES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Employment Test</td>
<td>Professional Consultation</td>
<td>Number of Workers</td>
<td>A Consultation</td>
<td>30.00 / 6 months</td>
<td>D * F</td>
<td>D * F</td>
</tr>
<tr>
<td>Worker</td>
<td>Hours/resources Normal Hourly production</td>
<td>Number of Workers</td>
<td>An hour</td>
<td>(Salary of each workers) + (cost of drop in the normal hourly production of each worker)/12 months</td>
<td>D * F</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

For employees:

- Increased motivation at work, which causes a feeling of safety which is in turn reflected by a greater productivity
- Real possibilities of improving to their income.

Model D: Return on Health, Safety and Environmental Investments (ROHSEI)

Fifteen member companies of the ORC Occupational Safety and Health Group—ALCOA, Allied Signal, ARCO, Bayer, Bristol-Myers Squibb, Colgate-Palmolive, Dow, Duke Power, Eli Lilly, IBM, Johnson & Johnson, Monsanto, M&M Mars, Rhone-
Poulenc Rorer, and Schering-Plough—formed a task force to work with ORC Worldwide and Arthur Andersen to tailor traditional financial investment analysis approaches and apply them to achieve a better understanding of the business impacts of health, safety and environmental investments.

The *Return on Health, Safety and Environmental Investments* (ROHSEI) process and tools were developed through interviews with financial, safety and health, and operational professionals; data collected from more than a dozen companies; focus group sessions; and field testing. Since 1997, ROHSEI has demonstrated that analytical tools currently used and accepted by the financial community can be applied to safety and health investments when appropriate data elements underpin the analysis. The process allows users to evaluate safety and health investments on a cost/performance basis. Building the business case employs the following four steps:

1. Understand the opportunity or challenge
2. Identify and explore alternative solutions
3. Gather data and conduct analysis
4. Make a recommendation.

The following figure highlights the relationship among these four steps and the business case development. It also introduces four tools to support the process: a *Business Case Summary*, a *Causal Loop Diagram*, a *Direct Impact Module*, and a *Decision Matrix*.

The following Table demonstrates how the tools are aligned with the process steps. For example, the *Causal Loop Diagram* is a tool designed to brainstorm alternative solutions, explore relationships, and identify other impacts of the project. It helps develop a comprehensive view of how each of the alternative investments impacts business performance, considering both direct and hidden benefits and costs.
Table II-12. The Alignment of ROHSEI Processes and Tools.

<table>
<thead>
<tr>
<th>ROHSEI Process</th>
<th>ROHSEI Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Understand the Opportunity or Challenge</td>
<td>Business Case Summary</td>
</tr>
<tr>
<td>2. Identify Alternative Solutions</td>
<td>Causal Loop Diagram</td>
</tr>
<tr>
<td>3. Gather Data And Conduct Analysis</td>
<td>Causal Loop Diagram, Direct Impact Module, Decision Matrix</td>
</tr>
<tr>
<td>4. Recommend a Solution Based on the Analysis</td>
<td>Business Case Summary</td>
</tr>
</tbody>
</table>

For each alternative, the ROHSEI process facilitates consideration of direct benefits and costs as well as hidden impacts, such as worker productivity. The following is a comprehensive list of the parameters and their definitions that are embedded in the program.

Operational Personnel Time

For program costs and benefits, consider the cost of operational personnel time spent on:

Safety and Health (S&H) program activities including maintenance, meetings, housekeeping, recordkeeping, and program implementation
S&H training
Conducting strategic analysis and planning driven by S&H issues. Examples of this include developing S&H objectives and performance measures, evaluating S&H concerns for capital purchases, and managing S&H issues.
Reviewing and modifying production methods or product designs to incorporate S&H concerns
Performing required or voluntary S&H inspections and audits such as compliance activities, audits, reporting, monitoring and testing, emergency response training, and drills.
Monitoring S&H performance.

For incident costs, consider the cost of operational personnel time spent on:

Reporting and investigating incidents, creating alternative solutions, and implementing solutions such as making process or equipment changes
Coordinating with S&H professionals
Working as replacements for injured workers (e.g., overtime)
Responding to emergencies.
Additional monitoring and testing of employees’ health and safety associated with incidents.
Safety and Health Personnel Time

*For project costs and benefits, consider the cost of S&H personnel time spent on:*

- Developing and implementing S&H programs and processes including auditing programs, S&H-related housekeeping, recordkeeping, an emergency response plan, and S&H reporting.
- S&H training.
- Conducting strategic analysis and planning driven by S&H issues, such as developing S&H objectives and performance measures, evaluating S&H concerns for capital purchases, and managing S&H issues. Also would include time spent communicating safety performance programs with regulators and community.
- Reviewing and modifying production methods or product designs to incorporate S&H concerns.
- Performing required and voluntary S&H inspections and audits, such as compliance activities, audits, reporting, monitoring and testing, emergency response training, and drills.
- Monitoring and testing the health and safety of employees (include only S&H employees’ time here; operational personnel time should be included in Operational Personnel Time). This includes the cost of S&H personnel time relating to air sampling activities and related laboratory analyses, noise monitoring, medical screenings, and worker physical examinations, etc. The cost of the equipment required is not included here, but rather in S&H Equipment.

*For incident cost, consider cost of S&H personnel time spent on:*

- Reporting and investigating incidents, creating alternative solutions, and implementing solutions.
- Responding to emergencies.
- Additional monitoring and testing of employees’ safety and health associated with incidents.

Design and Engineering Personnel Time

*For program costs and benefits, consider:*

- The time that design and engineering personnel dedicate to safety and health-related functions.

Other Personnel Time

Customize this parameter to the analysis. If, for example, the project will either require or obviate significant management resources, consider defining the parameter as "Management Personnel Time." See the definitions for Safety and Health Personnel Time, Operational Personnel Time, and Design and Engineering Personnel Time as guidance in writing the definition.
Vendors, Consultants and Contract Labor

For program costs and benefits, consider the cost of vendors, consultants, and contract labor spent on:

- Conducting ongoing S&H activities (e.g. training, strategy development, etc.), S&H inspection and audits, employee S&H monitoring and testing, and ensuring compliance.

For incident costs, consider the cost of vendors, consultants, and contract labor spent on:

- Tasks associated with H&S incidents, including incident investigations.
- Tasks required in the process of replacing injured employees. This includes the cost of using a third party to train replacement labor (contracted and internal) required to replace employees impacted by a S&H incident.

Health and Safety Supplies

This parameter should include only expense items. Any S&H supplies that will be capitalized should be included in the Capital parameter.
* H&S supply purchases such as Personal Protection Equipment (PPE).

Operations and Maintenance

For project costs and benefits, consider operating and maintenance cost related to S&H, including:

- Maintenance supplies (do not double count with the S&H Supplies parameter)
- Utility costs of running S&H-related equipment (e.g., ventilation equipment, monitors) and operations equipment associated with S&H-related projects.
- Ongoing preventative maintenance done for S&H purposes—beyond that which is done to optimize production processes. This should not include personnel time already captured in other parameters.

For incident cost, consider:

- Additional equipment maintenance or repair due to an S&H incident
- Cost of repairing equipment after an S&H-related problem or failure.

Production Downtime

The ROHSEI strategy provides flexibility with regard to use of the Production Downtime parameter.

Method 1. This parameter can be used to capture all costs associated with Production Downtime which may include overtime, replacement labor, equipment repair, lost material, lost profits, the cost of purchasing capacity to meet customer demands, as well as other relevant items.

Method 2. Alternatively, this parameter can be used to capture only those types of costs that cannot reasonably be captured in other parameters. In other words, overtime associated with Production Downtime would be captured in the appropriate Personnel Time parameters and external replacement labor would be included in the Vendors, Consultants, and Contractor Labor parameter. With
Method 2, The Production Downtime parameter may include lost material, lost profits, the cost of purchasing capacity to meet customer demands, as well as other relevant items.

The activities included as Production Downtime depend upon which method you pursue. In either case, you may use the builds the strategy provides for you by clicking on the "Go to Build" button.

For program cost and benefits, consider:
Net loss of revenues (after accounting for averted costs) or loss of raw materials from scheduled production downtime to perform preventive maintenance on equipment due to S&H concerns.

For incident costs, consider:
Net loss of revenues (after accounting for averted costs) or loss of raw materials from unscheduled production downtime due to an S&H incident.

Business Interruption Insurance

For program benefits, consider:
If a S&H program is expected to decrease the cost of business interruption insurance premiums, the expected cost savings should be entered as program benefit. Premium reductions may be due to reduced risk of having incidents or reduced expected severity of incidents. The rationale for this parameter should be documented in the “Scenario Assumptions” worksheet.

For program costs, consider:
If a S&H program is expected to increase the cost of business interruption insurance premiums, the expected additional cost should be entered as a program cost. The rationale for this parameter should be documented in the “Scenario Assumptions” worksheet.

For incident costs, consider:
The increased cost of business interruption insurance premiums due to S&H incidents.

Legal Fees, Workers Comp & Settlements

For program benefits, consider:
If an S&H program is expected to decrease legal fees, claims management processing, and worker’s compensation costs (including legal settlements) paid out due to S&H claims, the expected cost savings should be entered as program benefit.

For program costs, consider:
If a S&H program is expected to increase legal fees, claims management processing, and/or workers’ compensation costs (including legal settlements) paid out due to S&H claims, the expected cost increase should be entered as program cost.
For incident costs, consider:

- Internal and external fees related to S&H incidents. This would also include the cost of maintaining claims management processors.
- Cost of workers' compensation (including legal settlements) paid out due to H&S claims.

Medical Costs and Insurance

For project costs and benefits, consider the cost of:

- Insurance premiums or set-asides for insuring against injuries and fatalities.
- Medical staff and facilities to perform medical screenings and other employee H&S monitoring and testing. This should not include S&H or operations personnel time.

For incident costs, consider:

- Premium increases and medical costs related to incidents.

Property Damage Insurance

For program benefits, consider:

- If a S&H program is expected to decrease the cost of property damage insurance premiums the expected cost savings should be entered as program benefit. Premium reductions may be due to reduced risk of having incidents or reduced expected severity of incidents. The rationale for this parameter should be documented in the “Scenario Assumptions” worksheet.

For program costs, consider:

- If an H&S program is expected to increase the cost of property damage insurance premiums, the expected additional cost should be entered as a program cost. The rationale for this parameter should be documented in the “Scenario Assumptions” worksheet.

For incident costs, consider:

- The cost of property damage insurance premiums due to H&S incidents.

Loss of Raw Materials, Product

For incident costs, consider:

- The cost of reproducing product and repurchasing materials that were wasted due to an S&H incident.

Fines and Penalties

For program benefits, consider:

- If a S&H program is expected to decrease fines and penalties, the resulting cost savings should be entered as program benefit.
For program costs, consider:
   If an H&S program is expected to increase fines and penalties, the resulting additional cost should be entered as program cost.

For incident costs, consider:
   The amount of fines and penalties paid to regulators as a result of S&H incidents and non-compliance events.

Emergency Response

Any capitalized equipment costs for emergency response should be included in the Capital parameter and not in the Emergency Response parameter. The ROHSEI strategy provides flexibility with regard to use of the Emergency Response parameter.

Method 1. This parameter can be used to capture all costs associated with Emergency Response--except capitalized items--which may include dedicated personnel, vendor expenses, and supplies.

Method 2. Alternatively, this parameter can be used to capture only those types of costs that cannot reasonably be captured in other parameters such as Vendors, Consultants, and Contractor Labor and S&H Supplies, and Operations & Maintenance.

The activities that Emergency Response should include depend upon the method pursued. In either case, the builds the strategy provides may be used by clicking on the "Go to Build" button when data are entered using the incident approach.

For project costs and benefits, consider:
   Maintaining emergency response resources and emergency response equipment and supplies.
   Cost of inspecting and repairing emergency response equipment.

For incident costs, consider:
   Using emergency response equipment (don't double count these costs with those in the personnel time parameters).
   Emergency response staff time. If operations and S&H personnel costs are included here, don't double count these costs with those in the personnel time parameters.
   Using vendors, consultants, and contracted labor for emergency response can be entered here, but don't double count with Vendor, Consultants, and Contract Labor parameter.

Material Recovery

For program benefits, consider:
   If a S&H program leads to an increase in material recovery, the resulting cost savings should be entered as program benefit.

For program costs, consider:
   If a S&H program leads to a decrease in material recovery, the resulting additional cost should be entered as a program cost.
Material Substitution

For program benefits, consider:
If an S&H program leads to material substitution, the cost of the material being substituted should be entered as a program benefit. Include the expected change in the material’s price over time.

For program costs, consider:
The cost of the new material should be entered as a program cost. Include the expected change in the material’s price over time.

Waste Disposal

For program benefits, consider:
If an S&H program leads to a reduction in waste disposal expenses when compared to the current situation, the resulting cost savings should be entered as program benefit.

For program costs, consider:
If an S&H program leads to an increase in waste disposal expenses when compared to the current situation, the resulting additional cost should be entered as a program cost.

Water Treatment

For program benefits, consider:
If an S&H program leads to a reduction in water treatment expenses when compared to the current situation, the resulting cost savings should be entered as a program benefit.

For program costs, consider:
If an S&H program leads to an increase in water treatment expenses when compared to the current situation, the resulting additional cost should be entered as a program cost.
The depreciation worksheet for capital investments associated with water treatment equipment should be used, so that the tax implications may be calculated properly.

Remediation Project Spending

For program benefits, consider:
If an S&H program leads to a reduction in remediation expenses when compared to the current situation, the resulting cost savings should be entered as program benefit.
For program costs, consider:

If an H&S program leads to an increased remediation expenses compared to the current situation, the resulting additional cost should be entered as a program cost.

Emissions Controls

For program benefits, consider:

If a S&H program leads to a reduction in emissions control expenses when compared to the current situation, the resulting cost savings should be entered as program benefit.

For program costs, consider:

If a S&H program leads to an increase in emissions control expenses when compared to the current situation, the resulting additional cost should be entered as a program cost.

The organization's financial professionals should be consulted regarding proper treatment (expense vs. capitalize) of emissions control equipment.

Energy

For program benefits, consider:

If a S&H program leads to a decrease in energy consumption or rates, the resulting cost savings should be entered as program benefit.

For program costs, consider:

If an S&H program leads to an increase in energy consumption or rates, the resulting additional cost should be entered as a program cost.

Using the ROHSEI strategy as prescribed, sufficient data will be collected to determine the following financial measures:

Net Present Value (NPV)
Internal Rate of Return (IRR)
Return on Investment (ROI)
Discounted Payback (DPP)
Production Equivalent Units
Impact on Unit Cost
Percent Impact on Unit Cost.

Conclusions

Only a limited number of value models have been used in the occupational safety and health field. The models presented here were selected because of their availability and transparency of the derivation of value. Each strategy included measures of the cost of occupational injury or illness and some measure of productivity loss. The extent to which they capture benefits, tangible and intangible, varies substantially in both quantitative and qualitative measures. Finally, while the models may have presented the hazard and a risk measure, they did not include a measure of the reduction of the risk in the workplace.
Literature Review

In addition to examining the full models presented in the previous section, it is also important to examine individual evaluation studies. Published individual studies of the economic or financial effectiveness of occupational safety and health interventions are few in number. In 2007, Emile Tompa from the Institute of Work & Health published a systematic review of such interventions that included an economic analysis. There were nearly 13,000 intervention evaluations published that met the initial criteria for inclusion. However, only 72 were evaluated in depth as it was determined that only these could answer their research question “What is the credible evidence that incremental investment in health and safety is worth undertaking?” The interventions spanned multiple industry sectors and included six kinds of interventions. These six included programs designed for:

- Ergonomic and other musculoskeletal disorder (MSD)
- Occupational disease
- Disability management
- Multiple interventions
- Health promotion
- Violence in the workplace.

Ergonomic and other MSD interventions were the most commonly evaluated among these studies. The following tables provide information on evaluations focusing on categories under the auspices of the industrial hygienist functions.

Table II-13. Literature Review Results: Monetary Consequences and Costs of S&H Interventions.

<table>
<thead>
<tr>
<th>Study Reference</th>
<th>Monetary Consequences</th>
<th>Monetary Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Productivity Changes</td>
<td>Insurance &amp; Health-Care Savings</td>
</tr>
<tr>
<td>Amick (2003); DeRango (2003)</td>
<td>Yes</td>
<td>~</td>
</tr>
<tr>
<td>Lahiri (2005)</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Rempel (2006)</td>
<td>~</td>
<td>Yes</td>
</tr>
<tr>
<td>Bradley (1996)</td>
<td>~</td>
<td>Yes</td>
</tr>
<tr>
<td>Kemmlert (1996)</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Tadano (1990)</td>
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<tr>
<td>Wahl (1998)</td>
<td>~</td>
<td>Yes</td>
</tr>
<tr>
<td>Lewis (2002)</td>
<td>~</td>
<td>Yes</td>
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<tr>
<td>Landstad (2002)</td>
<td>Yes</td>
<td>~</td>
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<tr>
<td>Landers (2004)</td>
<td>~</td>
<td>~</td>
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<tr>
<td>Feuerstein</td>
<td>Yes</td>
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<td>Yes</td>
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<tr>
<td>Study Reference</td>
<td>Details of Analysis</td>
<td>Outcome(s) used in economic Analysis</td>
</tr>
<tr>
<td>-----------------</td>
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<td>--------------------------------------</td>
</tr>
<tr>
<td>Amick (2003); DeRango (2003)</td>
<td>Cost Benefit Analysis</td>
<td>Value of productivity per year</td>
</tr>
<tr>
<td>Lahiri (2005)</td>
<td>Cost Benefit Analysis</td>
<td>1. Medical care costs associated with low-back pain cases; 2. value of lost work time due to sick leave (productivity); 3. Productivity loss due to low-back pain at work; 4. productivity enhancements due to intervention</td>
</tr>
<tr>
<td>Rempel (2006)</td>
<td>Cost Benefit Analysis</td>
<td>Workers' compensation expenses</td>
</tr>
<tr>
<td>Bradley (1996)</td>
<td>Partial Economic Analysis</td>
<td>Workers' compensation expenses associated with</td>
</tr>
<tr>
<td>Study Reference</td>
<td>Details of Analysis</td>
<td>Outcome(s) used in economic Analysis</td>
</tr>
<tr>
<td>-----------------</td>
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<td>--------------------------------------</td>
</tr>
<tr>
<td>Kemmlert (1996)</td>
<td>Cost Benefit Analysis</td>
<td>Payback period was 3 months</td>
</tr>
<tr>
<td>Tadano (1990)</td>
<td>Cost Benefit Analysis</td>
<td>Net savings were $53,053.34 over 6 months</td>
</tr>
<tr>
<td>Wahl (1998)</td>
<td>Cost Benefit Analysis</td>
<td>Benefit cost ratio was 17.8</td>
</tr>
<tr>
<td>Lewis (2002)</td>
<td>Cost savings with reduction of VDT-related WC claim</td>
<td>Average workers' compensation expense per claim decreased from $15,141 to $1,553</td>
</tr>
<tr>
<td>Landstad (2002)</td>
<td>Payback period</td>
<td>Payback period was 46.4</td>
</tr>
<tr>
<td>Landers (2004)</td>
<td>Cost Benefit Analysis</td>
<td>Benefit cost ratio was 8.86</td>
</tr>
<tr>
<td>Feuerstein (2000)</td>
<td>Partial Economic Analysis</td>
<td>Time-loss expenses were reduced by 64%</td>
</tr>
<tr>
<td>Study Reference</td>
<td>Details of Analysis</td>
<td>Outcome(s) used in economic Analysis</td>
</tr>
<tr>
<td>-----------------</td>
<td>---------------------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>Laufer (1994)</td>
<td>Cost-effectiveness analysis</td>
<td>Number of needle stick injuries</td>
</tr>
<tr>
<td>Yassi (1995)</td>
<td>Cost-benefit analysis</td>
<td>Expenses associated with treatment of needle stick injuries</td>
</tr>
<tr>
<td>Orenstein (1995)</td>
<td>Cost-effectiveness analysis</td>
<td>Cases of needle stick injuries</td>
</tr>
<tr>
<td>Korniewicz (2005)</td>
<td>Before-after comparison of costs and consequences</td>
<td>Workers' compensation expenses</td>
</tr>
<tr>
<td>Cameron (1997)</td>
<td>Cost-minimizing analysis</td>
<td>Consequences not considered since cost minimization study</td>
</tr>
<tr>
<td>Collins (2004)</td>
<td>Cost-benefit analysis</td>
<td>Workers' compensation expenses (medical and indemnity payments) related to resident handling injuries</td>
</tr>
<tr>
<td>Chhokar (2005)</td>
<td>Cost-benefit analysis</td>
<td>Workers' compensation expenses</td>
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<td>Details of Analysis</td>
<td>Outcome(s) used in economic Analysis</td>
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<tr>
<td>-----------------</td>
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<tr>
<td>Gundewall (1993)</td>
<td>Cost-benefit analysis</td>
<td>Value of absence days due to lower back pain</td>
</tr>
<tr>
<td>Evanoff (1999)</td>
<td>Cost-consequences analysis</td>
<td>Workers' compensation expenses</td>
</tr>
<tr>
<td>Engst (2005)</td>
<td>Cost-benefit analysis</td>
<td>Workers' compensation expenses</td>
</tr>
<tr>
<td>Li (2004)</td>
<td>Before-after comparison of annual workers' compensation expenses per FTE</td>
<td>Workers' compensation expenses</td>
</tr>
<tr>
<td>Ore (2003)</td>
<td>Cost-benefit analysis</td>
<td>Average (per claim) workers' compensation expenses</td>
</tr>
<tr>
<td>Brophy (2001)</td>
<td>Cost-benefit analysis</td>
<td>Total expenses of low-back injury (consisting of medical, compensation, and replacement wages expenses)</td>
</tr>
<tr>
<td>Charney (1991)</td>
<td>Cost-benefit analysis</td>
<td>Workers' compensation expenses</td>
</tr>
<tr>
<td>Study Reference</td>
<td>Details of Analysis</td>
<td>Outcome(s) used in economic Analysis</td>
</tr>
<tr>
<td>-----------------</td>
<td>---------------------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>Guthrie (2004)</td>
<td>Before-after trends analysis of work-related injury expenses</td>
<td>Replacement and salary expenses for staff unable to work due to a work-related injury</td>
</tr>
<tr>
<td>Linton (1992)</td>
<td>Cost-benefit analysis</td>
<td>Wage value of sick days due to pain</td>
</tr>
<tr>
<td>Yassi (1995)</td>
<td>Comparison of workers' compensation expenses between intervention and control groups</td>
<td>Workers' compensation expenses</td>
</tr>
<tr>
<td>Bernacki (2003)</td>
<td>Before-after trends analysis of workers' compensation expenses</td>
<td>Workers' compensation expenses</td>
</tr>
<tr>
<td>Study Reference</td>
<td>Details of Analysis</td>
<td>Outcome(s) used in economic Analysis</td>
</tr>
<tr>
<td>-----------------</td>
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<td>--------------------------------------</td>
</tr>
<tr>
<td>Tracz (1992)</td>
<td>Post only analysis of savings obtained with wage costs associated with intervention</td>
<td>Wage value of time off work due to back injury claim</td>
</tr>
<tr>
<td>Davis (2004)</td>
<td>Before-after comparison (of workers' compensation expenses) of each of three years before the intervention with one year of the intervention</td>
<td>Workers' compensation expenses</td>
</tr>
<tr>
<td>Collins (1990)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caulfield (1996)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Martin (1995)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hocking (1991)</td>
<td>Net present value (NPV)</td>
<td>Manual and non-manual handling accidents expenses</td>
</tr>
<tr>
<td>Study Reference</td>
<td>Details of Analysis</td>
<td>Outcome(s) used in economic Analysis</td>
</tr>
<tr>
<td>-----------------</td>
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<td>--------------------------------------</td>
</tr>
<tr>
<td>Lanoie (1996)</td>
<td>Net present value (NPV)</td>
<td>Direct and indirect medical expenses associated with back-related injuries</td>
</tr>
<tr>
<td>Lahiri (2005)</td>
<td>Cost-benefit analysis</td>
<td>1) Medical care associated with low-back pain cases; 2)value of lost work time due to sick leave (productivity); 3)productivity loss due to low-back pain at work; 4)productivity enhancements due to intervention</td>
</tr>
<tr>
<td>Lahiri (2005)</td>
<td>Cost-benefit analysis</td>
<td>1) Medical care associated with low-back pain cases; 2)value of lost work time due to sick leave (productivity); 3)productivity loss due to low-back pain at work; 4)productivity enhancements due to intervention</td>
</tr>
<tr>
<td>Abrahamsson (2000)</td>
<td>Cost-benefit analysis</td>
<td>Value of absenteeism, production quality, and production efficiency</td>
</tr>
<tr>
<td>Study Reference</td>
<td>Details of Analysis</td>
<td>Outcome(s) used in economic Analysis</td>
</tr>
<tr>
<td>-----------------</td>
<td>---------------------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td>Halpern (1997)</td>
<td>Before-after comparison of workers' comp expenses</td>
<td>Workers' comp expenses</td>
</tr>
<tr>
<td>Kemmlert (1996)</td>
<td>Cost-benefit analysis</td>
<td>Value of sick leave/absenteeism (and associated losses and expenses averted)</td>
</tr>
<tr>
<td>Kemmlert (1996)</td>
<td>Cost-benefit analysis</td>
<td>Value of sick leave/absenteeism (and associated losses and expenses averted)</td>
</tr>
<tr>
<td>Moore (1998)</td>
<td>Percentage change in workers' compensation expenses from baseline year</td>
<td>Workers' compensation expenses</td>
</tr>
<tr>
<td>Study Reference</td>
<td>Details of Analysis</td>
<td>Outcome(s) used in economic Analysis</td>
</tr>
<tr>
<td>-----------------</td>
<td>---------------------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td>Lemstra (2003)</td>
<td>Comparison of workers' compensation expenses per 100,000 hours worked (for all time-loss claims, upper extremity and back time-loss claims before/after and between two companies with diff. interventions)</td>
<td>Workers' compensation claim expenses (per 100,000 hours worked)</td>
</tr>
<tr>
<td>Bunn (2001)</td>
<td>Trends analysis of workers' compensation short- and long-term disability expenses</td>
<td>Workers' compensation expenses per worker, long- and short-term disability expenses per worker</td>
</tr>
<tr>
<td>Study Reference</td>
<td>Details of Analysis</td>
<td>Outcome(s) used in economic Analysis</td>
</tr>
<tr>
<td>-----------------</td>
<td>---------------------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>Maniscalco (1999)</td>
<td>Cost-benefit analysis</td>
<td>Expenses associated with lost days and back injuries (medical expenses and productivity losses)</td>
</tr>
<tr>
<td>Shi (1993)</td>
<td>Cost-benefit analysis</td>
<td>Lost-time and medical expenses</td>
</tr>
<tr>
<td>Hilyer (1990)</td>
<td>Partial economic analysis, comparison of post-intervention workers' compensation expenses for the intervention and control groups</td>
<td>Workers' compensation lost-time, medical, and total expenses</td>
</tr>
<tr>
<td>Brown (1992)</td>
<td>Partial economic analysis</td>
<td>Lost-time, medical, and total expenses</td>
</tr>
<tr>
<td>Banco (1997)</td>
<td>Cost-benefit analysis</td>
<td>Wage value of time-loss from work due to injury, workers' compensation (indemnity and medical care expenses)</td>
</tr>
<tr>
<td>Study Reference</td>
<td>Details of Analysis</td>
<td>Outcome(s) used in economic Analysis</td>
</tr>
<tr>
<td>-----------------</td>
<td>---------------------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>Daltroy (1997)</td>
<td>Total expenses per back injury claim compared using the Wilcoxon rank-sum statistic</td>
<td>Back injury expenses</td>
</tr>
<tr>
<td>Versloot (1992)</td>
<td>Net present value (NPV)</td>
<td>Absenteeism expenses</td>
</tr>
<tr>
<td>Tuchin (1998)</td>
<td>Costs and consequences considered separately</td>
<td>Absenteeism expenses</td>
</tr>
</tbody>
</table>

**Conclusions**

The majority of these studies use workers’ compensation expenses as the only cost measure. Workers’ compensation expenses generally include the value of changes in health outcomes and the value of wages paid for lost time, or a combination of those two. The additional measures used are few and are primarily associated with lost work time, such as absenteeism.

**Additional Efforts**

In 2003, the *American College of Occupational and Environmental Medicine* (ACOEM) administered a questionnaire to nine Corporate Medical Directors, six of whom responded that their organizations were more focused on the values of health and
productivity management than cost. The survey also showed that the two of the three areas with the largest performance gaps were: disease management and absentee management. Both areas are at the forefront of IH responsibilities.

Other key findings included:

a. Chief Financial Officers’ (CFOs) concerns over healthcare go well beyond out-of-pocket costs. CFOs recognize a strong link between health, productivity, and corporate financial success.

b. This strategic understanding does not help CFOs crystallize workforce challenges. They emphasize such traditional issues as attracting, retaining and training employees, rather than keeping them healthy, productive, and at work.

c. CFOs have difficulty linking health benefits to the corporate bottom line. Their program success measures—costs, employee satisfaction and employee retention—are different from financial performance success measures (cash flow and growth in revenue and earnings).

d. CFOs value workforce productivity as a means to financial success. CFOs would invest to change benefits management if a modest productivity gain would result.

e. With the right information—keyed to the way they think—CFOs can be expected to understand and support the need for further investment in effective health-related benefits delivery.

Although the focus of the survey was on health benefit programs, the extension of these lessons to IH activities is an easy leap.

The *National Business Group on Health*, an Institution dedicated to finding solutions to health care issues, presented the following four model types that can be used to determine the return on investments in health care by an employer.

*Population-based models*—defined as a “strategy for financial outcomes expected from a program that is based on demographic assumptions for an employer’s own population and savings or outcome results observed in published study results”

*Assumption-based models*—defined as a “strategy for financial outcomes that measures an employer’s own experience, typically both before and after a program/initiative is implemented, and links outcomes to the programs.”

*Quasi-experimental*—defined as a “strategy for financial outcomes that more directly links an employer’s own experience, typically both before and after a program/initiative is implemented, by developing a retrospective control group approach—matching a group of like members who participate to those who don’t participate in the program.”

*Randomized controlled trial studies*—defined as a “model for financial outcomes that is carefully constructed on a scientific basis to identify changes in outcomes, both before and after a program/initiative is implemented, by building a control group for whom the program/initiative is available and comparing results to a similarly-matched group for whom the program/initiative is not available.”
The following figure is a slide from a Towers Perrins HR Services presentation in June 2006 that provides a visual description of these return-on-investment methods.

Figure II-4. Four Strategies for Determining Return on Investment (ROI).

In addition to providing the four study types, the group determined that it is important to provide a “multi-dimensional measurement approach.” They purported that the outcomes should include changes in health outcomes, changes in employee satisfaction, changes in productivity, and changes in business performance engagement. However, they did not provide methods to derive the value for each of the suggested parameters.

The Washington Business Group on Health and Integrated Benefits Institute’s work on EMPAQ (Employer Measures of Productivity, Absence, and Quality) began in 2001 when the Council on Employee Health and Productivity (CEHP) was formed. They specifically wished to address three questions posed by many Chief Executive and Chief Financial Officers. Those questions were:

How is the firm doing relative to its operating plan?
How is the firm doing relative to its competition?
Who is considered best in class?

To answer those questions, the group developed quality and performance measures to determine the effect of health-related lost time programs. The measures of concern were cost, productivity outcomes, and administrative effectiveness. The group provided the following metrics descriptions to determine that effectiveness.
Table II-15. Metrics for Determining Effectiveness of Health-related Lost Time Programs.

<table>
<thead>
<tr>
<th>Category</th>
<th>Metric Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cost</strong></td>
<td></td>
</tr>
<tr>
<td>Benefit cost per employee</td>
<td></td>
</tr>
<tr>
<td>Average benefit cost per claim</td>
<td></td>
</tr>
<tr>
<td>Benefit cost as a % of payroll</td>
<td></td>
</tr>
<tr>
<td><strong>Outcome/Productivity</strong></td>
<td></td>
</tr>
<tr>
<td>Lost workdays per 100 employees</td>
<td></td>
</tr>
<tr>
<td>Average claim duration</td>
<td></td>
</tr>
<tr>
<td>Claim frequency</td>
<td></td>
</tr>
<tr>
<td>Employee satisfaction</td>
<td></td>
</tr>
<tr>
<td>Return to work effectiveness</td>
<td></td>
</tr>
<tr>
<td>Family medical leave measures</td>
<td></td>
</tr>
<tr>
<td><strong>Administrative Effectiveness</strong></td>
<td></td>
</tr>
<tr>
<td>Timeliness of claim payment</td>
<td></td>
</tr>
<tr>
<td>Accuracy of payment of benefits</td>
<td></td>
</tr>
<tr>
<td>Timely decision of claim acceptance</td>
<td></td>
</tr>
<tr>
<td>Accuracy of decision of claim acceptance</td>
<td></td>
</tr>
</tbody>
</table>

From these metrics, the group developed standardized reports for presentation of the information, which could be used to drive successful program evaluation and achieve the optimal goal of measuring and enhancing organizational health. The full-cost program includes what the program costs the employer, where that money goes in terms of claims, how much lost time has been incurred (a surrogate measure of productivity), and additional program-specific results that may be of importance to the enterprise.

**Selecting Strategy Elements**

As discussed in an earlier section, the value of the IH profession is determined by what the organization gets from their work; it is this impact or the effect they have on the organization. It was concluded that by reducing risk (the principle function of the Industrial Hygiene profession), the health of the employees will change; the business process will change and the work of the industrial hygienist will change and constitute the intermediate outcomes of an IH action.

These three categories of change have been incorporated in the Qualitative and Quantitative Approaches of the IH Value Strategy. In the Qualitative Approach they were used to identify steps in the thinking process that translated risk reduction to business value. That effort is done by using a sequential cause and effect analysis to translate reductions in risk to changes in health, the IH risk reduction process, or the business process. The business impacts resulting from those changes are then isolated and a value case is then made for those impacts.

The comprehensive list of potential changes that comprise the first layer of intermediate outcomes is provided below. These changes were drawn from existing strategies and the reviewed literature.
Table II-16. Potential Changes Resulting from IH Work.

<table>
<thead>
<tr>
<th>Changes in:</th>
<th>Health Outcomes:</th>
<th>IH Management</th>
<th>Business Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality</td>
<td>Duties</td>
<td>Process Design</td>
<td></td>
</tr>
<tr>
<td>Injuries</td>
<td>Responsibilities</td>
<td>Equipment Needs</td>
<td></td>
</tr>
<tr>
<td>Illnesses</td>
<td>Administrative Load</td>
<td>Management Efforts</td>
<td></td>
</tr>
<tr>
<td>Disabilities</td>
<td>Recording Keeping</td>
<td>Work Flow</td>
<td></td>
</tr>
<tr>
<td>Quality of Life</td>
<td>Hierarchy of Controls</td>
<td>Materials</td>
<td></td>
</tr>
<tr>
<td>Functionality</td>
<td>Monitoring</td>
<td>Pace</td>
<td></td>
</tr>
<tr>
<td>Mental Health</td>
<td>Medical Surveillance</td>
<td>Inputs</td>
<td></td>
</tr>
</tbody>
</table>

The list of changes needed to be followed by a similar list of the impacts that these changes produced that correlate with the identified intermediate outcomes—health outcomes, IH management functions, and business processes. A number of analytical tools or methods could have been used to determine the elements that are impacted by the IH activities, including process maps, cause-and-effect matrices, and causal loop diagrams.

The list of business impacts follows:

Table II-17. Potential Business Impacts Resulting from IH Work.

<table>
<thead>
<tr>
<th>Related Impacts:</th>
<th>Health Outcomes:</th>
<th>IH Management</th>
<th>Business Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absenteeism</td>
<td>Staff Levels</td>
<td>Process Steps</td>
<td></td>
</tr>
<tr>
<td>Presenteeism</td>
<td>PPE Costs</td>
<td>Raw Materials</td>
<td></td>
</tr>
<tr>
<td>Insurance Premiums</td>
<td>Training</td>
<td>Cycle Time</td>
<td></td>
</tr>
<tr>
<td>Labor Turnover</td>
<td>Equipment Maint./Calibration</td>
<td>Staff</td>
<td></td>
</tr>
<tr>
<td>Medical Removal</td>
<td>Operational Downtime</td>
<td>Equipment</td>
<td></td>
</tr>
<tr>
<td>Job Transfers</td>
<td>Process Interruptions</td>
<td>Maintenance</td>
<td></td>
</tr>
<tr>
<td>Training/re-training</td>
<td>Other</td>
<td>Waste</td>
<td></td>
</tr>
<tr>
<td>Worker Productivity</td>
<td>Environmental Emissions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td>Compliance Pressures</td>
<td></td>
</tr>
</tbody>
</table>

These items are discussed in more detail in the section describing Phase III.

In the *Quantitative Approach*, the categories are used to organize the user’s thinking on key business and financial measures.

Risk reduction is related to the same three categories—changes in health status, the IH risk reduction process, and other business processes. Health changes focus on the impacts of risk reduction on fatalities, days away from work injuries and illnesses, restricted work injuries and illnesses, and medical treatment injuries and illnesses. To gauge the impact of the risk reduction on the IH risk management process and other business processes requires a detailed assessment of the impact on capital costs, operating costs, costs related to managing the IH risk, and costs of IH incidents related to the hazard. There are detailed parameters for each one of these subject categories—selected as a subset from the ROHSEI categories listed above and supplemented with parameters identified in some of the site visits conducted as part of this study.
The Quantitative Approach has less sequential steps than the Qualitative Approach, but examines each step in significantly more detail.

Identifying Key Interrelationships Between Strategy Elements

The individual strategy elements have maximum value when they are interrelated. To identify key interrelationships the team chose to employ the ROHSEI Causal Loop Diagram, which has the ability to identify complex processes and root causes. Through a chain of causes of effects, the tool provides a visual demonstration of how variable $A$ affects variable $B$ and how variable $B$ affects variable $C$. When all causes, effects, and interactions have been explored, the behavior of the entire system (in this case the IH function) will be revealed. William Rushing, publishing for Six Sigma, has touted the strength of this tool by stating “only through this thorough analysis can an organization make changes that are lasting.” The following diagram demonstrates a first level of analysis indicating the relationship between ill employees and productivity.

Figure II-5. First Level of Analysis Example.

This subsequent analysis demonstrates more clearly the relationship between employees available to work, productivity, and the impact of a positive change in productivity.
The second reason that the team selected the *Causal Loop Diagram* tool was that it is an integral part of the ROHSEI system, which has been used for well over 10 years. Additionally, it demonstrates the relationship of reduction in risk to health outcomes and business process intermediate outcomes. The following diagrams are included in the documentation for the ROHSEI strategy and are presented below for illustrative purposes.

---

**Figure II-7. Causal Loop Diagrams from ROHSEI Documentation.**
Combining information from case studies using ROHSEI tool, published works, and brainstorming sessions of the team, Table II-18 presents elements that represent the impacts from change that were incorporated into the IH Value Strategy.

Table II-18. IH Value Strategy Impact Elements.

<table>
<thead>
<tr>
<th>Impact from Changes in:</th>
<th>Health Outcomes:</th>
<th>IH Management</th>
<th>Business Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days away from work</td>
<td>Staffing needs</td>
<td>Number of steps needed</td>
<td></td>
</tr>
<tr>
<td>Absenteeism</td>
<td>PPE needed</td>
<td>Qty and type of materials</td>
<td></td>
</tr>
<tr>
<td>Presenteeism</td>
<td>Training needs</td>
<td>Time allotments</td>
<td></td>
</tr>
<tr>
<td>Medical care</td>
<td>Equipment maintenance</td>
<td>Waste</td>
<td></td>
</tr>
<tr>
<td>Restricted work activity</td>
<td>Calibration activities</td>
<td>Compliance pressures</td>
<td></td>
</tr>
<tr>
<td>Labor turnover</td>
<td>Downtime</td>
<td>Environmental emissions</td>
<td></td>
</tr>
<tr>
<td>Employee physical capacity</td>
<td>Time allocation</td>
<td>Staffing requirements</td>
<td></td>
</tr>
<tr>
<td>Medical removal</td>
<td>Process interruption</td>
<td>Equipment needs</td>
<td></td>
</tr>
<tr>
<td>Job transfer</td>
<td>Maintenance</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As was demonstrated in the Causal Loop Diagram discussion, these elements are interrelated—one element may affect another element within the initial intermediate outcome or among intermediate outcomes. However, while there are some universal relationships, each IH activity or program should be evaluated to best demonstrate the extent of the resulting impact.

The next step explores the methods to identify appropriate sub-elements to demonstrate the value of these elements which represent the impact on the intermediate outcomes that resulted from changes in those outcomes that occurred because of changes in risk.

**Experience Using Selected Strategy Elements**

*Past Experience Using Selected Strategy Elements in ROHSEI*

Over the last 10 years, the ROHESI strategy has demonstrated the validity of collecting and valuing sub-elements resulting from the impact of specific occupational safety and health activities and programs to the business enterprise. Data collected using the ROHSEI sub-elements, parameters as defined in that strategy, can be aggregated to show the impact on intermediate outcomes (employee health, IH risk management process, and business process) that are defined in this Strategy.

Summaries of ROHSEI analyses were developed to identify what sub-elements were considered and the relationship of those sub-elements to the elements (or intermediate outcomes) named within this Strategy. These case studies were revisited following the creation of the Quantitative Approach to validate the ability of the user to access the data, to understand the elements, and to calculate the costs and benefits as well as determining if the major cost categories (operating and capital) were included. The following section presents pertinent information on a case study that used ROHSEI to determine the cost-benefit of an occupational safety and health intervention. The remainder of cases that were examined can be found in Appendix A.
Process Hazard Assessment Case Study Validation

The ROHSEI case study determined the value of a process hazard analysis for a representative chemical process step. The PSM program incorporated 4 elements with defined costs for each step. The value of a PSM program includes the financial benefits associated with reduction of risk as defined by reduced probabilities and consequences of process safety incidents.

The company used “Design and Engineering Personnel Time” to calculate what would be considered the total operating costs within the data element “design and engineering” in the quantitative tool. This resulted in an improved business process and reduced the level of risk by engineering out the problems.

The company used “Emergency Response” to calculate what would be considered the total operating costs within the data element “total other costs related to the current method of managing the risk” in the quantitative tool. This resulted in no significant increased cost associated with PSM directly, but reduced the level of risk.

The company used “Operational Personnel Time” to calculate what would be considered the total operating costs within the data element “Operation Personnel Time” in the quantitative tool.

The company used “Operations and Maintenance” to calculate what would be considered the total operating costs within the data elements “operating costs” and “maintenance costs” in the quantitative tool. The incorporation of these elements allowed for an improved business process and a reduction of risk.

The Process Hazard Assessment case study indicated:
1. The user had access to the data
2. The user understood the elements
3. The user understood the elements over time
4. Different users understood the elements
5. The user was able to calculate the value.

Figure II-8. Sample Case Study.

Experience from the Current Study

In addition to examining cases collected over the past 10 years of ROHSEI application, current cases from project site visits were used to test the strategy and were analyzed to determine the viability of the elements found in this strategy.

The questions asked were:

1. Is the element the right one for the strategy?
2. Are its key sub elements listed correctly?
3. Is it correctly named? Will the users know what it means?
4. Is it adequately defined, so that consistent answers will be given by different users?
5. Will it be consistently interpreted over time?
6. Do companies have the data to support it?
7. Will the industrial hygienist be able to access the data?

In general, the results indicate that collecting and valuing the elements for this strategy are viable. A sample site visit validation follows; additional case results are presented in Appendix E.

Table II-19. AIHA Value of the Profession Data Element Analysis Matrix.

<table>
<thead>
<tr>
<th>QUANTITATIVE ELEMENT</th>
<th>DATA ELEMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>CASE STUDY: COMPANY A</td>
<td>Health</td>
</tr>
<tr>
<td>Data Element Criterion</td>
<td>Total Cost of Occupational Illnesses</td>
</tr>
<tr>
<td>1. Is the element the right one for the model?</td>
<td>Company A incorporated the element by number/type and costs</td>
</tr>
<tr>
<td>2. Are its key sub-elements listed correctly?</td>
<td>Company A considered recordable hearing shifts and cost per case.</td>
</tr>
<tr>
<td>3. Is it correctly named?</td>
<td>Will the users know what it means?</td>
</tr>
<tr>
<td>4. Is it adequately defined, so that consistent answers will be given by different users?</td>
<td>Company A provided fact based (consistent) data of cost and number/type of illness.</td>
</tr>
<tr>
<td>5. Will it be consistently interpreted over time?</td>
<td>Company A considered the elements to be sufficient for collecting data on occupational illness costs necessary for retrospective and prospective analysis.</td>
</tr>
</tbody>
</table>

Data: Table II-19. AIHA Value of the Profession Data Element Analysis Matrix.
Conclusions

The Contract and Statement of Work called for a list of model elements reviewed, model elements selected for further analysis, correlations found among model elements, sensitivities found among model elements and between model elements and intermediate business results and impacts, and methods used to assess specific IH program/activity contribution to intermediate outcomes and business results.

The purpose was to assess various program elements’ suitability for inclusion in the Qualitative and Quantitative Approaches.

In Phase II, additional work was needed to identify and fully assess potential model components. Therefore, in addition to the contract requirements, the team defined key concepts and terms, conducted a comprehensive literature search, and explored existing models that were thought relevant to making the value case for industrial hygiene. Once model elements were identified, the interrelationships between model components were examined using the ROHSEI Causal Loop Diagram that has been in use for more than a decade. Finally, the potential model elements were evaluated by examining cases in the ROHSEI User’s Library. (Again, these reflect more than a decade of experience.) In addition, strategy elements were assessed based upon the site visits and case studies undertaken as part of this study.

After reviewing the literature, analyzing existing models, and re-examining its own experience in demonstrating value, the study team concluded that the best way to capture the value that IH brings to the business was to start with the IH risk reduction process and track its impact on employee health, the industrial hygiene risk management process, and the business process in general. Impacts can be quantifiable in terms of reduced cost or even added revenue, or they may be more general contributions to key business objectives.

Model sub-elements and parameters can be imported from the existing ROHSEI tool and from other models and sources. These elements are listed in the Phase III, IV, and V sections of this report. They clearly passed the first tests applied to them in completing this phase of the work concerning reasonableness, clarity of definition, and accuracy and consistency of result. However, they will no doubt be improved over time through continued use and re-evaluation.
Phase III: Develop and Test the Qualitative Approach of the IH Value Strategy

Introduction

The purpose of Phase III of the Value of the Industrial Hygiene Profession study was to develop and test a qualitative method for determining and illustrating the business value of IH programs and practices.

The Contract Statement of Work called for:

1. A description of the Qualitative Approach and its components;
2. Assessment of potential representative values and/or processes to obtain them;
3. Recommended approaches, protocols, processes, and tools and processes to gather qualitative and quantitative value using quality-based systems and methods, such as those associated with the Malcolm Baldrige National Quality Program and ISO-14001 systems;
4. A “template” of an education training module;
5. A summary of the results of applying some of the tools to some actual situations.

The study team has met all of the deliverables in this phase of the work. Items 1, 2, and 4 are addressed in this section of the report; item 5 is included in the summary of site visits and case studies that are included in the Phase II and Phase V sections of this report; and item 3 is addressed in the final section of the report entitled Management Practices Demonstrating the Value of the Profession.

Background

As with the ROHSEI tool described earlier, most of the experience in making the business case for S&H has been with detailed, quantitative approaches (see also the Phase II and IV sections of this report) that are designed to capture the benefit of specific interventions. However, investigation and research from site visits indicates that another approach is needed. In addition to intervention-based approaches, industrial hygienists need to be able to make the value case for entire programs at the facility, business unit, and enterprise levels. Furthermore, they need to be able to make them when quantification is difficult and detailed auditable financial information is inaccessible.

Consequently, the study team developed different methods that are incorporated into the Qualitative Approach outlined in this phase of the report. In addition, a Quantitative Approach for capturing value is discussed in Phase IV of the report. Both methodologies are tied together by an Overarching IH Value Strategy that provides a common platform for an integrated value analysis. The Overarching Strategy is addressed in Phase V. To differentiate between the two approaches:

The Quantitative Approach allows the user to calculate generally accepted financial business metrics, such as return on investment (ROI) and net present value (NPV) by capturing detailed business data on the industrial hygiene impact on cost avoidance, cost savings, revenue generation, and other strategic aspects of the business.
The *Qualitative Approach* allows the user to *estimate* the value of the industrial hygiene contribution by tracking its impact on health, risk, and the business process through an *evidentiary cause and effect chain* that relates intermediate outcomes to the value streams listed above and concurrently *isolates* confounding factors that could have produced the same effects.

When attempting to demonstrate the value of an IH program or activity, a quantitative analysis with generally accepted financial business metrics is usually preferable to a qualitative approach that facilitates an (albeit) credible estimation analysis. By developing a detailed business case for an IH program or activity the IH function is more likely to be viewed favorably as a business partner and the value of IH activities and programs can more readily be compared with competing financial opportunities within an organization.

However, given the fact that many IH benefits are largely intangible, IH programs and activities sometimes defy the accurate and comprehensive quantification of financial benefits. While these benefits are less tangible, the IH should still try to capture them. That can be done by using the *Qualitative Approach*. For example, reduction of the potential for long-term occupational illness or of non-work-related ill-health effects usually defies assigning a reliable financial value. However IH activities or programs that impact them are important, and their contributions should not be lost.

Both quantitative and qualitative assessments can be used to fully capture the benefits to the organization of the IH program or activity. The more general *Qualitative Approach* to capturing value may be preferred or needed in the following situations:

1. Projects that impart a sense of urgency with respect to employee health, business process, or regulatory compliance generally do not require a strict financial analysis as a prerequisite.
2. Higher levels of documented, visible risk are less likely to require detailed financial justification.
3. Projects that address existing documented risk to employees, facilities, the product or the community are less likely to require strict financial support.
4. If the cost data that defines a project benefit is not readily available a project cannot be justified on a strict financial basis.
5. Less leadership scrutiny generally requires less financial justification.
7. Using a qualitative approach is prudent when dealing with general organizational benefits that management recognizes, but that are difficult to assign actual value, such as: improved employee morale, enhanced community image, achieving reputation objectives, etc.

Finally, using the *Qualitative Approach* is advisable when one doesn’t have the time or the resources to conduct a detailed quantitative analysis.

The material that follows represents a new way of thinking in which the business value of IH activities and programs is captured by understanding their interconnectivity with and impact on key business objectives. Their impact on cost, revenue generation, and other business objectives that may or may not lend themselves to dollar quantification, is isolated.
Problem Statement

How does one demonstrate the value of IH activities and programs to the business when the costs and benefits are not directly quantifiable? In these scenarios the benefits may be intangible, there may not be a direct relationship between the industrial hygiene investment and the value generated, and/or there may not be sufficient time or data or necessary resources for a quantitative analysis.

Study Approach

The study approach was to identify potential links between risk-based IH programs and activities, key intermediate outcomes, and the business, and to capture benefits generated by those links in terms of cost reduction and avoidance, new revenue generation, and/or furthering other key business objectives. This is accomplished through a comprehensive strategy that borrows from the legal profession and other disciplines and utilizes deductive reasoning to establish the likelihood of those connections. The strategy also isolates and assesses the impacts of other factors that could have produced the same result.

Utilizing existing ROHSEI tools and materials:

The team started the analysis by reviewing the existing Return on Health, Safety, and Environmental Investment (ROHSEI) tool. ROHSEI was developed to assist users in understanding, measuring, demonstrating, and communicating how S&H investments impact S&H and business performance. ROHSEI helps answer the following questions:

Which investments should we make?
When should we make the investment; this year or next?
How do safety and health investments compare to operational investments?
To which projects should we allocate our human resources?
Which S&H investments create the greatest value for the organization and how can this value be demonstrated?

ROHSEI measures direct benefits and costs and assesses the likely effect of hidden benefits and costs. The ROHSEI process involves four steps:

Understand the safety and health opportunity or challenge
Identify alternative solutions
Gather data and conduct analysis
Recommend a solution based on the analysis.

The Causal Loop Diagram: ROHSEI analyses are done through applying a Causal Loop Diagram, a Direct Impact Module, and a Decision Matrix. The group started by assessing the applicability of the Causal Loop Diagram to IH programs and activities.

Users identify alternative solutions to a S&H problem and then calculate the business impact of the alternatives. Potential impacts from the Causal Loop Diagram are identified and assessed in terms of whether or not they can be quantified. Quantifiable impacts are included in a Direct Impact Module; impacts that can not be quantified are addressed in the ROHSEI Decision Matrix.

The ROHSEI Causal Loop Diagram identifies probable links between safety and health outcomes and key business measures. The diagram takes into account key safety- and
health-related results, such as medical expenses, workers’ compensation costs, fines and penalties, lost employee time, replacement time, investigation expense, non-productive investigation time, etc., and relates them to productivity, product quality, and customer satisfaction.

*The Decision Matrix:* The Decision Matrix is a structured tool that captures subjective assessments of the impact of the different proposed S&H interventions on productivity, product quality, and customer satisfaction. Sub elements are available for each category. For example, to assess the overall effect on productivity users could be asked to provide their view (H-, L-, =, L+, H+) of the intervention impact on:

- Task automation and productivity
- Process changes and productivity
- Non-production activities and productivity
- Task interruptions and productivity
- Physical strain and productivity
- Mental stress and productivity
- Overtime and productivity
- Task repetition and productivity
- Training and productivity
- Worker skill level and productivity
- Temporary workers and productivity
- Perception of management commitment and productivity
- Employee involvement and productivity
- Outsourcing and productivity
- Other factors and productivity.

The *Causal Loop Diagram* and *Decision Matrix* ended up being fundamental building blocks for the *Qualitative Approach* included in this report. However, the ROHSEI tool was not sufficient to accomplish all of the study objectives, and as a result had to be modified and expanded.

*Capturing Value:* The ROHSEI program captures value by collecting data on two aspects of benefit: the impact of IH programs and activities on costs related to health incidents and on operating costs related to IH risk management. In addition, the program captures the impact on costs of implementing an IH program or activity. ROHSEI then calculates the overall benefit and produces financial metrics that describe how it relates to company performance.

*Leveraging concepts from other disciplines:*

The Law

The ROHSEI strategy was expanded using concepts borrowed from other disciplines. The objective was to enable industrial hygienists to identify the impact of their activities (interventions) and programs on risk, and then track the effects of those risk reductions on the business, by making a compelling case that the impacts were in fact driven by industrial hygiene.

One of the disciplines leveraged by the team was law. Legal cases are won and lost by the evidence offered at trial and by the application of the law to the facts of a particular case. The law of evidence governs the use of testimony (oral or written statements) and physical exhibits and documentary material in criminal and civil trials. Evidentiary rules
determine what is admissible and what is not. In a sense, making the value case is analogous to making a case in a legal proceeding.

When the evidence is direct, the case is easier to argue and more likely to prevail. When the evidence is not direct, the proponents try to prove their assertions through circumstantial evidence. Circumstantial evidence is evidence of an indirect nature; it is the use of one or more facts to prove the existence of another fact; proof of a chain of facts and circumstances indicating a conclusion—usually that a person is guilty or not guilty. The main fact is deduced from indirect or circumstantial evidence by a process of probable reasoning. For example, the existence of a defendant’s fingerprints or DNA sample at a crime scene is circumstantial evidence that he or she was there. An argument is deductively valid if, whenever all premises are true, the conclusion is also necessarily true.

The team utilized these concepts in creating the Qualitative Approach. The Approach uses deductive reasoning to establish a chain of cause-and-effect analyses that utilizes intermediate outcomes to link the IH-related reductions in risk to business value. Confounding factors (other factors that could have produced the same result) are identified and isolated at each step.

Basically it is a sequential process: IH programs or activities reduce risk; risk reduction results in changes in health, the risk reduction process, and the business process; those changes have impacts on the business; those impacts can be valued.

Continuous Improvement

A recommended approach for conducting cause and effect analysis of relationships between intermediate outcomes and IH-related reductions in risk and business value is to create what is commonly known as a “fishbone diagram.” This is a loosely-structured thought process designed to identify and evaluate the potential causes of an observed effect. (See Figure III-1)

![Figure III-1. Cause and Effect (Fishbone) Diagram.](image-url)
By brainstorming all the possible causes of the observed effect in key areas—such as manpower, machinery, materials, and methods—and looking at the positive and negative contributions of each, a team of IH; supervisory; hourly; and operations, engineering, and management representatives; and others who are affected by the program or activity, can determine the relationship between the IH program or activity and the effect.

Business Objectives Strategy

IH programs are often viewed in terms of their proximate values, such as 1) recognition, evaluation, and control of workplace chemical, physical, and biological agents, and 2) compliance with associated regulatory requirements. These values are real and substantial. However, there often are additional, more key business values associated with IH programs. These additional values to the enterprise must be recognized, understood, communicated, nurtured, and leveraged. The IH professional needs to “step back” and look beyond “tactical” IH programs. Specifically, the professional needs to establish how IH contributes to the greater mission of the enterprise. By clarifying and communicating value-added linkages, the IH effort becomes recognized throughout the organization as an effective, integrated asset, important for overall business success.

The Business Objectives Strategy was developed to assist health professionals in identifying how IH efforts deliver or can deliver strategic business values. The strategy correlates six categories of major objectives that an organization may consider important functions of their business. Business objective categories are often interrelated. Specific strategic business values vary by company and reflect the industry, customer base, product lines, market spaces and a host of other factors. Each of these factors must be carefully evaluated to determine how IH plays or could play a role. Nevertheless, there are some generic key business objectives common to most all organizations.

The following diagram (Figure III-2) illustrates a universal framework for capturing key business objectives and relating IH programs and activities to them.
Key business objectives within most successful companies include managing a robust Human Resources system, maintaining a strong Operational function, enhancing company Reputation, continually improving the Product/Service, and exploring potential for Growth (Figure III-4). These values are interdependent. For example, an Operational improvement that results in an enhanced Product/Service will often also lead to improved Human Resources and Reputation.

Health professionals must view their IH programs in the context of these overall business objectives. How does industrial hygiene help deliver or support these business objectives and deliver overall value? Which IH programs have the biggest influence or potential to contribute to the overall success of the enterprise? How can IH efforts best be aligned with strategic business objectives? By carefully considering each of the key business objectives, the health professional can determine the contributions of IH programs. This in turn helps senior business leadership gain a full appreciation for the value of industrial hygiene to the organization.

Approach Description

The Qualitative Approach that follows represents a trade-off between the simplicity needed to be “user friendly” and the detail needed for credibility. (See Figure III-3). Need for detail varies by user, by the subject of the value study, and by the target audience for the information. The approach is constructed to provide the maximum amount of information with minimum difficulty. Materials are relatively straightforward and easy to navigate. Users have “options” for entering the approach. They only need use the steps and elements that are relevant for their particular study. Furthermore they can substitute their own existing applications and approaches whenever possible.

The Qualitative Approach is part of a larger, more comprehensive Overarching IH Value Strategy that captures the ORC Value Proposition. The eight-step Overarching IH Value Strategy provides a common architecture for the analysis. Steps 1 - 4 involve a structured approach to understanding IH risks and key business objectives—key steps for identifying IH value opportunities. Risk reduction resulting from the subject IH activity or program is also captured. For steps 5, 6, and 7 the user then has the option of capturing value through a Qualitative Approach, a Quantitative Approach, or some combination of the two. The last step of the Strategy ties the value assessments together in a common presentation framework that can be modified to best meet the needs and expectations of the target audience.

Although the architecture for the qualitative and quantitative steps are the same, the approach to capturing value is very different. The Qualitative Approach uses Likert scale-like measures where value is sometimes estimated from non-financial data such as expert opinions or prior experience.

After capturing the IH risk reduction, the first step of the Qualitative Approach is to identify changes that are likely to have resulted from the IH program or activity. The changes may be in health status, in the IH risk management process, or in the business process. Health status changes include factors such as changes in mortality, disabling injuries and illnesses, restricted work activity cases, and the like. Changes in risk management processes include changes in the complexity of IH-related duties and responsibilities, such as risk management responsibilities, recordkeeping, etc. Changes in business process include process design, work flow, material inputs, equipment, etc.
At this stage users should also consider possible confounding factors—things other than the IH program or activity that also could have produced the changes or significantly contributed to them. Those factors should be ruled out, or they should be factored into the assessment by assigning and extracting proportionate values.

The next step in the Qualitative Approach is to consider the impacts that result from the changes. Again, the impacts may be on health status, the IH risk management process, and on the business process. The idea behind capturing the impacts at this point is that the impacts should take the user one step closer to capturing business value. Health-related impacts include absenteeism, presenteeism, insurance premiums, labor turnover, etc. Impacts on the IH risk management process include staffing levels, PPE costs, training, equipment calibration, and the like. Business process impacts include operational process steps, cycle time, maintenance, waste, etc.

Again, once the impacts are identified, users should identify and ferret out the confounding factors—internal and external changes that have affected the business that could have produced similar results. The cause and effect analysis approach can be applied here as well.

The final step in the Qualitative Approach is to capture the value of the impacts that have been identified in the cause-and-effect chain. For each of the three categories (health, the IH risk management process, and the business process), the user should try to capture some value. This is done by quantifying cost savings and cost avoidance, new revenue generation, and other benefits. Cost savings can be in items such as workers’ compensation premiums, health insurance, replacement labor, long and short term disability, administrative costs, materials rework, etc.

Revenue generation should only include new revenue that is created as a result of the “impacts.”

Other benefits include improved productivity, product quality, employee recruiting retention, morale, improved capacity, business strategy, etc.

It is important to note that the Qualitative Approach is not linear. By that we mean that changes in health status that result from an IH activity or program often result in multiple benefits outside of health. They not only result in health-related impacts and health-related value, they may also result in changes to the business process, and in some circumstances may even result in the generation of new revenue. At each step of the Qualitative Analysis the user should consider all three categories of potential value—health, the IH risk management process, and other business processes—when trying to identify key linkages.

This requires some sensitivity. The user should avoid double-counting where it is inappropriate (see the Phase IV section of this report for more explanation). However, some improvements will legitimately result in multiple benefits, and industrial hygienists should take credit for all of their different value contributions. For example, an IH intervention that reduces disabling illnesses may result in less absenteeism and lower workers’ compensation costs. As a result workers’ compensation premiums may decrease and replacement costs may be lowered. Capturing these benefits is clearly an opportunity. If, at the same time, the intervention resulted in improvements in productivity, those benefits should also be captured.
The *Qualitative Approach* is important because it captures downstream effects and links to key business objectives (outlined in Step 8 which is covered in detail in the Phase V section of this report). The value captured by the *Qualitative Approach* can be summarized in quantitative terms, qualitative terms, or a combination of both. A graphic depiction of the *Qualitative Approach* follows on the next page (Figure III-3).

**The Issue of Representative Values**

Making the value case for IH requires that industrial hygienists think differently about what they do and about the business. The *Qualitative Approach* is unique in that it provides industrial hygienists with maximum flexibility—they can use parts of the *Strategy* that work for them and not use others, and they can substitute their own data and processes for components of the *Strategy* architecture.

However, in some situations industrial hygienists trying to make the value case may not have access to all of the data needed. This is clearly the case for some quantitative assessments and it might even be the case for some qualitative assessments. In those situations it would be useful to have some representative or default values from “like companies” in similar industries with similar operations that could be plugged in to the *Strategy* to facilitate a complete analysis.

The study team recognized this from the outset and agreed to examine the data in the ROHSEI Users’ Library and other sources to see if assembling representative data were feasible at this time. The study team concluded is that it is not feasible at this time. Certainly some data could be gleaned from past ROHSEI analyses. But the challenge is whether that data would really be “representative” of anything that would be connected to industrial hygiene. To be useful a default value must be an accurate approximation of what the data would be if users were able to obtain it from within their own operations. There simply aren’t enough data in the ROHSEI Users’ Library to compile those kinds of values. Also, much of the data in the ROHSEI Users’ Library is related to safety investments.

Certainly the topic warrants further study. An examination of possible outside sources indicates that the most fertile ground for these data may be organizations related to health. Possible sources include the cost of treating cases, state workers’ compensation agencies, major rate-setting organizations, workers’ compensation research organizations, medical expenditure surveys, the National Center for Health Statistics, and on-line workers’ compensation calculators, such as one posted by Michigan’s Economic Development Corporation. But evaluating these sources will take a substantial amount of additional work, and there are still the non-health issues that require additional investigation.

Developing representative values may be the next iteration of the value equation. The study team encourages AIHA to develop an AIHA users’ library, and would be glad to continue to work with AIHA to develop representative values where appropriate and to accomplish this purpose.

Here is how the strategy works: (the *Qualitative Approach* is part of a larger strategy that includes risk.)
Figure III-3. The Qualitative Approach.
**Education and Training Template**

ORC has trained hundreds of users on making the value case for S&H over the years; mostly with the ROHSEI application. The ORC experience is that users need clear direction and understanding of the concepts. But even more important, they need experiential learning. Case study analysis often is the best way to familiarize users with the concepts and approaches.

The template which follows (Figure III-4) reflects the ORC experience and serves as an initial attempt at a training program outline. It is only an attempt because to be effective training really needs to be targeted and adjusted to meet the needs of each audience.

<table>
<thead>
<tr>
<th>Qualitative Strategy for Determining IH Value: <em>Training Outline</em></th>
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<td>i. Evidentiary method</td>
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<td>ii. Qualitative Process Map</td>
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<td><strong>II. Identify Changes</strong></td>
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<tr>
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<td><strong>III. Assess Impacts</strong></td>
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<td>a. Qualitative and Quantitative Summary</td>
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<td>b. Presentation Tool</td>
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</table>

Figure III-4. Training Program Outline.
Potential Qualitative Approach Application

The application of the strategy was tested in several ways. The study team conducted several site visits that are summarized in the Phase V section of this report. The purpose of those visits was to capture the value generated by IH by applying the Quantitative Approach, the Qualitative Approach, or both.

The site visits were also used to answer fundamental questions about the questionnaire elements, including:

1. Is the element the right one for the strategy?
2. Are its key sub elements listed correctly?
3. Is it correctly named? Will the users know what it means?
4. Is it adequately defined, so that consistent answers will be given by different users?
5. Will it be consistently interpreted over time?
6. Do companies have the data to support it?
7. Will the IH be able to access the data?

These site visit analyses are summarized in Appendix E of this report.

Furthermore, a retrospective analysis of the strategy was performed by going back to the ROHSEI User’s Library and applying the new concepts from the current Quantitative and Qualitative Approaches to the existing ROHSEI case studies. The concepts worked favorably in those circumstances too. A summaries of these analyses is included in Appendix E of this report.

Conclusion

ORC has trained users on a quantitative approach for capturing the value of S&H for over a decade. While the strategy has received very positive feedback regarding its completeness, it must be acknowledged that there are other quantitative strategies and approaches in the marketplace.

However, this Qualitative Approach appears to represent several “firsts.” It is likely to be the first strategy that is totally focused on industrial hygiene (the Quantitative Approach provided in the Phase IV section of this report also fits within this special category). It is also one of the first strategies for looking at value in a broad context and providing techniques and approaches for capturing value when data are not available to support a quantitative analysis. Finally it appears to be one of the first attempts at a comprehensive, integrated approach to value analysis, where a wide range of benefits are captured by using a mixed bag of approaches—qualitative and quantitative—custom tailored to each individual situation.

The concepts behind the Qualitative Approach are not new. They have been used by ROHSEI users, legal professionals, and others for years. What may be new is the organization of the thought process.

Hopefully this will lead to something that is even more important and groundbreaking: industrial hygienists actually choosing to do the value analysis for their activities and programs and starting to take credit for their very significant contributions to the business
process and business strategy that heretofore have been largely ignored. The real value of the *Qualitative Approach* is that it can be used where detailed costs and benefits are hard to obtain, and where time or resources are inadequate for a quantitative approach.
Phase IV: Develop and Test the Quantitative Approach of the IH Value Strategy

Introduction

The purpose of Phase IV of the Value of the Industrial Hygiene Profession study was to develop and test a quantitative method for determining and illustrating the business value of IH programs and practices.

The overall study is aimed at identifying the ultimate benefits gained through IH programs and/or activities undertaken to mitigate or reduce health risk to the workforce. Both the Quantitative and Qualitative Approaches are designed to enable the industrial hygienist to identify the impact(s) of risk reduction initiated by such activities, determine its value, and present a value proposition for investing in IH to key stakeholders.

The team found that there were several factors involved in deciding which approach, quantitative or qualitative, was appropriate for a given analysis, including the amount of accessible data, the time available in which to perform the analysis, the audience to whom the IH Value Proposition will be addressed, and the type of IH program or activity to be analyzed. As a result, the team concluded that one could use a Quantitative Approach, using concrete data based on experience or educated estimate of future expenditures, or a Qualitative Approach, based on estimating a combination of tangible and intangible value.

Background

Demonstrating value requires tracking change or potential change in the level of health risk and measuring potential improvement. The basic principle for making the IH Value Proposition is that, generally, the difference between the combined costs of operating a manufacturing or service process and managing an existing IH hazard and the costs of operating it following the intervention represent net reduced costs to the enterprise; reduced costs less the costs of the intervention represent cost savings, and the savings plus the other benefits represent the value realized. Simply put:

\[
\text{Pre-intervention costs (A) – Post-intervention costs (C) = Reduced costs (D)}
\]

\[
\text{Reduced costs (D) – Intervention costs (B) = Net Savings (E)}
\]

\[
\text{Net Savings (E) + New Revenue + Other benefits (O) = Value}
\]
This phase of the project, development of the *Quantitative Approach*, started with the assumption that the Return on Health, Safety and Environmental Investment (ROHSEI) value proposition and financial analysis instrument could provide a basis for an expanded framework for cost/benefit data collection and analysis. ROHSEI was developed in 1995 by a task force of 15 Fortune 500 companies that were members of the ORC Worldwide Occupational Safety and Health Group, in conjunction with Arthur Andersen, LLP, the former accounting firm. The companies sponsored the development of a process and supporting tools designed to help health, safety, and environmental (HSE) professionals answer important questions about their programs and activities, such as:

- What HSE investments should we make?
- How do we know we are doing the “right things” in the “right way”
- To which projects should we allocate our resources?
- Which HSE investments create the greatest value to the organization?
- How do we demonstrate the value of our investment decisions?

Financial metrics can help decision makers understand the direct impact to affected budgets and the organization’s bottom line in well-understood terms. ROHSEI incorporates generally accepted accounting principles so as to facilitate communication of the value of HSE investments in terms of key financial metrics such as net present value (NPV), return on investment (ROI), internal rate of return (IRR), discounted payback period (DPP), and others that have proven to be used most frequently by Chief Financial Officers (CFOs). This enables industrial hygienists and other HSE professionals to define the value of IH programs and activities by using common financial metrics where adequate data exist. It also makes it possible for them to link IH programs and activities to the financial objectives of their organizations. ROHSEI has been used successfully to develop a wide variety of HSE business cases, including process safety management, selection of fire protection systems, fleet safety, storm water system design, machine guarding risk assessment, behavior-based safety programs, and disability management programs. With respect to IH, professionals have reported using the ROHSEI process to analyze both IH management and workplace protection business decisions, including issues such as selecting an MSDS tracking system, implementing an
interactive S&H training system, and developing an Internet-based S&H publishing process. Fewer studies are known that examine the value of IH for improving employee health protection, other than those related to ergonomics.

The above cases indicated to the IH value study team that the general ROHSEI process could readily be adapted to address the value of IH in protecting employee health at different levels of detail. Thus, opportunity exists to develop business analyses to demonstrate value of IH programs and activities to business.

It was understood from the beginning of the study that the final Quantitative Approach would be designed to be used both with the ROHSEI software and independently of ROHSEI. Industrial hygienists would have the option to use the Quantitative Approach either by hand, using the equations included with the instructions, or with Excel or other financial management software. It may be possible to calculate simple quantitative analysis without the use of software; however, multiyear projects that have multiple scenarios and parameters and that involve the time value of money will generally require electronic computational capability.

**Problem Statement**

The goals of Phase IV, development of the Quantitative Approach, were to:

1. Identify the elements to be incorporated into the Approach, including elements that are indicators of financial performance and/or program/activity success related to IH program activity and investment.

2. Test the Approach with respect to:
   - usability
   - sensitivity, and
   - the ability and willingness of IH program managers to collect, track, and analyze the required inputs.

3. In addition, the challenge of enabling roll-up of individual IH program elements to represent a complete IH program, as called for in the original proposal and the statement of work (and as illustrated in the chart that follows on the next page), had to be addressed.

**Study Approach**

*Adaptation of ROHSEI*

The team projected that the ROHSEI instrument could serve as the starting point for the Quantitative Approach. From it, the elements of an IH program or activity could be identified, and IH project intervention data collected and analyzed. Customizing the ROHSEI strategy specifically to evaluate IH applications required modification of the existing global parameter definitions to apply uniquely to IH value proposition analysis. The study team created 153 user-defined parameters specific to IH to reflect the range of data that could be collected for value propositions that assess the value of moving the level of employee protection up the IH hierarchy of controls. The parameters were aligned with the steps in the IH Value Equation (Figure IV-2), and a method and tools were developed to collect data for IH interventions at the process, facility, and program levels.
Phase IV

Although the overall ROHSEI process has been used successfully for 10 years it was important to pilot the data collection tool for IH interventions and subsequent entry of data into the ROHSEI software to demonstrate the successful development of a value proposition for IH programs and/or activities. ORC member companies were contacted to determine if value propositions had been developed for successful IH interventions and, if so, could the data be utilized for the study. Although most of the companies contacted agreed to participate, very few had developed value propositions for previous IH programs and/or activities, and none had post-intervention measures as to the value the organization realized from the intervention. The lack of post intervention business outcomes was surprising and will be explored in detail in subsequent phases of the study.

Therefore, in order to confirm that the IH Value Strategy could be used successfully, retrospective analyses of both the costs and the benefits of past IH programs and activities had to be reconstructed. Company study participants were eager to develop these costs and benefits, but had to be guided stepwise through the data collection form. With explanation, the study participants were able to reconstruct and accurately capture costs at all stages of their IH programs and activities.

Based on the data collected during Phase I of the project, which involved assessing the availability of IH and health data within ORC member companies, and a second survey of IH program characteristics, potential participants were contacted and asked to provide IH programs or activities that could serve as examples for testing the Quantitative Approach, as well as sources for lessons learned about how IH can add value to an organization. Twenty-eight companies volunteered.

The first step in creating the strategy was to develop a questionnaire for gathering cost data by adapting cost/benefit parameters contained in the ROHSEI program to IH applications. These parameters are primarily safety program oriented and do not address IH programs and activities specifically. Some also were found among information housed
in the ORC library and other ROHSEI user libraries, and others were added based on the unique characteristics of IH practice.

The initial questionnaire was designed to reflect the before and after approach taken in the IH Value Equation (Figure IV-1), by asking participants first to identify capital costs associated with managing the original IH hazard, and then provide operating costs (expenses) of same. A second section of the questionnaire requested cost information related to the implementation of the program or activity intended to mitigate the hazard, again in terms of capital and operating costs. The third and final section focused on the costs that were expected or had resulted for the same parameters following the implementation. These costs were projected over a three-year period, and the depreciation of capital costs considered as well. The differences between the costs before and costs after IH activity were regarded as cost savings. Cost of implementation of program or activity subtracted from cost savings was regarded as net benefit. A fourth section captured other benefits that had been or were expected to be realized from the IH program or activity.

Company representatives were asked to complete one data collection sheet for each IH program or activity, identified through a telephone interview with an ORC team member as a candidate for the study. In order to provide these data, participants were required to research site records to reconstruct the conditions that existed at the time just preceding the implementation of the IH program or activity under study. ORC team members emphasized that because the quantity and quality of the data would determine the effectiveness of the analysis, participants should make every attempt to obtain information for each data element on the form.

The Strategy is built on the presumption that it is preferable to have an educated guess to estimate the value of a given parameter rather than not to include data. Recognizing that it may not have been feasible to complete all of the data fields, and that not all may have applied to each case, the team requested that participants provide hard data or estimate a value for the data fields that were appropriate. Companies were assured that all information provided would be kept strictly confidential and not disclosed to anyone without their permission.

To simplify the construction of the value proposition using the ROHSEI software, each data element on the data collection template was correlated numerically with an IH user-defined parameter to simplify the process of entering data into the ROHSEI software. The data collection template was designed to intuitively reflect how value propositions are developed.

For the majority of IH case studies, ORC consultants conducted site visits to complete the analysis of the programs and activities, to review relevant data, and request additional information. The site visits were useful also because of the lessons and insights gained about the roles industrial hygienists play in their organizations and the different ways they contribute value. A summary of lessons learned is found beginning on page 127 of this section.

**Representative IH Programs and Activities**

As a means to identify “sentinel” IH projects and programs that were to be analyzed and then aggregated to represent an entire IH program, the team identified common areas of focus for typical IH programs. These included biological and chemical exposures,
ergonomics, noise, and physical hazards (including heat, cold, vibration, and radiation). Additionally, for each area of concern, the hierarchy of controls was considered as a way to gauge the relative degree of reliability of protective measures taken to control the hazard. Three levels: PPE/Administrative/Work Practice Control, Engineering Control, and Hazard Elimination were used. By this means, the project team would be able to demonstrate the relative value of protective measures across a typical IH program based on the level of control.

Projects identified and completed field study examples were received in the following program categories:

1. Biological Exposure; Hazard Elimination (1 project)
2. Chemical Exposure; PPE/Administrative/Work Practice Controls (1 project)
3. Chemical Exposure; Engineering Controls (5 projects)
4. Chemical Exposure; Hazard Elimination (2 projects)
5. Ergonomics; Engineering Controls (3 projects)
6. Noise; PPE/Administrative/Work Practice Controls (2 projects)
7. Noise; Hazard Elimination (2 projects)

In addition, three projects that provided general lessons learned and qualitative but very broad quantitative information, were also analyzed. Two of these were in the Other Physical Hazards; PPE/Administrative/Work Practice Controls category and one was in the Chemical Exposure; Engineering Controls category. Sixteen of these studies are described in the Phase V section of this report and are referred to in this section for findings and lessons learned.

The 19 projects for which field study data were collected were fewer than the original 28 projected, for a variety of reasons. Primarily, company contacts were unable to place the study at the top of their lists of priorities because of heavy work loads. In some cases, contacts commented that the information-gathering process was too complex, leading the team to re-design the data collection forms. Still others were unable to gain cooperation from their colleagues at the site or business unit level.

**Study Findings**

The projects and case studies analyzed during this study could not meaningfully be aggregated to constitute a representative IH program because of the lack of consistency between data collection approaches, and the differences in completeness of data among participating companies. Had training in the overall concept of looking for value and the importance of documenting sources been provided, it is likely that this goal could have been accomplished.

However, doing so is possible where cost and benefit data are available for all the projects to be combined. Because of the need for consistency in data quality and quantity, it is more practical to add together all cost and benefit data for a group of programs and/or activities within a company and treat them as one program or activity, calculating financial metrics to demonstrate value. This would require working with the calculated benefit for each sub-activity rather than beginning with costs associated with individual program components.
As described earlier, a means to identify “sentinel” IH projects and programs that could be analyzed and then aggregated to represent an entire IH program, is to identify the common areas of focus for typical IH programs within a company, such as biological, chemical, ergonomic, noise, and other physical hazards, and collect appropriate data on an ongoing, yearly basis. The costs and benefits of each individual project and program can then be calculated for each year, using the value equation provided in the strategy (cost before-cost after, etc.). Without double-counting, these numbers in turn can be added together to represent a total cost before, cost after, cost of implementation, etc. These aggregated numbers then can be used to calculate financial benefit for the sum total of IH programs and activities.

Using the parameters of the Quantitative Approach consistently across programs and activities will provide adequate data to use for value analysis. Having the data on hand will enable the industrial hygienist both to respond spontaneously to questions from management and to make the value proposition effectively as a matter of routine.

**Description of the Quantitative Approach and its components**

The Quantitative Approach of the IH Value Strategy is designed to enable the industrial hygienist to identify the impacts of changes that have been or will be made to a manufacturing or service process by an IH program or activity to control or eliminate IH risk, to capture and analyze the costs and benefits (including interventions to control a specific hazard) of those changes, and to present the value proposition for the IH program or activity either prospectively or retrospectively.
**Identify Impact of Change**

The **Approach** is based on identifying and determining the value of the changes that are impacts of IH programs and activities on the entire manufacturing or service process, both upstream and downstream of the intervention, as well as the direct value of the programs and activities themselves. (See Figure IV-4, Step 5-6.) The basic principle for making the value proposition is that, generally, potential benefit is represented by the difference between the costs of operating a process that requires management of an existing IH hazard and the costs of operating it following an intervention to reduce health risk. This cost, less the costs of the intervention represents potential cost savings, and these potential savings plus new revenue and other benefits represent the value realized. The value can then be expressed through financial metrics that are recognized by business leaders and that can be compared to key financial business objectives.

The **Strategy** enables the industrial hygienist to quantify the value realized from activities that control IH hazard(s) by changing the level of worker protection from use of PPE to a higher level of control such as local exhaust ventilation, substitution, or elimination, (with the higher levels of control being more desired from a health protection standpoint) in terms of their economic benefit.

![Figure IV-4. The Quantitative Approach.](image-url)
Mirroring the structure of the *Qualitative Approach* presented in the Phase III section of this report, the *Quantitative Approach* tracks and calculates the financial impact on three key areas: health status, the IH risk management process, and the business process. Other areas that may be impacted such as product quality, productivity, and employee morale may also be evaluated, where quantitative information exists. The *Approach* calls for the user to capture before and after costs in each of the three areas, the costs of the IH program or activity itself, any new revenue that may be generated as a result of process changes, and other benefits that may be quantified. The elements that contribute to understanding the impact within each area are also identified to facilitate and simplify data gathering and analysis. Users are urged to consider every potential source of benefit carefully, so as to build the best possible value proposition for their IH program or activity.

**Impact on Health Status**

In this *Approach*, the impact of IH programs and activities on employee health status is captured in terms of the total cost impact on occupational illness. (See Figure IV-4, Step 5-6 A.) This cost is further defined as operational cost associated with administration and treatment of occupational illnesses associated with the hazard(s). Capturing the true cost of occupational disease is a difficult challenge for several reasons, including the long latency of many illnesses, the failure of both employees and the medical profession to attribute many conditions to occupational exposures, and the pressure to avoid reporting work-related conditions in general. Examining non-occupational records may be one way to increase knowledge about the incidence of occupational illnesses, however, it is fraught with its own difficulties and is for the most part impractical for industrial hygienists to do so as to obtain meaningful results.

By determining the before and after costs of fatality cases, days away from work injury/illness cases, restricted work injury/illness cases, medical treatment injury/illness cases, and first-aid treatment injury/illness cases, a basic knowledge of readily-identifiable cost impact on health status can be attained. Although the *Approach* does not call for investigation into additional areas of potential health costs, the IH who has access to the health records and understanding of how to identify occupationally-related disease is not precluded from using it in the *Strategy*.

It turns out, based on the findings of this study, that while it is important to understand the impacts of IH programs and activities on health status, such information may not be as significant to the value proposition as are the process benefits. In terms of the best place to focus efforts for the best return, users should consider the options carefully.

**Impact on the IH Risk Management Process**

Managing health hazards and risks requires human and material resources and affects the manufacturing or service process. This can represent significant cost. When there is a change in the level of risk in the process, there will likely be changes in the resources required to manage it. Capturing the cost impact of such changes is a major step in making the IH value proposition.

The two categories of costs that must be quantified in order to understand the full impact of an IH program or activity are capital costs and operating costs. Capital costs are costs incurred on the purchase of land, buildings, construction, and equipment to be used in the
production of goods or the rendering of services. Operating costs are the recurring expenses which are related to the operation of a business, or to the operation of a device, component, piece of equipment, or facility. Both types of costs can be obtained by working with engineering and operations managers.

Capital costs are sometimes associated with managing a hazard before any IH intervention is made. In evaluating the incremental costs associated with an IH program or activity, capital costs must be included as part of the original scenario, or the base case, as well as after the change has been implemented. Capital costs associated with implementing the IH program or activity itself must also be captured in order to calculate the net savings from the change.

The **Strategy** includes costs that are generally classified as capital and required to be budgeted separately, such as the cost of the purchase of equipment and buildings that have a multiyear life expectancy; the costs associated with the installation of capital equipment; any other capital expenses that are associated with the base case, including design and engineering time or software that is specifically purchased for use in the capital project; any residual value that the capital equipment will have once the useful life of the equipment has ended; and the expected life of the equipment (this parameter is required in order for the capital equipment to be properly depreciated for tax purposes).

For most projects a capital cost is usually an up-front, one-time expense. However, it is possible that a capital cost could occur over multiple time periods. The strategy has the ability to address capital costs that may be required in multiple years. A financial specialist for the organization should be consulted to determine if a particular equipment purchase would be treated as a capital expense, and how various costs and benefits should be captured and recorded.

Operating costs are usually a significant part of managing hazards and risks before an IH program or activity is implemented. There will often be a change in these costs following implementation of such a program or activity, and often (but not always) the change will result in cost savings. The difference between pre-intervention operational costs and post-intervention operational costs represents the resulting net operating savings (or loss).

Categories of operating costs that may be spent to manage the health risk include: time spent by operations, IH and safety, and other personnel; the costs for vendors, consultants and contract labor; costs for IH supplies, operations and maintenance; medical surveillance costs; and other costs, including excess insurance premiums, fines and penalties, legal proceedings and settlements, and emergency response. Each category of cost is significant depending on the specific issues presented by the hazard or risk.

In addition to the previous “routine” operating costs, the **Strategy** asks industrial hygienists to include excess or incremental costs that result from non-routine events, or incidents, that were caused by the IH risk but that may or may not have resulted in illness or injury. Potential cost savings are determined by calculating the difference between the cost of incidents before the hazard is (or was) abated to the expected cost of incidents after the hazard is (or was) abated. The categories of costs included here are the same as those for the routine costs, only more narrowly focused on incidents alone. Users are cautioned not to double-count costs in these two categories.

The costs of past incidents (before abatement) can best be determined by calculating the average cost per incident for each parameter over the past 5-year period, then multiplying by the number of incidents over the same period. To determine the expected cost of future incidents following the abatement, the total 5-year average cost of incidents for all
parameters is multiplied times the projected number of incidents based on the reduction in health risk expected due to the intervention.

**Impact on Business Process**

The change(s) to the manufacturing or service process that result from an IH intervention may have impacts on other aspects of the business (downstream effects) that are independent of their impacts on health and risk management. These impacts may be in many different aspects of the process, but may not be obvious or intuitive to IH professionals. In order to fully account for the value of IH programs and activities, industrial hygienists should give careful attention to understanding all of their business process impacts. In general, some partnership with management directly involved in the business process is essential.

Just as in the IH risk management area, in the business process section the *Strategy* prompts industrial hygienists to consider possible impacts in the areas of capital and operating costs. In this case, capital expenditures are not those that are required to implement the program or activity itself, but rather are made in response to the program or activity because the change to the process requires new or different land, buildings, or equipment. Capital cost categories are the same as those requested for the IH risk management process impacts.

Operating costs, however, are oriented toward effects that change the functioning of the process by increasing or decreasing factors such as cycle time, equipment costs, materials and inputs, inventory costs, regulatory compliance, environmental emissions, and waste. Cycle time is controlled by process steps and motion and non-value-added processing. Inputs include material recovery and substitution, and energy consumption. Excess inventory costs are determined by inventory turnover. Equipment costs include maintenance, equipment downtime, and costs of operating the equipment. Costs of treatment of environmental emissions may be through waste water, air, hazardous waste, and solid waste. Finally, collection, disposal, and recycling account for costs of waste.

**Determine Value**

Net savings and/or avoidance of cost are determined by comparing the total cost of managing the hazard before the IH program or activity was initiated to the total cost after the program or activity was implemented. The cost of the IH program or activity itself is then subtracted from the difference to calculate the actual cost savings. In the ROHSEI program, this number is referred to as benefit, and is the information that is used to calculate the financial metrics used in discussions of value. The *IH Value Strategy, Quantitative Approach* incorporates additional factors into the calculation of value—new revenue and other benefits.

An important consequence that often results from eliminating health risk by implementing an IH intervention is creation of new sources of revenue for the organization. New revenue is different from cost savings, in that it represents a new opportunity made possible through process improvement and cost savings measures. It can be generated in different ways, including by increasing demand for products and services, by increasing production and service capacity, or by enabling an increase in price. Sometimes an IH program or activity can result in process efficiency gains that enable a company to produce more with the same labor and infrastructure. Where there is a market or demand for that increased production, or where new sales are generated, the resulting income can be considered new revenue.
In addition to the cost and revenue benefits IH may contribute in the areas of health status, IH risk management, and business process, IH programs/activities may generate other benefits that support or contribute to key business objectives. The Quantitative Approach encourages industrial hygienists to consider whether specific contributions can be identified that are related to operational, growth, human resource, product or service, reputational, or other business objectives. Such contributions may be difficult to quantify in some cases, but those for which a dollar value can be assigned can be incorporated into the calculation. Those that cannot be given a monetary value may be included in the Qualitative Approach (See the Phase III section of this report).

The dollar amounts from net savings/cost avoidance, new revenue, and other benefits can then be combined into a single benefit figure, which represents the sum total of all the benefit gained (or lost) as a result of the IH program or activity. To understand the meaning of this benefit relative to the financial objectives of the organization, this benefit is usually expressed in terms that explain its value. Metrics commonly used by companies to express value include:

---

**Net Present Value (NPV):** Today’s value of a series of future costs and benefits, this is calculated by subtracting the total of all discounted costs from the total of all discounted benefits. The model calculates NPV based on costs, benefits, and the discount rate that are entered by the user.

\[
NPV = \sum_{i=1}^{t} \left[ \frac{B_i - C_i}{(1 + r)^i} \right] = \sum_{i=1}^{t} \left[ \frac{B_i (1 + n)^i}{(1 + r)^i} \right] - \sum_{i=1}^{t} \left[ \frac{C_i (1 + n)^i}{(1 + r)^i} \right]
\]

**Internal Rate of Return:** The internal rate of return for a project’s costs and benefits is the interest rate when the net present value of the project is set to equal zero. The model calculates IRR based on costs and benefits that are entered by the user.

\[
IRR = r \text{ when } \sum_{i=1}^{t} \left[ \frac{B_i - C_i}{(1 + r)^i} \right] = 0
\]

---
Discounted Payback Period refers to the amount of time it takes for a project to pay for itself. As such, the project is “paid back” in the year that the cumulative discounted benefits exceed the total discounted costs. Note that this metric uses straight-line extrapolation to calculate payback period to the nearest tenth of a year.

Discounted payback period is the year \( y \) when

\[
\sum_{i=1}^{y} \left[ \frac{B_i - C_i}{(1 + r)^i} \right] - \sum_{i=1}^{t} \left[ \frac{C_i}{(1 + r)^i} \right] \geq 0
\]

Where \( t \) denotes the total lifetime of the project (duration of analysis).

Production equivalent units: Shows returns in terms of production units. If production equivalent units is calculated to be 10, this means that the project’s NPV is equivalent to the profit earned from 10 units of production. If production equivalent units is calculated to be -5, this means that the project’s return is equivalent to the loss of profit from producing 5 units.

Additional input this metric requires: profit per unit.
Present the Value Proposition

The financial metrics are only part of the full value proposition equation. Together with the benefits identified through the qualitative portion of the **IH Value Strategy**, the industrial hygienist can develop a complete picture of how IH programs or activities have contributed to the key business objectives of the organization. Further details on how to create a value proposition presentation for management are given in the Phase V section of this Report.
Presentation of pilot test results

Understanding of Mission, and Use of Data Collection Forms

Nearly all of the company contacts who offered case study data were able to provide the type and quality of information sufficient for a financial analysis with minimal instruction. In most cases, however, the examination of the potential benefits of the projects under study was fairly narrow and left a large amount of savings out of the equation, particularly in the area of employee productivity.

It is clear that if industrial hygienists are to be able to make effective use of the IH Value Strategy, training in the conceptual framework of ferreting out as much benefit as possible will be as important, if not more so, than training on the mechanics of performing the financial analysis. Industrial hygienists must be committed to finding every scrap of value in their programs and activities in order to make as strong a case as possible.

Many of the parameters included in the data sheets were not used by the respondents, for a combination of reasons. Several industrial hygienists commented that there were too many, and that the form was too long. This comment led to re-configuration of the data collection form, to which a summary form was added to enable users to add aggregated data. The comment indicated that there was a general lack of understanding of the degree of effort and detail required for thorough value analysis. Another reason for not using certain parameters was lack of understanding of their meaning, which indicated that definitions would be needed. Development of instructions and definitions is a key part of making the data collection tools as effective as possible. Of course, these must be supplemented by training in the use of the strategy.

Another factor was that not all parameters were applicable to all cases. Some, such as emergency response, excess insurance premiums, and fines and penalties were almost never used. This does not mean that they should be excluded, because they will be very important to some cases, such as those that involve flammable, reactive, or explosive materials. As predicted, the parameters dealing with health-related incidents and illnesses also were rarely used, for reasons mentioned earlier with respect to detecting and recording them.

The pilot case studies also demonstrated that the cross referencing of the data collection template to the customized ROHSEI IH user parameters allowed the data entry to be conducted in a very efficient manner. This will specifically simplify the use of ROHSEI as a data collection tool and financial calculator. It should also assist users of the IH Value Strategy who choose to use other financial software tools to generate the financial metrics, particularly if multiple analyses are performed over a period of time.

Summary of Lessons Learned

In addition to the technical aspects of data collection and use, the case studies provided numerous insights into the cost and benefit aspects of implementing IH programs and activities, and highlighted the significance of IH participation in business processes. Industrial hygienists contribute to business value in many ways, and should be able to understand and articulate their specific contributions.
The benefits of making IH-related process improvements that many times are designed to reduce or eliminate employee health exposures often also result in significant business improvements and/or savings. IH professionals can be the catalysts to drive management actions, and to enable organizations to make process or business changes that not only protect employees but also result in significant business improvements that can save money and enhance an organization’s competitive advantage. (See Figure IV-5 for summary of financial analysis of specific projects by hierarchy level.) The study found that:

1. The hierarchy of controls generally applies for financial and economic reasons as well as IH reasons, although it is not a one-to-one relationship. The financial aspects vary with the industry and the type and magnitude of risk.

   The greatest cost savings and other benefits tended to be associated with hazard elimination and the elimination of PPE usage. Material substitution can have very large pay-offs because the change often has impacts that create efficiencies throughout the business process. Containment projects can result in improvements in employee health exposures and significant savings in labor and waste disposal costs with little incremental capital investment. Engineering controls are most often, but not always, better financially than PPE. In cases where financial benefit cannot be shown for engineering controls, there are often other benefits that make them preferable. The use of PPE versus engineering controls or containment is usually the least effective and most costly way to protect people. The economic circumstances of PPE programs support the IH hierarchy of controls. However:
   - PPE can be a cost-effective measure to protect employees in high noise areas
   - Relying on PPE as the primary means of protection requires extraordinary measures to ensure that expected levels of protection are validated in actual field operations
   - Even in highly responsible organizations management may delay taking action if they have the perception that employees are adequately protected by PPE.

2. Sound IH investigations and measurement can be a key to simultaneously reducing employee exposures, ensuring regulatory compliance and contributing to business profitability.

3. Industrial hygienists, working together with business partners, can help maintain the overall viability of a business and protect revenue streams.

   IH expertise can be an essential component of making a process work.

   Industrial hygienists can provide technical knowledge and advice that enables a process to continue functioning during a repair instead of having to be shutdown, thus preserving revenue.

   Integrating industrial hygienists into the planning of operations at the right time is of key importance. Early communication of IH hazards to management will allow for more efficient and less risky interventions.

   Industrial hygienists need to help management realize and learn where IH fits in the process and where it can be most effective.
4. Health and safety consequences should be considered when work systems are designed or retrofitted to ensure the benefits to the organization are optimized.

5. IH value can be demonstrated even where benefits are negative.

6. Industrial hygienists add intellectual capital to the business by providing the ability to solve problems that cannot be addressed by other professions.

7. Utilizing IH principles and practices of hazard elimination and product containment can achieve reductions in the potential for both employee and community exposures to potentially hazardous substances.

8. Integrating IH concepts into process redesign can significantly expand production capacity.

9. Improvement in health and safety conditions often results in improved labor productivity.

**Potential Strategy Application:**

The case studies have shown that the approach taken in developing the Strategy is versatile enough to be applied for quantitative IH value analysis in a wide range of industries, types of hazards and risks, and levels on the IH hierarchy of controls. It is also comprehensive in its potential to maximize the calculated value of IH programs and activities, because it includes parameters that are directly linked not only to those programs and activities but also to their downstream process effects. This is a component that is missing from the current ROHSEI program.

This strategy is applicable wherever a ROHSEI analysis is appropriate, but may be able to perform better for making the value proposition because of its capability to capture quantitative data for a wider range of benefits related to IH programs and activities.

**Conclusion: Next Steps:**

All of the goals outlined in the Problem Statement were achieved during the course of Phase IV.

As a result of the pilot site visits and retrospective value analyses, the study team is confident that when the IH Value Strategy data collection template is properly used, the output of the Strategy will represent accurately the direct and measurable financial benefits that organizations have received from implementing IH programs and activities.
<table>
<thead>
<tr>
<th>Hierarchy Level</th>
<th>Case/Type of Exposure</th>
<th>NPV</th>
<th>IRR</th>
<th>ROI</th>
<th>DPP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazard Elimination 8. Chemical</td>
<td>$20 million</td>
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<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
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<td>Hazard Elimination 6. Noise</td>
<td>$198,015/47,249</td>
<td>161%</td>
<td>98%</td>
<td>0.6 yr</td>
<td></td>
</tr>
<tr>
<td>Hazard Elimination/Material Substitution 7. Biological</td>
<td>$991,888</td>
<td>120%</td>
<td>22%</td>
<td>0.5 yr</td>
<td></td>
</tr>
<tr>
<td>Material Substitution 2. Chemical</td>
<td>$504,694</td>
<td>n/a</td>
<td>293%</td>
<td>0 yr</td>
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</tr>
<tr>
<td>Engineering/Containment 1. Chemical</td>
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<tr>
<td>Engineering/Containment 11. Chemical</td>
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</tr>
<tr>
<td>Engineering/Material handling 4. Ergonomic</td>
<td>$39,708</td>
<td>32%</td>
<td>25%</td>
<td>3.1 yr</td>
<td></td>
</tr>
<tr>
<td>Engineering/Ventilation 5. Chemical</td>
<td>($1,005,597)</td>
<td>-25%</td>
<td>-56%</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>Engineering/Material handling 12.Ergonomic</td>
<td>($1,385)</td>
<td>n/a</td>
<td>-66%</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>PPE/Administrative 3. Noise</td>
<td>($49,467)</td>
<td>n/a</td>
<td>-66%</td>
<td>n/a</td>
<td></td>
</tr>
</tbody>
</table>

Figure IV-5. Summary of Financial Analysis of Case Studies, by Hierarchy Level.
Phase V: Develop and Test the *Overarching IH Value Strategy*

**Introduction**

The purpose of Phase V of the Value of the Industrial Hygiene Profession study was to use data, information, products, and knowledge obtained during Phases I through IV of the study, to build an *Overarching IH Value Strategy* that would enable the determination and illustration of the business value of IH programs and activities. This *Overarching IH Value Strategy* effectively links the **Qualitative** and **Quantitative** Approaches. In addition, activities in Phase V included the organization, design and execution of a pilot-test of the *Overarching IH Value Strategy*. The results of this test are listed in section

**Background**

The study team recognized at the outset that, in addition to producing detailed financial and business metrics, a need existed for capturing value in situations that were hard to quantify. The Return on Health, Safety, and Environmental Investment (ROHSEI) Tool had addressed both quantitative and qualitative issues for more than a decade, but the focus had primarily been on cost reduction. As a result of study investigation and field pilot testing, new categories of value were identified and were incorporated into the *Overarching IH Value Strategy*, including: 1. the generation of new revenue; and 2. value contributions to other parts of the business. Value contributions were captured by aligning them with key business objectives.

![Categories of Business Objectives](image)

*Figure V-1. The Business Objectives Strategy.*

Health professionals must view their IH programs in the context of these overall business objectives. How does industrial hygiene help deliver or support these business objectives and deliver overall value? Which IH programs have the biggest influence or potential to
contribute to the overall success of the enterprise? How can IH efforts be best aligned with strategic business objectives? By carefully considering each of the key business objectives, the health professional can determine the contributions of IH programs. This in turn helps senior business leadership gain a full appreciation for the value of IH to the organization.

The Business Objectives Strategy was developed to assist health professionals in identifying how IH efforts deliver or can deliver strategic business values. The strategy incorporates six categories of major objectives that an organization may consider important functions of their business. Business objective categories are often interrelated. Specific strategic business values vary by company and reflect the industry, customer base, product lines, market spaces and a host of other factors. Each of these factors must be carefully evaluated to determine how IH plays or could play a role. Nevertheless, there are some generic key business objectives common to most organizations.

The Overarching IH Value Strategy enables managers and IH professionals to conduct business case analyses for the purposes of determining and illustrating the business value of IH programs and activities.

The Strategy has three categories of activity: preliminary investigation and study prioritization, value assessment, and value presentation. These categories include eight specific strategy components, and each component includes specific steps and approaches in a sequential construct.

A key issue that was addressed in completing the Strategy was the trade off between keeping it simple and user friendly and including enough detail for it to be credible. The solution was to develop a flexible approach that allows the user multiple entry points and allow them to substitute their own existing information whenever possible.

Problem Statement

Is there a way to provide a practical framework for demonstrating the value of IH programs or activities using a qualitative approach, a quantitative approach, or a combination of both qualitative and quantitative approaches?

Study Approach

As mentioned previously in this report, the concepts underpinning the Overarching IH Value Strategy start with ROHSEI tool, which addressed both quantitative and qualitative issues. But those concepts have been refined and significantly modified and expanded as a result of this study. The concepts of the Overarching Strategy were pilot-tested with approximately 12 participating ORC member companies offering 18 individual case studies. Questionnaires and site visits explored the existence and understanding of the quantitative and qualitative aspects of measuring the value that IH brings to the business. Pilot test and case study findings are provided later in this section of the report.

The final Overarching Strategy will be retested with these companies to ascertain their understanding of key concepts and to see if they feel the Strategy sufficiently captures the critical data needed to meet their needs. Companies will be provided with instructions, trained in the strategy, and then asked to apply the strategy and provide feedback through a questionnaire instrument on the strategy’s usefulness, effectiveness, and any potential issues for resolution.
General Study Findings

Significant knowledge was gained from the iterative and interrelated study process, where findings evolved and built upon other concurrent study work. For example, lessons emerged in testing the Quantitative Approach that also applied to the Qualitative Approach and vice versa. Several key findings that relate to the Overarching IH Value Strategy are:

Finding #1. Many study participants were eager to make an IH value assessment, but they had no idea of where to start. A key study finding was that the Value Strategy had to provide guidance in the initial stages, before the actual value assessment, so the industrial hygienists would not have to waste their time and effort on a value “fishing expedition.”

Finding #2. Locating value in an IH setting requires an understanding of the intersection between IH risk and the business. A common framework for understanding the business is a census of key business objectives. A logical way to understand IH risk is to inventory common IH hazards.

Finding #3. The process of identifying and controlling risk is the principal component of the IH work. The industrial hygienist must anticipate, recognize, evaluate, prevent, and control workplace factors which could result in adverse health effects among workers. The IH professional must first fully understand the business process to anticipate risk and identify potential hazardous exposures. Properly implemented, the IH program will protect workers from biological, chemical, and physical hazards (including ergonomic, noise, and radiation hazards).

Finding #4. IH professionals need guidance in determining the most appropriate value approach to take. Quantitative assessments often provide the most credible information. But qualitative assessments are critical to capturing some of the most significant business contributions. In many instances, a complete IH program value assessment will require a combination of quantitative and qualitative approaches.

Finding #5. Qualitative and quantitative value assessments have the same basic steps. Both start with risk. They then capture changes in health, the IH risk management process, and other aspects of the business that result from the IH activity or program. These changes are further analyzed to determine the resulting impact on the business. The impacts are then valued. The values are then captured and catalogued for presentation.

Finding #6. Traditional value analysis focused on cost reduction significantly understates the value that industrial hygiene adds to the business. The pilot studies revealed significant IH value generation in the areas of new revenue and other business benefits.

Description of the Overarching IH Value Strategy

The Overarching IH Value Strategy provides an approach for determining and illustrating the business value of IH programs and activities. Many times the industrial hygienist is faced with designing and implementing an IH program or activity to mitigate a specific risk, exposure, or compliance issue and may not entirely appreciate the other values that the IH program or activity brings to the business. The Strategy helps guide the
industrial hygienist in developing and presenting a more complete business value proposition for IH programs and activities.

The Overarching Strategy consists of 8 steps:

1. Understand Business Objectives and IH Hazards
2. Identify and Prioritize Value Opportunities
3. Assess Risk Reduction
4. Determine Value Approach: Qualitative or Quantitative
5. Determine Changes
6. Determine Impacts
7. Determine Value
8. Present Value Proposition.

The diagrams on the following three pages provide further description of each step in the Strategy (Figures V-2, V-3, and V-4).

Step 1: Understanding Business Objectives and IH Hazards

In the first step of the Strategy, the industrial hygienist completes an inventory of both business objectives and IH hazards.

Completing a business objectives inventory is important in order to have a broad perspective of how IH programs and activities have or could support attainment of overall business goals. The Strategy asks industrial hygienists to identify business objectives for their companies in the following broad areas: Operational, Growth, Product/Service, Reputational, Human Resources, and Other. The industrial hygienist needs to consider corporate, business, and local goals and objectives, as well as, mission statements, strategic plans, and annual operating plans. Along with business objectives, key performance indicators (KPIs) associated with each objective should be captured in the inventory.

Completing an IH hazards inventory is another important activity in this step of the Strategy. A process-by-process hazards inventory is prepared. The Strategy then asks the industrial hygienist to characterize hazards by their actual or potential business significance. Criteria for IH hazard business significance include actual illnesses, claims or allegations, known or suspected employee overexposures, known or suspected compliance issues, emerging regulatory issues, new or uncertain health impacts and special interests by the public, non-government organizations (NGOs), and other stakeholders. This approach of screening hazards by specific criteria helps the industrial hygienist narrow down which IH programs and activities are likely candidates to contribute value to the overall business.

Step 2: Identify and Prioritize Value Opportunities

In this step, the industrial hygienist identifies and prioritizes value opportunities that can be further evaluated.

Once the company-specific business objectives inventory is built in Step 1, the Strategy asks the user to evaluate how the IH program or activity under consideration influences those business objectives—either favorably, unfavorably, or not at all. For example, an IH program of periodic monitoring employee exposures strongly supports and aligns with
Figure V-2. The Overarching IH Value Strategy.
Figure V-3. The Qualitative Approach of the **IH Value Strategy**.
an overall Human Resource business objective of “creating a great place to work.” By thoughtfully considering how an IH program or activity influences each business objective, the industrial hygienist begins to identify potential value streams to the overall enterprise. While this analysis can be completed by the industrial hygienist, it is recommended that a small cross-functional team of internal stakeholders work together to complete the influence ratings. A cross-functional team can help ensure full identification of value opportunities and a balanced approach. After the evaluation, the industrial hygienist makes plans to study more thoroughly those selected IH programs and activities with the strongest favorable influence on business objectives. In subsequent steps of the Strategy, risk reductions associated with these selected IH activities are studied as well as their qualitative and/or quantitative business value contributions.

**Step 3: Assess Risk Reduction**

In this step, the industrial hygienist identifies the actual or predicted risk reduction(s) associated with the implementation of an IH program, activity or intervention. The risk reduction(s) are part of the overall IH value proposition. The industrial hygienist conducts a pre-intervention or baseline risk assessment and follows it up with a post-intervention risk assessment. The health risk reduction that

In subsequent steps of the Strategy, other changes, impacts and benefits associated with the risk reduction are identified and incorporated into the value proposition. These changes, impacts and benefits may take many forms including more efficient operations, improved

**Step 4: Determine Value Approach: Qualitative or Quantitative**

Here the industrial hygienist evaluates the data available related to an IH program, activity or intervention and determines if the value approach is best made through a qualitative approach, a quantitative approach, or a combination of both.

The *Overarching IH Value Strategy* splits into two paths at this point, either a qualitative path or quantitative path. The Strategy guides the industrial hygienist in choosing between *Qualitative or Quantitative Approaches*. Important considerations include the level of leadership scrutiny and likelihood of project challenge, risk perception, compliance status, company policy on financial justifications, and time available to collect supporting data. In general, the industrial hygienist should make every effort to be as detailed as possible in defining the financial costs and benefits of the IH program, activity, or intervention.

Study findings have demonstrated that in addition to risk reduction many IH programs and interventions also provide direct and indirect financial benefits many times exceeding the costs of the intervention. In attempting to demonstrate value of an IH intervention a quantitative analysis with "hard numbers" is usually preferable to a qualitative approach that makes (albeit credible) estimation analysis. By developing a detailed business case for a program, activity, or intervention, the IH function is more likely to be viewed favorably as a business partner and the value of IH interventions can be more readily compared with competing financial opportunities within the organization.

Given the nature of the many intangible benefits associated with IH programs, activities and interventions; there will be activities that deny the accurate and comprehensive quantification of financial benefits. In these instances, the industrial hygienist should use the *Qualitative Approach* to fully capture and define the benefits to the organization. The Strategy is flexible in that the industrial hygienist may follow either the qualitative or quantitative path or choose to conduct the analyses contained in both paths and combine the analyses when making a final value determination and value presentation.


Step 5: Determine Changes

Following selection of the Qualitative or Quantitative Approach, the next step in each path is for the industrial hygienist to identify the changes or anticipated changes resulting from the IH program, activity, or intervention. The intent of this step is to simply identify or “flag” changes; the magnitude of each change is measured in the next step.

In both the Qualitative and Quantitative Approaches, changes are categorized into three areas:

- Health status
- IH risk management process
- Business process.

Identification of changes in these three areas helps to understand and build the value proposition for the IH program, activity, or intervention.

In terms of changes in health status, the industrial hygienist identifies changes in mortality, morbidity (lost time, restricted, and medical treatment cases), and other employee health or functionality changes such as employee stress, absenteeism, or other factors. The Strategy allows the industrial hygienist to identify any “confounding factors,” for example, if there is some uncertainty as to whether or not a noted health status change occurred as a result of the IH program, activity, or intervention, or due to other factors. As an example of a confounding factor, consider the situation where the industrial hygienist believes that an ergonomics intervention has resulted in a net change (reduction) with respect to employee stress levels. It may also be possible that the change in stress levels was actually due to a more liberal employee absenteeism policy. The industrial hygienist can consider the “confounding factor” of the new absenteeism policy and provide an estimate on the likelihood that it was responsible for a noted health status change. Because changes and their causes and effects are often complex, it is useful to make careful consideration of the root causes of noted changes.

The second change category is change in IH risk management processes. The Strategy prompts the industrial hygienist to look at whether or not there were changes in overall IH duties and responsibilities, administrative load/recordkeeping, management of hierarchy of controls, management of monitoring/medical surveillance, or other IH risk management processes. Again, the Strategy allows the industrial hygienist to identify and evaluate potential confounding factors.

The third category for change is business process. Specific areas of change within this category include changes in process design, changes to inputs/equipment/materials, changes in how the process is managed, changes in process flow and pace and other business process changes. Confounding factors are also considered in this change category.

After completing the evaluation of changes in health status, IH risk management processes, and business processes, the industrial hygienist can proceed to evaluate the impacts of the identified changes.

Step 6: Determine Impacts

In this step of the Strategy, the industrial hygienist identifies impacts associated with identified changes in health status, IH risk management processes, and business processes. In the Quantitative Approach, impacts are entered into the Strategy as costs in
dollars. In the *Qualitative Strategy*, impacts are categorized as high, moderate, or low and supplemented with reasonable cost estimates where available.

It is important in this step to capture as many impacts as possible associated with the changes from IH programs, activities, or interventions. Impacts may be positive or negative. From a health status viewpoint, impacts may include workers’ compensation and other costs of illnesses, as well as other impacts such as changes in absenteeism, presenteeism, insurance premiums, labor turnover, medical removal, job transfer, training/re-training, worker productivity and other factors. Where exact costs are not available, defensible estimates should be used. In the qualitative approach, impacts are captured as high, moderate, or low, with supporting rationale provided.

From an IH risk management viewpoint, costs are captured in the categories of IH duties and responsibilities, administrative load/recordkeeping, hierarchy of controls, monitoring/medical surveillance, and other IH risk management processes. For example, an IH intervention may reduce the need for personal protective equipment (PPE) and reduce downtime associated with donning and doffing PPE. These cost impacts can often be directly measured or estimated and then entered into the *Quantitative Approach*. Where a *Qualitative Approach* is chosen, the industrial hygienist will capture impacts as high, moderate, or low, with supporting rationale as well as any cost estimates in dollars.

From a business process point of view, impacts are measured across the previously identified change categories (process design, inputs/equipment/materials, management, flow/pace, and other business process changes). For example, if an IH intervention reduces or eliminates process steps, the costs savings in terms of improved cycle time can be measured or estimated and entered into the *Quantitative Approach*. Similarly, these savings can be characterized as high, moderate or low in the *Qualitative Approach*.

**Step 7: Determine Value**

In this step the industrial hygienist determines the overall value of the IH program, activity, or intervention. Considerations include the cost of the intervention (investment cost) and cost savings/avoidances, new revenue generation, and other benefits resulting from the intervention. Results are used to prepare a value presentation in the final step of the *Strategy*. A value equation appears in Figure V-5.

The *Quantitative Approach* of the *Strategy* focuses on guiding the user through a series of worksheets to define intervention costs and capture the costs before and costs after a particular IH program, activity, or intervention across the categories of health status, IH risk management process, and business process. In addition, the *Quantitative Approach* captures a number of parameters and business assumptions, such as depreciation, corporate tax rate, inflation rate, discount rate, loaded wages, and others. These data are used to calculate financial metrics such as Return on Investment, Payback Period, Internal Rate of Return, and Net Present Value in the *Quantitative Approach*.

The *Quantitative Approach* also captures other benefits such as any improvements in product ordering, time to market, protection of revenue/market share, utilization of people, employee morale, product and service reliability, and company reputation. While many of these parameters are difficult to quantify exactly, the industrial hygienist is asked to make credible estimates where possible.
In the Qualitative Approach, the value of the actual or proposed IH programs, activities, and interventions is based on estimates of several costs. These are often difficult to precisely calculate; however, the industrial hygienist can sometimes estimate these benefits and provide evidentiary value arguments.

The Qualitative Approach has built-in limitations, and caution must be used. Unlike a strict Quantitative Approach, the Qualitative Approach looks at very rough estimates of value over a short time-frame and provides an evidentiary rationale for conclusion made. Calculations of future year impacts, the impact of financial interest and discount rates, and the time-value of money are not factored into a Qualitative Approach, for example. This will cause inaccuracies. The Quantitative Approach makes these and other considerations and takes a much more “data driven” approach to the analysis. That Quantitative Approach allows calculation of financial Return on Investment (ROI), Net Present Value (NPV) and Payback Period. Nevertheless, with the Qualitative Approach, the industrial hygienist can make some defensible cost estimates and provide rationale that can be discussed with Management during a value presentation.

**Step 8: Value Presentation**

In the final step of the Strategy, the industrial hygienist pulls together an executive summary presentation that describes the value of the IH program or activity. Areas of focus include quantitative and qualitative analyses that address cost savings/avoidance, new business revenue and other benefits.

The executive summary value presentation is a critical termination of both the underlying Quantitative and Qualitative Approaches within the Overarching IH Value Strategy. Key components of the presentation are:

- IH program or activity description
- IH hazard and risk reduction
- IH opportunity
- Changes and impacts
Costs of IH program or activity
Value determination and financial metrics
  o Cost savings/avoidance
  o New revenue
  o Other benefits
Summary statement and recommendations.

**Strategy Application and Pilot Test**

Because of its flexibility, the *Overarching IH Value Strategy* can be applied and integrated into a host of business processes, including but not limited to capital appropriation projects, plant and facility expansions and modifications, due diligence reviews for acquisitions and divestitures, changes in hierarchy of controls, supplier evaluations, contractor selections, outsourcing decisions, and customer interactions.

The *Strategy* can be used retrospectively or prospectively to determine value of IH programs, activities, or interventions. For example, on the retrospective side, consider an existing respiratory protection program. The industrial hygienist can demonstrate value by considering the changes and impacts that would have occurred if the respirator program was not in place. On the prospective side, the industrial hygienist can assess the value of IH interventions to be implemented. For example, consider the design of a new paint booth. The value of IH interventions such as ventilation controls built into the design can be measured and valued before implementation through the *Strategy*.

The following Case Studies illustrate the findings from pilot testing the concepts contained in the *Overarching IH Value Strategy*. In several instances the *Strategy* and *Approach* components were refined after the case study visit. The study team will retest the completed version of the *Strategy* and *Approach* components with the case study participants and with additional ORC member companies.

**Case Study 1: Pharmaceutical Powder Exposure Reduction**

**Background:** The following case study involves a company with operations in pharmaceutical manufacturing. To control IH risk, the company uses a control banding process that specifies what employee protection measures are appropriate based on where a specific compound falls within a predetermined airborne exposure range. The control band is ranked from 1-5 with range 1 being the most potent and 5 being the least potent.

**Hazard Identification**
The hazard identified within this particular chemical manufacturing operation involved exposure to highly potent active pharmaceutical powders. Pharmaceutical powders at varying exposure levels can be extremely hazardous to workers who handle or work near them. These powders have many exposure routes including inhalation, skin contact, skin absorption, or ingestion.

**Hazard Intervention**
The company identified the hazard as a chemical exposure to employees. The abatement approach involved a change in the engineering controls to eliminate the need for operator use of powered air purifying respirators (PAPRs) in the hazard ranges from 2-5. The capability of containment bags to prevent release of powder into the work environment was augmented.
Impacts of the IH Activity
Many positive health, business, and risk management benefits resulted from the implementation of the engineering control and containment modifications. Health improvements resulted from the intervention because employees were not directly exposed to the pharmaceutical powders. Operator exposure rates were significantly reduced. The business process was improved because savings in the amount of $172,800 per year resulted from reduced PPE usage; employee time to put on PPE was also reduced resulting in a savings of $78,000 per year. The intervention allowed for a 40% reduction in non-hazardous waste generation. Since less waste was generated, less waste required disposal. Less IH sampling was needed to verify an adequate level of employee protection. Savings from reduced IH sampling were $30,000 per year. Positive risk management changes included assurance of regulatory compliance, potential FDA/EMEA benefits for contained processing, and less processing area to be cleaned.

Financial Metrics
After entering the data into the ROHSEI software the intervention resulted in a positive net present value (NPV) of $76,668. The internal rate of return (IRR) was 16% while the return on investment (ROI) was 7%. The discounted payback period (DPP) was 4.2 years.

Lessons Learned
This case study demonstrated that the use of PPE versus containment is not always the best business practice or best way to reduce costs. Many cost savings resulted from the elimination of the hazard (containment) and the elimination of PPE usage.

Case Study 2: Reduction of Exposure to Chromate-Based Paint Primer

Background: The manufacturing process evaluated was a rework operation that involved sanding of chromium-based paint primers to achieve adequate surface characteristics for subsequent painting steps. Parts received from subcontractors had surfaces that were not uniform and had chips that had to receive additional sanding prior to being assembled or receiving the final surface painting. Failure to address the inadequacy of the primer coat could result in quality issues in the finished products resulting in further and more costly rework later in the manufacturing process or, potentially, after receipt by the customer.

Hazard Identification
The imperfections in the primer coat had to be hand-sanded by manufacturing operators, resulting in additional in-process rework and potential chromate exposures to employees. The danger of chromate dust exposure was well-recognized by the company and adequate steps were taken to provide and use personal protective equipment to ensure worker safety. Previous sampling exposure monitoring determined that unprotected worker exposure to airborne hexavalent chromium was five times the permissible exposure limit (PEL) when spraying the primer, and two times the PEL during vacuum sanding. In addition, OSHA had recently issued a new standard revising the current PEL downward (to 1 microgram per cubic meter of air as an 8-hour time-weighted average), thus putting additional focus on the chromium exposures at the facility.

Hazard Intervention
The company had long recognized the hazard associated with chromate-based paints. However, in complex operations many priorities compete for management’s time and focus. Since employees were receiving adequate protection from local exhaust ventilation and PPE, there was no sense of urgency to find options to eliminate the use of chromate-based primers.
The IH-generated project provided impetus to the re-evaluation of the requirement to use chromate-based primers in the aircraft manufacturing process. The project required both time and resources from the production and engineering staffs to demonstrate that non-chromate based primers would be adequate substitutes to ensure a high level of both product quality and employee protection. Once the testing was satisfactorily completed, additional costs were incurred to make the design change to the product specifications and communicate the changes to the appropriate sub-contractor.

**Impacts of the Intervention**
The new priming material reduced paint chipping, which resulted in improved quality of the primer-coated parts. Along with a concurrent project to address the quality of vendor-produced parts, eliminating the need to rework chromate-primed parts resulted in a significant labor productivity savings.

The intervention eliminated worker exposure to chromate dusts from rework sanding. Employees were still exposed to non-chromate dust, but as a result of the intervention the level of respiratory protective equipment required could be reduced from full-face powered air-purifying respirators (PAPRs) to half-face air-purifying respirators.

As a result of the elimination of chromate dust, the company was also able to avoid implementing costly changes to the facility’s exhaust ventilation systems. The new hexavalent chromium standard would have required a more robust ventilation design to comply with the 2010 compliance date for the new OSHA PEL. Without the need to comply with more stringent requirements, existing exhaust ventilation systems were deemed acceptable or would require significantly fewer design upgrades to meet company IH standards.

Other benefits of the intervention included:
1. Increased customer satisfaction due to product deliveries that required less follow-up surface rework
2. Elimination of chromate primers improved a corporate social responsibility metric associated with corporate Materials of Concern (MOC)
3. Increased employee morale due to the elimination of chemical exposures greater than the company’s occupational exposure limit (OEL)
4. Decreased regulatory risk due to the elimination of hexavalent chromium in this operation
5. Lessons learned from the project have the potential to be transferred to other products and facilities within the corporation.

**Financial Metrics**
A ROHSEI analysis was conducted on the benefits and costs associated with the intervention. The analysis showed that the substitution of non-chromate priers resulted in an after-tax net present value savings of $504,694 over the 5-year duration of the project evaluation. This represented profit that could be attributed to an additional unit of production per year. In addition, the substitution resulted in significant productivity gains.

**Lessons Learned**
A key lesson learned for the project was that in some cases management is aware of the need for certain actions but is distracted by a multitude of other issues associated with operating the business or organization. In addition, even in highly responsible organizations management may delay taking action if they have the perception that employees are adequately protected by PPE. In this case management knew the right thing to do and the project should have proceeded on its own merit; however, the project
did not rise up the company’s priority list until the proper management focus was created by IH professionals.

IH professionals can be catalysts to enable organizations to make process or business changes that not only protect employees but also result in significant business improvements that can save money and contribute to an organization’s competitive advantage.

**Case Study 3: Hearing Conservation Case Study**

This small company has one forge plant with approximately 68 employees who produce custom-ordered parts manufactured in a hot forged and trimming process. Forging operations at the plant consist of heating various steel and bronze materials to high temperature (2,300 degrees F), placing the parts between tool steel dies, and striking them repeatedly to form predetermined shapes.

**Hazard Identification**

Hammer forges generate loud noise due to the multiple impacts required to form each part from preheated metal stock. Employees are required to handle the parts with tongs and continuously insert the parts into multiple dies where there is metal-to-metal contact as the parts are struck repeatedly by the hammer forge. The operators are thus exposed to frequent loud impact noise. The operators for the manual forging presses are within 3 to 15 feet of the source of very high noise levels. Over a typical 10-hour shift workers were routinely exposed to Time Weighted Average (TWA) exposures of 110-115 dBA, which far exceeded the OSHA 8-hour TWA permissible exposure limit (PEL) for noise of 90 dBA.

**Hazard Intervention**

The company had long recognized the potential risk of the loud noise exposure to employees. A hearing conservation program was in place and employees wore hearing protection of their choice. Audiometric testing was conducted to screen for audiometric threshold shifts, and several shifts were noted during each annual testing program. However, follow-up testing and medical evaluation demonstrated that only one permanent threshold shift had occurred. In 2005, the company was inspected by the Tennessee Division of Occupational Safety and Health (TOSHA) and was issued a citation for failure to provide hearing protection that attenuates employees’ exposure to below the OSHA PEL. After the inspection, the company began requiring exposed employees to wear double hearing protection (ear plugs covered by ear muffs) when the forging operation was in progress. However, using the published criteria for estimating actual Noise Reduction Ratings (NRR), the double hearing protection could only reduce the noise exposure to the employees’ ears to an equivalent 8-hour TWA of 92 dBA and thus still exceeded the OSHA PEL.

The company had already implemented a series of engineering controls which provided some noise reduction. However, given the inherent loud noise levels associated with the hammer forging process it was felt that the incremental progress made was not sufficient to provide employee protection in the short run. Administrative controls were also considered but the maximum employee exposure to levels of 92 dBA would only be 6 hours per day which would cause serious problems with the facility’s 10-hour schedule and the incentive pay structure for hammer mill operators. Replacement of the hammer mills with mechanical screw presses was evaluated, but the capital cost of the presses
would be prohibitively expensive to the point of making the facility non-competitive in the marketplace.

The company contracted with a speech and hearing center to test subjects in a controlled setting to determine the maximum effectiveness using the combined hearing protection. The center found that an attenuation of 41.5 dBA was possible which meant that an effective noise exposure to the employees’ ears could be less than a TWA of 80dBA. However, it has long been known that laboratory testing does not equate to real world experience, therefore the company retained a consulting firm that had developed technology to measure the noise dose to the ear during actual workplace operations. By embarking on a detailed sampling and monitoring program using the contractor’s technology, the company was able to demonstrate that, with proper training and supervision in the use of the dual hearing protectors, employees were protected to an average TWA of 79.6 dBA, thus reducing employee exposures to below both the OSHA action and compliance levels.

**Impacts of the Intervention**

As a result of the intervention the company was able to demonstrate to TOSHA that its employees were receiving an adequate level of hearing protection despite the published NRR calculation formulas. TOSHA accepted the intervention as proof that employees were not overexposed to damaging noise levels, in violation of the OSHA PEL. The intervention also provided additional assurance to both management and employees that the dual hearing protection was protecting their hearing. The intervention also demonstrated that the employee who had been removed from high noise exposure due to a permanent threshold shift could return to his former (and higher paying job) as a hammer forge operator.

**Financial Metrics**

No formal value proposition associated with the intervention was initially developed, as it was determined that other options would likely make the facility non-viable. Therefore, as part of the IH Value Study, a retrospective analysis was conducted of three possible strategies to achieve compliance: 1) use administrative controls, 2) purchase a mechanical screw press, and 3) use the hearing dose measuring technology to demonstrate an effective level of protection for employees. The following net present values (NPVs) for each of the projects was calculated for a project length of 5 years:

<table>
<thead>
<tr>
<th>Intervention Evaluated</th>
<th>Net Present Value</th>
</tr>
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<tbody>
<tr>
<td>1. Administrative Controls</td>
<td>($1,799,801)</td>
</tr>
<tr>
<td>2. Purchase Mechanical Screw Press</td>
<td>($563,108)</td>
</tr>
<tr>
<td>3. Demonstrate PPE Effectiveness</td>
<td>($49,467)</td>
</tr>
</tbody>
</table>

Thus, the formal retrospective analysis confirmed management’s judgment that demonstrating PPE effectiveness provided the most cost-effective and rapid solution to achieving regulatory compliance and ensuring the protection of their employees’ hearing. Management also realized that their efforts to reduce employee noise exposures via engineering controls needed to continue on an ongoing basis. However, due to the loud metal-to-metal contact associated with hammer forging processes, it is likely that employees will need hearing protection against hazardous noise exposures as long as this technology is in use.
Lessons Learned

1. The case study demonstrated that an industrial hygienist working with business partners can help protect the overall viability of a business. In this case, management estimated that without the selected intervention it would not have been possible to maintain operational continuity given the nature of a commodity product and the highly competitive global marketplace.

2. The use of PPE can be an effective measure to protect employees in high noise areas.

3. Relying on PPE as the primary means of protection requires extraordinary measures to ensure that expected levels of protection are validated in actual field operations.

4. Where PPE is a primary means of protection, employees must be properly trained and understand the level of hazard so that they can utilize the PPE in the most effective manner.

5. Sound IH investigations and measurement can be a key to reducing employee exposures, ensuring regulatory compliance, and contributing to business profitability.

Case Study 4: Chemical Drum Handling

Background: The operation analyzed was a manufacturing step which involved the manual transfer of materials into a kneader for processing. The original process involved the manual handling of drums, bags, and pails associated with the addition of powders and liquid into the kneader for mixing. The process of weighing out powder and liquid to blend in the kneader was labor intensive and also introduced process fluctuations due to the variability of material mixed caused by manual dispensing.

Hazard Identification
The company is considered a world leader in the prevention of injuries and illness. As part of their safety management system, workplace risk assessments identified the operation as having the potential to cause ergonomic injuries and/or illnesses due to the routine handling of drums, bags, and pails of various weights. The open handling also introduced exposure to low-toxicity dusts, which required air-purifying respirators to be worn.

Hazard Intervention
The intervention involved the design and installation of an automated system to add liquids and powder to the kneader. This design eliminated the manual handling of powders using bags, pails, and scoops at the filling stage. The project included the installation of lifting devices to handle drums at raw material and finished product loading and unloading stations. It also reduced airborne dust exposures that eliminated the need for employees to wear respiratory protective equipment (RPE).

Impacts of the Intervention
The intervention significantly reduced the ergonomic exposure associated with the routine handling of drums, bags, and pails. The company estimated that the intervention would normally eliminate one serious injury over a 10-year period. However, the operation is in a country with very liberal laws regarding injury/illness reporting and disability and as such it is likely that the intervention could achieve even greater cost reductions associated with fewer injuries being incurred. The intervention also enclosed the transfer operation resulting in a more efficient containment of dusts and eliminating the need for RPE at this manufacturing stage.
The intervention also resulted in a significant productivity improvement resulting in one less person needed to operate the kneader process. During the project implementation, a scale was incorporated into the closed transfer process thus allowing more accurate liquid addition and reducing the variability of the quality of the final product.

Financial Metrics
A financial analysis of the intervention showed a 5-year net present value (NPV) of $39,708 with an internal rate of return (IRR) of 32%. This scenario assumed that if the intervention had not been undertaken, one serious ergonomic injury would have occurred during the 5-year period. The company uses an internal cost of $40,000 per ergonomic injury/illness. A second scenario that assumed no injury would occur yielded an NPV of $24,160 with an IRR of 25%. Both scenarios resulted in a discounted payback period (DPP) of 3.1 years.

Lessons Learned
Facility management recognized the ergonomic risk associated with the routine manual handling of drums involved in this production operation. From a financial viewpoint, it was hard to determine future health and safety benefits associated with the project rather than to project that a serious ergonomic injury was likely during the next 5 years. However, the productivity improvement associated with the more efficient handling of drums and the transfer of product were the financial drivers to justify the project. Improvement in operator health and safety, along with improved product quality, were intangible benefits. This project demonstrated that health and safety consequences should be considered when work systems are designed or retrofitted to ensure the benefits to the organization are optimized.

Case Study 5: Carbon Monoxide Control

Background: The following case study involves a company with operations in industrial manufacturing. The case study will focus on a heat-treating facility. The process entailed open-room exhaust of natural gas-fired furnaces and open-room exhaust of endogas (a carbon rich atmosphere used in heat-treating furnaces). Once exhausted to the room, the only ventilation was achieved through axial roof fans.

Hazard Identification
The hazard identified with this particular industrial manufacturing operation involved carbon monoxide (CO) exposure to employees working within a heat-treating facility. CO is a poisonous gas that is odorless, colorless, and tasteless. Carbon monoxide is harmful when inhaled because it displaces oxygen in the blood and deprives vital organs such as the heart and brain from receiving oxygen. CO poisoning can be reversed if caught in time, but even with recovery, acute poisoning may cause permanent damage. OSHA standards prohibit worker exposure to more than 50 parts per million (ppm) over an 8-hour time-weighted average (TWA).

Hazard Intervention
The company identified the hazard as a chemical exposure to employees. The abatement approach involved a change in the administrative and engineering controls. Data points for CO were routinely collected and administrative controls were implemented as necessary. The corporate goal for CO levels was less than half of the TLV for CO (12.5 ppm). This goal was reached by implementing local exhaust ventilation (LEV) as the primary engineering control. All CO emission points (burner exhausts and endogas exhausts) were identified and targeted for LEV source controls. A ventilation system with
variable-speed fans controlled by real-time direct reading electrochemical sensors for CO was installed in the heat treating facility.

**Impacts of the Intervention**
There were many positive health, business and risk management results from the implementation of the engineering controls. Health improvements resulted from the intervention because employees were not directly exposed to CO. Employees were healthier, happier, and more comfortable in the workplace. Health-related absenteeism was reduced drastically. Employee morale increased significantly, improving the quality of the work. The business process was improved because there was a reduction of CO concentration in the heat treat.

While this project did not demonstrate a significant financial payback, many benefits resulted from it. The project demonstrated the leadership commitment to HSE. A major facility aesthetic improvement resulted because all of the smoke and haze were properly exhausted through the LEV system under a state-permitted emission source. There were no changes in product quality or customer satisfaction or service resulting from the intervention.

**Financial Metrics**
The project’s capital requirements were $1.6 million to install the ventilation system. The intervention resulted in a negative net present value (NPV) of -$1,005,597. The internal Rate of Return (IRR) was -25% while the return on investment (ROI) was -56%. Utility costs associated with running the IH-related equipment were expected to increase once the intervention was in place.

**Lessons Learned**
Retrospective analyses do not provide the opportunity to evaluate the costs and benefits of alternative hazard control solutions, but even in negative cost situations IH value can be demonstrated. In this case, the heat-treat operation was an ultimate financial negative but a health, morale, and productivity positive. The benefits were valuable to management, and in time will very likely be shown to have financial payback as well.

**Case Study 6: Noise Abatement**

**Background:** The following case study involves a company with operations in equipment manufacturing. The facility had 27 mechanical pump presses, 16 injection mold machines, and 7 assembly lines for boxing plastic interiors and safety switches. Products were also painted at the facility, using powder coat paint.

**Hazard Identification**
The hazard identified with this particular equipment manufacturing operation involved noise exposure to employees working on the assembly line. The company had a demonstrated history of one hearing shift per year. Approximately 130-150 employees worked in the assembly line area where there was borderline overexposure to noise. Employees working in the fabrication group were exposed to a time-weighted average (TWA) of 89 decibels (dBA) over 8 working hours.

**Hazard Intervention**
The abatement approach involved a change in the engineering controls, but more importantly, an elimination of the hazard altogether. A few engineering changes were made to the process prior to this hazard intervention such as air nozzle replacements; however they were not as effective. One year prior to the intervention, 90% of the facility
was based on hearing conservation. The hearing conservation program was developed in accord with OSHA’s program. The program was intended to protect workers with considerable occupational noise exposures from hearing impairment. Once the hazard intervention was implemented, the need for such a program was eliminated. Every year the company hired consultants to select company sites where they could conduct noise surveys, develop noise maps, and make recommendations to improve working conditions in the assembly line area. This particular sound level reduction project was completed in three days by the consulting group. The project focused on the assembly area with less emphasis on the fabrication area. Employees working in the assembly area were rotated and only worked a maximum of one hour per day.

**Impacts of the Intervention**

There were many positive health, business, and risk management results due to the implementation of the hazard abatement intervention. Health improvements resulted from the intervention because employees were not directly exposed to high noise levels. Employees were healthier, happier, and more comfortable in the workplace. Health related absenteeism reduced drastically. Employee morale increased significantly, improving the quality of the work.

The business process was improved because there were no costs associated with the hearing conservation program for the assembly line. Hearing protection, audiometric booths, and training requirements had been eliminated because the noise level was below 85 dBA in the assembly room. The costs associated with following these requirements were saved. Studies showed the fabrication area still had a few hydraulic presses that made noise after the sound levels reduction project was implemented.

The only major financial impact that resulted which affected the business process was the cost of hiring a consulting firm to assess the situation. Many positive benefits resulted from the intervention. The company was able to obtain a more accurate calculation of the true time-weighted average (TWA) for the noise exposure through noise surveys and mapping. The process used was more accurate than using noise dosimeters. Temporary employees were also eliminated from the Hearing Conservation Program. The program was reduced by 75 employees. Employees were also at a lower risk of being written up for having improper PPE. Industrial hygienists were necessary to complete an accurate survey of noise levels within the assembly areas. The company plans to conduct an IH study on sound reductions in the future.

**Financial Metrics**

The costs associated with time spent on managing the noise hazard by industrial hygienists and safety staff increased during the time the project was being implemented; however, once the intervention was completed the costs associated with the time spent by these individuals was greatly reduced. The noise abatement intervention resulted in a Net Present Value (NPV) of $47,249 and a NPV for future hearing loss of $198,015. The Internal Rate of Return (IRR) was 161%, while the Return on Investment (ROI) was 98%. The discounted payback period (DPP) was 0.6 years.

**Lessons Learned**

The economic circumstances of PPE programs support the IH hierarchy of controls. Personal protective equipment (PPE) programs that require periodic monitoring of the workplace and employee health status, as well as enforcement, equipment purchase and follow-up, are often more expensive in the long run and less effective than either engineering controls or complete hazard elimination. Management of PPE programs requires costly resources, and should be considered as a last resort in situations where other measures are not available or are in the process of installation.
Case Study 7: Metal Removal Fluid Management Control Plan

Description of Operation
The following case study involves a company with operations in auto manufacturing. The process involved an automotive transmission machining plant for a global transportation company. This case study focuses on a machining department where metal removal fluids (MRF) such as lubricants and coolants are utilized in production processes.

Hazard Identification
The hazard identified with this particular equipment manufacturing operation involved employee exposure to contaminated metal removal fluids in the automotive transmission machining plant. In 2002, an employee reported to the plant medical department with complaints of respiratory illness while working in machining plant. The employee was working in a machining department where metal removal fluids (MRF) such as lubricants and coolants were utilized in production processes.

A subsequent medical examination confirmed that the employee was diagnosed with occupational hypersensitivity pneumonitis (HP). The employee received medical treatment, was placed on medical leave, and an investigation of the cause of the disease was undertaken. Hypersensitivity pneumonitis is a serious lung disease associated with exposure to microbiologically-contaminated aerosols of some synthetic, semi-synthetic and soluble oil metalworking fluids. In the short term, HP is characterized by coughing, shortness of breath, and flu-like symptoms (fevers, chills, muscle aches, and fatigue). The chronic phase (following repeated exposures) is characterized by lung scarring associated with permanent lung disease.

Hazard Intervention
The company identified the hazard as microbiological contamination of the metal removal fluid. The abatement approach was to change the type of fluid in use and implement a comprehensive MRF Control Plan that provided for proper selection of metal removal fluids, development of efficient coolant and machine maintenance schedules, and design of effective ventilation systems to maximize control of coolant aerosols.

The initial study and completion of IH risk assessments did not identify a clear relationship between known air contaminants in the work environment and the respiratory disease. Therefore a multifunctional task force was created, with the primary objective to eliminate the risk of respiratory disease (HP) associated with metal removal fluid (MRF). The task force represented the following: division and plant functions, corporate/plant IH, corporate research and development IH, plant union S&H and IH, division/plant medical, corporate/plant environmental engineering and chemical management, plant manufacturing leadership, manufacturing engineering, and maintenance. The task force conducted numerous exposure assessments, research studies, production process changes, and maintenance process improvements.

Impacts of the Intervention
There were many positive health, business, and risk management benefits that resulted from the implementation of the comprehensive MRF Control Plan. Health improvements resulted from the intervention because the air contaminant exposure associated with MRF machining was eliminated or reduced and employees were no longer directly exposed. No further cases of HP have been reported in the four years following the intervention. Employee respiratory complaints were eliminated or reduced. Employees were healthier,
happier, and more comfortable in the workplace. Employee morale increased significantly, improving the trust and confidence of employees in the S&H program.

The business process was improved as tooling life was extended and therefore tooling costs were reduced. Many risk management benefits resulted from the intervention, including enhanced relationships between the division and plant union management. Management and engineering systems to support MRF S&H goals were enhanced. Another benefit involved the development of improved bio-stable coolant strategies.

**Financial Metrics**

As part of the value study, a retrospective analysis was conducted with an incremental approach to reduce workplace illnesses, and improve the risk management and business processes. After using the Value Study Data Collection Tool and entering the data in the ROHSEI software, the net present value (NPV) for the project was calculated for a project length of 5 years, resulting in $991,888 NPV. The internal rate of return (IRR) was 120%, while the return on investment (ROI) was 22%. The discounted payback period (DPP) was 0.5 years. Total costs after reducing, mitigating, or controlling the IH hazards were $2,883,573.

Management also realized that their efforts to reduce employee exposures to air contaminants from metal removal fluids through a comprehensive MRF Control Plan needed to continue on a regular basis. The process is now institutionalized.

**Lessons Learned**

Without IH involvement in this problem, it would have been difficult to identify the source of the hazard because the relationship between illness and MRF is not well understood. With experience investigating complaints of this nature, IH was able to pinpoint the microbiological nature of the hazard and make recommendations that solved the problem.

Ultimately, the task force concluded that an effective MRF Management Program is essential for ensuring the health and safety of employees working in aluminum and iron metal machining operations. This was accomplished by developing a comprehensive MRF Control Plan that provided for proper selection of metal removal fluids, development of efficient coolant/machine maintenance schedules, and design of effective ventilation systems to maximize control of coolant aerosols. A multifunctional taskforce, including IH, was required to consider all aspects of S&H as well as manufacturing processes. The industrial hygienists played a key role in this task force.

**Case Study 8: Control of Lead Exposure in a Foundry**

**Description of Operation**

The facility is a foundry that makes automatic diesel engine blocks using both cupola and induction melting processes. The facility purchases various forms of scrap metal from scrap metal suppliers, re-melts the scrap, and pours it into engine block molds. After cooling, the casts are machined before being sent to the engine assembly facility.

**Hazard Identification**

Some of the scrap metal purchased from scrap vendors contained lead bearings and bushings, structural steel scrap with lead-based paints, and chunks of lead-containing materials. The melting of lead-contaminated scrap creates airborne lead exposure to employees as well as poor casting quality. As a result of the employee lead exposures, the company instituted a series of changes in its IH program including a medical surveillance
program to monitor employee blood lead levels. A respiratory protection program was also initiated to protect employees who worked in the melting and metal pouring processes from overexposure to lead.

**Hazard Intervention**
The foundry was faced with either continuing to implement a more stringent lead exposure control program or finding another means of eliminating the lead in the process. In addition to medical surveillance and PPE the facility was also faced with the prospect of expensive engineering controls to control lead exposures. As an alternative, a process was developed to ensure that suppliers supplied scrap metal that was free of lead contamination. Such a purchasing specification existed but was ineffective and required changes that included the aggressive enforcement of the supplier scrap procurement requirements and the use of internal scrap inspection procedures.

**Impacts of the Intervention**
As a result of the aggressive purchasing specifications and increased inspections of incoming scrap metal, the melting and pouring processes were maintained free of any significant employee airborne lead exposures. Medical surveillance demonstrated that there was no lead detected in employee blood tests and the need for respiratory protection for lead exposure in manufacturing operations was eliminated.

The option to focus on the elimination of lead versus providing employee protection and engineering controls resulted not only in higher levels of employee protection, but also in millions of dollars in savings for the facility. Given the strong competitive pressures in the industry, it is possible that eliminating the hazard through stringent purchasing controls helped to keep the facility viable and saved hundreds of jobs.

The elimination of lead in the scrap metal feedstock also resulted in the prevention of lead from being introduced to the cast engine blocks. Any significant amount of lead in the engine blocks would degrade the overall strength of the casting. Previous quality problems that resulted from lead contamination had been noted.

**Financial Metrics**
A retrospective ROHSEI analysis was computed for the actual costs associated with the purchasing controls versus the potential costs associated with enhanced respiratory protection and engineering controls. Improving the purchasing controls and enhanced inspections required the hiring of additional inspectors, rewriting scrap specification procedures, and retraining of management and employees. The 5-year cost was a net present value (NPV) of ($1,125,347). The estimated 5-year cost associated with enhanced employee respiratory protection and significantly upgraded exhaust ventilation was a net present value (NPV) of ($20,735,212). Thus the option to eliminate the exposure was both a far superior business option as well as an approach that virtually eliminated employee lead exposure and the associated health hazard.

**Lessons Learned**
At this facility, management recognized the threat that lead contamination presented to the employees and the product. Contracts with waste suppliers clearly stated the need to severely restrict any lead-containing materials in the scrap metal provided. However, there was reluctance by management to take firm action to control vendors due to the competitiveness of the scrap market and a concern about not receiving sufficient scrap to supply the facility.

The site IH professional served as the catalyst to drive management actions. Identification of employee health risks, as well as defining the necessary actions to
control those risks via PPE and engineering controls, convinced management that firm action was needed to enforce contract provisions and implement stringent on-site scrap audits to verify supplier compliance with the contract provisions.

**Case Study 9: Chemical Containment**

**Description of Operation**
The operation where the intervention occurred is a process step in the manufacturing of active pharmaceutical ingredients which are subsequently formulated in various drug products. The current operation was an open process involving the repack of resin columns using an acetonitrile (ACN) slurry.

**Hazard Identification**
The current operation involved the addition of ACN into an open manway of a process tank. During the operation two operators were exposed to levels of ACN ranging from 60-100 parts per million (PPM). Operators were required to wear powered air-purifying respiratory protective equipment to protect against airborne ACN exposures that were created during the solvent charging process.

**Hazard Intervention**
To reduce exposure an engineering control consisting of purchasing and installing a high containment valve was implemented. By using the high containment valve for charging the tank, airborne exposures of ACN were virtually eliminated.

**Impacts of the Intervention**
Due to the installation of engineering controls the airborne levels of ACN were reduced from the 60-100 PPM range to less than or equal to 1 PPM. The resultant exposure level eliminated the requirement for operators to wear respiratory protective equipment (RPE). As a result there was a cost savings associated with the elimination of the RPE as well as the associated time required to properly don/doff the RPE. Prior to the intervention the process step required three operators, which was subsequently reduced to two operators after the implementation of the containment project thus significantly reducing overall labor costs associated with the operation.

Although no quality deviations had been previously associated with this manufacturing step the containment and enclosure of the open process were also recognized as a quality control improvement. In addition, containing the process also eliminated foaming issues sometimes noted during the operation of the process, but the benefit of the reduction has yet to be fully evaluated.

The process change also reduced by one third the amount of ACN lost to the environment during the operation thus allowing a small material savings and a corresponding lowering of volatile organic compound (VOC) air emissions. The enclosed process would require additional Leak Detection and Repair (LDAR) monitoring points to be added to the environmental monitoring schedule, but the incremental cost was minimal.

Another benefit of the project was the elimination of the need to dispose of used RPE as hazardous waste. As a result one drum of hazardous waste per month and the associated disposal costs were eliminated.

**Financial Metrics**
The financial metrics associated with the intervention indicated that the project yielded a 5-year net present value (NPV) of $23,629 with an internal rate of return of 14%. The
project had a discounted payback period of 3.8 years. Therefore in addition to the benefits of lower employee ACN exposures, improved quality, reduced air emissions and reduced hazardous waste the project also yielded a competitive rate of the return on the organization’s investment. The project also resulted in some improvement in employee morale due to eliminating the need for the wearing of respiratory protective equipment.

**Lessons Learned**
The benefits of making IH-related process improvements that many times are designed to reduce or eliminate employee health exposures can also result in significant business improvements or savings. In this case the implementation of engineering controls resulted in a process change that reduced labor and material costs, improved product quality, reduced air emissions, and reduced the volume of hazardous waste generated and its associated disposal cost and liability.

**Case Study 10: Potent Pharmaceutical Compound Containment**

**Description of Operation**
Pharmaceutical manufacturing operations require the mixing, blending, and processing of multiple compounds to obtain finished drug products. Increasingly, new active drug compounds are becoming more potent thus increasing their toxicity to workers who may be exposed to the substances during manufacturing. One area of potentially high exposure to workers is the dispensing of pharmaceutical ingredients during various stages of the manufacturing process. Traditionally, dispensing was performed by carefully hand scooping powders into containers or directly into process equipment.

**Hazard Identification**
With the increasing potency of new drug entities, companies are finding that high levels of personal protective equipment are required to meet minimum protection requirements. As drug research has identified even more potent compounds, respiratory protective equipment with Assigned Protection Factors (APF) as high as 1000 have been found to be insufficient to provide adequate employee protection. In this case the manufacturer recognized that the use of powered air-purifying respirators (PAPR) with an APF of 1000, although currently sufficient, would not effectively protect operators from the new generation of drug substances being developed. It was determined that containment technology needed to be developed that would allow for the accurate measurement and dispensing of powered drug compounds but that would also protect workers from potent compound dust exposures.

**Hazard Intervention**
The company formed a team to determine a dispensing method that incorporated the necessary parameters to optimize the combination of manufacturing accuracy, quality control, cost control, and employee safety and health. The team determined that using flexible containment glove bag technology verses fixed containment systems was the most effective solution to control dust exposures during dispensing operations.

**Impacts of the Intervention**
The intervention achieved all of the necessary requirements of the project. The glove bag technology lowered the exposure risk by a factor greater than 1000 with the actual exposure measures being significantly less than 10% of the established Occupational Exposure Limit (OEL). As a result of the intervention there was no longer a need for operators to wear respiratory protective equipment. Used glove bags are required to be
incinerated after use however the overall volume of hazardous waste for incineration was reduced by 75% since the need to dispose of PAPRs was eliminated.

As a result of the intervention operator confidence in the level of protection being provided is extremely high.

**Financial Metrics**
The project resulted in a 5-year net present value of $27,585 with an internal rate of return of 98%. The discounted payback period for the project was 0.9 years. No capital investment was required since the glove bag equipment was already available at the facility. The savings in respiratory protective equipment, labor time to don the RPE, and disposal costs of the RPE more than offset the planning time associated with the project and the cost of purchasing and disposal of the glove bags.

The intervention also demonstrated a level of containment that satisfies the requirements of EU and US pharmaceutical regulatory agencies with regard to the cross-contamination of active pharmaceutical ingredients. The alternative to the solution provided by the intervention would have required a segregated facility to dispense compounds. Such a facility would have cost several millions of dollars in capital expense. These costs were not considered in the financial metrics listed above.

**Lessons Learned**
The project showed containment projects can result in improvements in employee health exposures and savings in labor and waste disposal costs. This case demonstrated an example where containment projects require little incremental capital investment to accomplish significant results.

The project not only addressed the current challenge of employees wearing cumbersome respiratory protective equipment but also addressed the developing concern about the existing RPE providing ineffective protection for newer and more potent pharmaceutical compounds.

**Case Study 11: Chemical Substitution; Process Containment**

**Description of Operation**
The company makes a proprietary product that is used in the manufacturing of hybrid car batteries. The product is manufactured at the nano-scale and has the potential to become part of a significant growth industry given the focus on reducing the USA’s carbon-based energy dependence. The operation prior to the intervention was a batched-based production process involving nine steps which included manual handling and potential employee nano-particle and ergonomic exposures at each step.

**Hazard Identification**
In addition to the threat of inhalation of nano-sized particulates the existing process used titanium tetrachloride (TiCl4) as a catalyst. Titanium tetrachloride is very irritating to the eyes, skin, mucous membranes, and lungs. The use of TiCl4 required extra levels of worker protection during the addition of the compound as well as the use of pollution control equipment to scrub out the chlorine gas from the production process before it was exhausted to the atmosphere. In one case, a breakthrough of chlorine gas through the scrubber system occurred, resulting in an air quality violation and fine from the city.
In addition to the TiCl4 catalyst, the old operation involved the manual transfer of lithium and titanium compounds in a nine-step batch manufacturing process. Each step involved the open-air transfer of product, creating the potential for air and skin exposures as well as the ergonomic hazards associated with the manual handling of 50-pound bags.

**Hazard Intervention**

The intervention involved redesign of the production process, changing the way the final nano-product was manufactured. As part of the intervention new capital equipment was purchased that reengineered or enclosed several of the existing process steps and as a result eliminated seven manual handling operations. The redesigned process now only requires manual handing at the beginning and end of the production process. Modifying the process also allowed for the elimination of TiCl4 for use as a catalyst in the process thus eliminating the potential for operator and community exposures to the material and its decomposition products.

**Impacts of the Intervention**

In addition to the elimination of TiCl4 the equipment containment also reduced exposure to the final nano-product particulates at three points in the process. Previously, operators were required to wear acid/dust respirators and now are wearing simple air-purifying respiratory protection at the first and last process steps, where loading of the raw materials and unloading of the finish product occurs. By changing the process the need to maintain and comply with air quality permits associated with chlorine emissions was also eliminated.

The redesign of the process also contributed significant production-related advantages. The new process has the capability of increasing the production output by a factor of 10 in the same building space. The production capacity increase has required the doubling of the production staff running the new process, resulting in a five-fold increase in product produced.

**Financial Metrics**

Financial metrics were calculated for the product costs but benefits of additional production capacity have not been provided.

**Lessons Learned**

By utilizing IH principles and practices of elimination and product containment, the project was able to achieve reductions in the potential for both employee and community exposures to potentially hazardous substances. This was accomplished by integrating IH concepts into a major process redesign which significantly expanded production capacity. This resulted in the benefit of increasing production output and subsequent revenue opportunities as well as improving employee health and welfare at several levels.

Specific benefits of the project intervention included:

1. Improved employee and facility productivity
2. Improved product quality – including fewer reworks
3. Improved public image through the elimination of the potential for chlorine emissions
4. Achievement of sales and production goals
5. Lower employee dust and ergonomic exposure levels
6. Improved employee morale due to less manual handling, lower PPE requirements, and a cleaner workplace.
Case Study 12: Automated Baler

Description of Operation
The facility manufactures paper packaging products. The intervention was performed on a waste paper baling operation.

Hazard Identification
The waste paper baling operation required that three operators spend approximately 30 minutes at the end of each shift (three shifts per day) loading paper scrap into the existing manually-loaded scrap baler. The operation was labor-intensive with operators grabbing armfuls of shredded paper and cramming the scrap into the baler. The operation required awkward lifting, twisting, and postures. An ergonomics risk assessment determined that, because of the various and continual ergonomic stresses present, the operation posed a high risk of causing a serious musculo-skeletal injury.

The facility had not experienced any ergonomic injuries associated with the baling operation but from past company experience the medical and disability costs associated with lumbar injuries averaged from $7,500 to $50,000 per injury.

Hazard Intervention
The company decided to eliminate the hazard by purchasing an automatic loading baler to fully replace the manual handling associated with managing the shredded paper scrap.

Impacts of the Intervention
The intervention completely eliminated the risks associated with the manual handling during the waste baling operation. The new baler takes waste directly from the packaging production equipment and automatically bales and stacks it. In addition to removing the ergonomic risks, the intervention eliminated the need for three operators to devote 30 minutes at the end of each of three daily shifts to hand-load scrap onto the old baler. The intervention also eliminated the need for operators to wear PPE for eye hazards and nuisance dust. From an operator morale viewpoint the intervention eliminated an unpopular task that was frequently rotated among the 47 production workers at the facility.

In addition to the direct labor saving benefits, the automated baler also reduced the amount of paper dust generated during the scrap handling operation. This resulted in less paper dust being distributed throughout the site, requiring less facility-wide cleaning while saving labor time and also contributing to a cleaner process and product.

The reduction in dust buildup was considered by the property insurance provider to have lowered the facility’s fire risk.

Financial Metrics
The 5-year net present value (NPV) of the project was -$1,385 using a discount rate of 8% and an inflation rate of 3%. The only costs included in the analysis were the labor savings from eliminating the need to manually load the baler and the capital cost of the baler purchase and installation. The costs associated with injury reduction, facility cleaning, and PPE elimination were not included.

Lessons Learned
Although the project did not yield a sizable financial return on investment, the intervention did return the company’s cost of capital while reducing a significant risk of injury due to manual handling. The project also illustrated that improvement in health and safety conditions often results in improved labor productivity. In this case the
positive benefits of the intervention were transferable to other facilities within the company thus serving as a best practice for the corporation.

Case Study 13: Radiation Safety Management

Description of Operation
The following case study involves a company with operations in petroleum processing and chemical manufacturing. The specific process where the involvement of industrial hygienists has contributed value is the delayed coking operation. Delayed coking is a thermal cracking process that upgrades and converts petroleum residuum (bottoms from atmospheric and vacuum distillation of crude oil) into liquid and gas product streams, leaving behind a solid concentrated carbon material called petroleum coke. The temperature inside the steel coking drum routinely reaches 800° F. Nuclear level gauges in conjunction with gamma-based detectors are used to measure rising levels of coke inside the coking drum because there are no other alternatives.

Hazard Identification
The radiation sources can create a considerable health risk to affected workers if it is not properly controlled. Therefore the Nuclear Regulatory Commission has strict requirements for licensing sources and training of those who handle them. IH helps maintain the license of the material and retains the level of training necessary to manage the testing process.

Hazard Intervention
The hazard was identified as ionizing radiation. The installers and users of the radiation devices were trained on the process hazards, including exposure to radiation. The entire nuclear process could not happen without the IH program—radiation-trained experts are essential to the process.

Impacts of the Intervention
The value of the IH program to the business process is that it enables the company to take advantage of the price margin that delayed coking offers. Delayed coking is much cheaper to install and operate than the alternatives, such as fluid coking. If the delayed coking process were not used, lighter, sweeter crude oil would be used instead of the heavier crude oil, essentially reducing profitability significantly.

Some small negative financial impacts resulted to the business process because it required training for the people installing the radiation devices and the employees using the devices. Overhead charges such as these are necessary in order to use the radiation devices. However, these are insignificant in comparison to the benefit.

The intervention produced a greater need for industrial hygienists therefore, their job functions changed in the process. Industrial hygienists were used effectively for maintaining the license of the training materials. Industrial hygienists determined that radiation trained experts were critical to the process.

Financial Metrics
The $10 per barrel profit margin that delayed coking enables is worth $81,250,000 per year, based on production of 125,000 barrels a day. This provides a profit of $1.25 million per day on the 65 days per year that the coker is operated.

Lessons Learned
By providing an essential function to a highly profitable process, industrial hygienists have contributed value. Without them radiation detection in the delayed coking process could not have happened.

Case Study 14: Furnace Repair- Heat Stress

Description of Operation
The following case study involves a company with operations in chemical manufacturing. The unit of focus was a furnace that was 22 feet across, 12 burners long and 60 feet high.

Hazard Identification
The hazard identified with this particular chemical manufacturing operation involved heat stress for employees completing heavy work on the furnace. Weather conditions involving 100° F temperatures for completing this type of work were not optimal. Problems with the furnace first began in late April of 2007. Unsupported bricks inside the furnace were in need of maintenance because they were falling apart and collecting on the furnace floor. If no action was taken, complete failure of the furnace would result. Furnace failure would lead to an inevitable shutdown. The operation involved high air temperatures, extreme heat sources, high humidity, direct physical contact with hot objects, and strenuous physical activities, which had a high potential for inducing heat stress in employees engaged in the work. The goal was to complete the repair job flawlessly and on time.

Hazard Intervention
The company identified the heat stress hazard as a physical hazard to employees. The abatement plan was developed by the Joint Safe Operations Committee (JSOC). The abatement approaches involved changes in the PPE, administrative controls, and engineering controls, although the latter was the more effective level of control. The method used to repair the furnace involved fixed equipment engineering, where the repair would take place from the outside. A slot 16 feet wide and 6 inches long was cut on the outside of the furnace to hold the bricks in place. Then a steel shelf (expanded metal plate) was inserted on the top edge of the furnace. Finally, ceramic fiber refractory was injected to fill in the hole. The furnace was under negative pressure. The team also conducted a “what if” analysis to anticipate all the hazards. Once the analysis was complete the team recognized that setting up a hot zone and cool-down tent was important for maintaining a safe environment.

Impacts of the Intervention
There were many positive health, business, and risk management results due to the implementation of the hazard abatement intervention. Employees were protected from exposure to heat stress, as heat stress management was used to control potential health risks. This included development of a work-rest schedule where 25% of time was spent working and 75% of the time employees were resting. There was also a very positive impact on employee morale.

The business process was improved since there was no shutdown of the process, which would have caused an $8-10 million loss. If the unit had been shutdown other units would have to be shutdown as well. A total shutdown for 10 days would cost approximately $15 million. The knock-off effect (2:1) was included in the estimation. If the wall inside the furnace had failed, a shutdown of 10 days would have occurred.
<table>
<thead>
<tr>
<th>Shutdown Type</th>
<th>PHLA</th>
<th>Knockoff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planned slowdown</td>
<td>$4 million</td>
<td>2:1</td>
</tr>
<tr>
<td>Emergency slowdown</td>
<td>$8 million</td>
<td>2:1</td>
</tr>
</tbody>
</table>

Many positive benefits resulted from the intervention. There was no impact on production rates during the repair process. The amount of time spent on planning was significantly shortened. Risk management was greatly improved because the intervention provided many opportunities for heat stress reduction throughout other areas within the plant.

**Financial Metrics**
The lost production parameter is the most important parameter. Additional process staff costs were minimal with approximately 12 hours of additional work required. The total cost for mechanical repair would be $150,000 if a shutdown occurred for 7 days.

**Lessons Learned**
Integrating industrial hygienists into the planning of operations at the right time is of key importance. Early communication of the hazards by industrial hygienists to the management level will allow for the interventions to be more efficient and less risky. Management needs to learn where industrial hygienists fit in the process and where they can be most effective. There is great value in having properly allocated resources. The Safety and Health Group was a core part of the team from the beginning of the intervention to the end. Completing the project the way it was could have been seen as inherently dangerous, but involving the IH and safety points of view allowed for the approach to work. The intervention was broken down into components, which were then analyzed to determine how to manage them.

**Case Study 14: Asbestos Case Study**

**Description of Operation**
The following case study involves a company with operations in chemical manufacturing. The unit of focus was an Atmospheric Distillation Tower where crude oil would flow through, eventually dividing into four various streams. The tower was 80-90 feet tall, 18 feet in diameter, and was insulated with 60% chrysotile asbestos.

**Hazard Identification**
The hazard identified with this particular chemical manufacturing operation involved asbestos exposure to employees working near the Atmospheric Distillation Tower, which contained asbestos insulation that was in exceedingly poor condition. Once the tower cooled down the insulation would come off and large pieces of asbestos would fall and strike employees working in the area. Severe weather was also of concern because during heavy rain the asbestos would become saturated, increasing the weight by 3-4 times the original weight.

**Hazard Intervention**
The company identified the asbestos hazard as a chemical exposure to employees. The abatement approach involved a change in the engineering controls. Four abatement options were considered by the company. The option chosen entailed abating the remaining asbestos during the turnaround (TAR) period by requiring a full enclosure of the tower, using a methodical, step-by-step approach. Repairing the insulation was not an option due to the poor condition the insulation was already in and the work schedule
conflicted for the upcoming TAR. Previously, a partial enclosure method, using metal jacketing had been attempted, but it was not effective in abating the asbestos.

**Impacts of the Intervention**
There were many positive health, business and risk management results due to the implementation of the hazard abatement intervention. Health improvements resulted from the intervention because employees were not directly exposed to falling asbestos. The business process was improved since there was no impact to the length of the TAR period, which allowed for no margin loss and essentially suspended over $6 million unit shutdown costs. Residual risks did not result from the TAR because it was easy to reduce the remaining asbestos. The full enclosure of the tower with fire-resistant material did have a higher cost than other options such as partial enclosure methods that were considered. Some negative financial impact resulted to the business process because it required supplied air, A/C systems, air movers, PPE, and other equipment. However, many positive benefits resulted from the intervention.

The company was able to avoid the potential for heavy litigation costs related to asbestos exposure and contamination. The intervention represented a new process that could be used not only in other facilities, but also in other such vessels within the plant. Since the hazard was eliminated, the effects of the intervention were felt over time, fundamentally reducing risk and operating expenses plant-wide. The emergency response processes were also greatly simplified and associated costs were saved. The company also avoided many environmental costs, including asbestos cleanup and regulatory costs associated with “willful” incidents. Safety issues concerning the process of abating the asbestos were extensively reviewed by company industrial hygienists.

**Lessons Learned**
Integrating industrial hygienists into the planning of operations at the right time is of key importance. Early communication of the hazards by industrial hygienists to the management level will allow for the interventions to be more efficient and less risky.

**Conclusion**
The AIHA Value Strategy and *Qualitative* and *Quantitative Approaches* work. The best way to capture the value that industrial hygiene adds to the business is to look at IH risk reduction and track it’s impact on employee health, the IH risk reduction process, and the business process in general. This can be done with a *Quantitative Approach*, a *Qualitative Approach*, or a combination of the two.

Additional work is needed to refine the *IH Value Strategy*, to develop representative values where appropriate, and test additional parameters. But these strategies represent a significant step forward for the IH profession. The hoped-for change in business perception of IH will occur only if industrial hygienists respond to the challenge and put these tools and techniques to use.
Management Practices Demonstrating the Value of the Profession

Introduction

A study was designed to identify components of management systems that have demonstrated the value that Industrial Hygiene and Occupational Health (IH/OH) program practices can have on an organization’s business results. A survey instrument was distributed by ORC to its participating companies late in 2007. Twenty-four companies responded. To identify these components, a survey instrument was developed and based on the Malcolm Baldrige Award Criteria for Performance Excellence (Criteria).

The Criteria are a set of empirically-derived, model business approaches pulled together into a system that represents the best practices of many of the best performing companies in the world. They form a comprehensive, complete business architecture and are looked upon internationally as a strategy for sustained performance excellence. They have also been refined and improved over their 20-year existence as more effective business approaches are demonstrated.

The National Institute for Standards and Technology (NIST) manages the Malcolm Baldrige National Quality Award program for the Department of Commerce. This award program recognizes those few excellent businesses that can demonstrate to a group of national award examiners that the implementation of the first six categories of Criteria produce the Business Results required in Category seven. The award is about excellent results using recognized best systems. A company cannot win the award without demonstrating sustained excellent business results through sustained implementation of the Criteria.

For this study, the Criteria served as an architecture upon which to base survey questions. The Criteria comprehensively covers all aspects of a business and would therefore catch most opportunities to identify the demonstrated value that Industrial Hygiene and Occupational Health (IH/OH) program practices can have on an organization’s business results.

The survey questions dealt specifically with an organization’s IH/OH focus through the lens of these Criteria. The aim was to examine the relationships between Business Results and the six Baldrige Criteria areas:

- Leadership
- Strategic Planning
- Customer Focus
- Management, Analysis and Knowledge Management
- Workforce Focus
- Process Management

Executive Summary – Results

In general, the analysis of the survey responses showed a positive relationship between selected “yes” answers to Leadership, Strategic Planning, Customer Focus, and Workforce Focus questions and “yes” answers to Business Results questions.
Specifically, the following relationships were statistically significant, i.e., high numbers of Yes answers to these questions corresponded to high numbers of Yes answers to Business Results questions. In other words, there was a statistically significant relationship between the following conditions and improved business results.

**Leadership:** When senior leaders regarded a productive IH/OH program as a competitive advantage.

**Strategic Planning:** When the IH/OH program made performance improvement projections as part of the strategic or action planning process.

**Customer Focus:** When external customers required evidence of a specific level of IH/OH program performance or proficiency.

**Workforce Focus:** When (1) IH/OH considerations were included as part of employee (including leadership) development, and (2) the company used IH/OH programs as a tool to recruit, hire and retain employees.

Although a direct cause and effect relationship cannot be statistically determined with limited data available, it appears that companies that pay particular attention to IH/OH programs and practices through the aspects listed above in leadership, strategic planning processes, customer issues, and workforce development are more likely to see improved business results than those companies that don’t.

**Methods**

*Data Collection and Analyses*

Seven business aspects related to Industrial Hygiene and Occupational Health programs were measured. Each was measured using 8 questions: 4 of the questions required a Yes/No response, and another 4 questions were aimed at a quantitative measure of each Yes/No response. Unfortunately, the number of missing answers to the quantitative responses was too high to examine relationships using the quantitative measures in the analysis.

Three distinct statistical analyses were used to examine relationships between the Business Results responses and the responses associated with Leadership; Strategic Planning; Customer Focus; Management, Analysis and Knowledge Management; Workforce Focus; and Process Management. Three analyses were used in order to obtain three different perspectives on the significance of the results. The 24 respondents offer a reasonable picture of the population of companies and insights into IH/OH practices. However, the sample size of 24 companies presented challenges when attempting to use all 48 predictive components of Business Results. For that reason, the predictive variables were combined for two of the analyses conducted.

*Analysis 1: Test of Proportions*

The first analysis was a hypothesis test to determine if the proportion of “Yes” Answers to each of the questions posed was the same as the proportion of yes answers to each Business Results question. Assume that i is a placeholder for each of the 24 questions asked in the survey, and j a placeholder for each of the 4 Business Results questions. Ninety-six hypothesis tests were run:

\[
H_0: p_i = p_j \\
H_1: p_i \neq p_j
\]
The test was run using Fisher’s exact test, and any test with a p-value < .05 was highlighted. [Note that with 96 tests, the average number of tests wrongly identified as significant would be about 5].

The results of this test are shown in Table 2. It shows the p-value of each of the 96 hypotheses tested. When the test showed a statistically significant difference, it practically means that the proportion of Yes answers of Business Results changed depending on the proportion of Yes answers of the dimension tested. The results from these tests showed that when answers to the questions were No, Business Results answers were typically No. However, when the answers to the questions were yes, the answers to the Business Results questions were just as often Yes as No, and sometimes more often Yes. These relationships are shown in Figures 1 and 2.

Analysis 2: Regression Analyses
The purpose of the regression analysis was to determine if knowing information about each of the Baldrige categories (e.g., Leadership, Strategic Planning) could help to predict improved Business Results. This set of analyses required a compilation of the questions from each dimension surveyed. Rather than examining each question separately, each dimension compiled all 4 of the Yes/No questions by taking the average number of yes responses, and comparing it to the average number of yes responses for Business Results. It was necessary to reduce the number of independent variables because of the limited sample size of the survey.

Note that this analysis offers insights into potential relationships. However, the analysis violates some underlying assumptions that should be in place to ensure the statistical rigor of regression, and results should be considered in that light.

Based on scatter plots of the data, a quadratic strategy was fit for the following relationships.

\[
\begin{align*}
BR &= 0 + 1L + 2L^2 \\
BR &= 0 + 1SP + 2SP^2 \\
BR &= 0 + 1CF + 2CF^2 \\
BR &= 0 + 1W + 2W^2 \\
BR &= 0 + 1M + 2M^2 \\
BR &= 0 + 1PM + 2PM^2
\end{align*}
\]

Two hypothesis tests were conducted for each strategy:

\[
\begin{align*}
H_0 &: 1 = 0 \\
H_1 &: 1 \neq 0 \\
\text{and} \\
H_0 &: 2 = 0 \\
H_1 &: 2 \neq 0
\end{align*}
\]

and p-values are shown for each strategy. When these tests were significant (p < .05), the strategy was constructed and the relationship described with a graph and the strategy listed. In addition to the strategy, prediction intervals were constructed for the strategies.

There are two key take-aways from this analysis. The first is that there were several significant relationships, i.e., knowing the proportion of Yes responses to the dimensions allows prediction of the proportion of Business Result Yes responses. The second take-away is that even though there are statistically significant strategies, examination of the
prediction intervals shows that the preciseness of prediction is limited. This is a function of sample size as well as underlying variability in the prediction.

**Analysis 3: Analysis of Variance**
The final analysis tested whether the proportion of Yes answers to BR questions changed depending on the proportion of Yes answers seen on the survey for each dimension measured. The following hypothesis test was conducted for each of the six dimensions measured in the survey:

\[ H_0: \quad \%\text{BR Responses when 0% yes responses for dimension in study} = \]
\[ \%\text{BR Responses when 25% yes responses for dimension in study} = \]
\[ \%\text{BR Responses when 50% yes responses for dimension in study} = \]
\[ \%\text{BR Responses when 75% yes responses for dimension in study} = \]
\[ \%\text{BR Responses when 100% yes responses for dimension in study} \]

**H_1:** at least 1 inequality

When this test was significant, the means that were different were identified at the end of the analysis.

**Survey Questions**
Below is a list of the survey questions used. Also below is Table 1 that links the survey question number (e.g., 1, 7, 12, 18) to the Baldrige category and question number within the category.

**Leadership Questions**
1. Have senior leaders implemented a company-level policy/other guidance to support the IH/OH program?
2. Is there a senior leadership sponsor for the IH/OH program?
3. Do senior leaders regard a productive IH/OH program as a competitive advantage?
4. Does senior leadership include IH/OH objectives (e.g. safe products and processes), as part of the communicated organizational vision and ethics expectation?

**Strategic Planning Questions**
1. Is the development of IH/OH strategic objectives part of your company's strategic planning process?
2. Do your IH/OH strategic objectives focus on meeting one or more strategic challenges?
3. Are specific action plans deployed to the organization to ensure the achievement of IH/OH strategic objectives?
4. Does your IH/OH program make performance improvement projections as part of the strategic or action planning process?

**Customer Focus Questions**
1. Do any company external customers require evidence of a specific level of IH/OH program performance or proficiency?
2. Do the IH/OH program functions use systematic approaches for listening to and learning from their internal customers in order to meet changing customer requirements?
3. Does the IH/OH program perform annual or other assessments of the health and safety hazards of the company?
4. Are any IH/OH program function metrics systematically monitored to ensure the function is consistently meeting customer requirements?
Measurement, Analysis and Knowledge Management Questions
1. Do IH/OH program functions align their performance measures with higher-level organizational performance measures that indicate achievement of IH/OH strategic objectives?
2. Do IH/OH program functions have a systematic approach for analysis of their performance against action plans?
3. Do IH/OH program functions utilize both leading (process) and lagging (outcome) metrics?
4. Do IH/OH program functions actively utilize the best practices identified by IH/OH and other functions in the company?

Workforce Focus Questions
1. Does your company use its IH/OH programs as a tool for increasing worker engagement?
2. Are IH/OH considerations included as part of employee (including leadership) development?
3. Does your company use IH/OH programs as a tool to recruit, hire and retain employees?
4. Does your company use IH/OH programs as a tool to maintain a safe, secure and supportive work climate?

Process Management Questions
1. Does the IH/OH program use a systematic, written procedure for assessing a potential internal hazard?
2. Do different IH/OH program functions systematically share lessons learned?
3. Are IH/OH program functions systematically audited for consistent use of approved procedures?
4. Does the IH/OH program have a corrective action system?

Business Results Questions
1. Is IH/OH program performance objectively linked to product or service cost reductions?
2. Is IH/OH program performance objectively linked to increases in employee productivity?
3. Is IH/OH program performance objectively linked to customer satisfaction with safer products or services?
4. Does your company use IH/OH achievements (e.g. dust, toxin, mold elimination) as evidence of being corporately responsible?

These questions have been labeled to facilitate the analysis described in the objective session. The labeling scheme is shown below in Table VI-1.
Table VI-1. Survey Questions Labeling Scheme.

<table>
<thead>
<tr>
<th></th>
<th>Question1</th>
<th>Question2</th>
<th>Question3</th>
<th>Question4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leadership</td>
<td>L1</td>
<td>L2</td>
<td>L3</td>
<td>L4</td>
</tr>
<tr>
<td>Strategic Planning</td>
<td>SP5</td>
<td>SP6</td>
<td>SP7</td>
<td>SP8</td>
</tr>
<tr>
<td>Customer Focus</td>
<td>CF9</td>
<td>CF10</td>
<td>CF11</td>
<td>CF12</td>
</tr>
<tr>
<td>Measurement, Analysis and Knowledge Management</td>
<td>M13</td>
<td>M14</td>
<td>M15</td>
<td>M16</td>
</tr>
<tr>
<td>Workforce Focus</td>
<td>W17</td>
<td>W18</td>
<td>W19</td>
<td>W20</td>
</tr>
<tr>
<td>Process Management</td>
<td>PM21</td>
<td>PM22</td>
<td>PM23</td>
<td>PM24</td>
</tr>
<tr>
<td>Business Results</td>
<td>BR25</td>
<td>BR26</td>
<td>BR27</td>
<td>BR28</td>
</tr>
</tbody>
</table>

Table VI-2. P-Values from Hypothesis test of Equal Portion of Yes Responses

<table>
<thead>
<tr>
<th></th>
<th>BR25</th>
<th>BR26</th>
<th>BR27</th>
<th>BR28</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>.280</td>
<td>.615</td>
<td>1.000</td>
<td>.155</td>
</tr>
<tr>
<td>L2</td>
<td>.280</td>
<td>.118</td>
<td>.280</td>
<td>.155</td>
</tr>
<tr>
<td>L3</td>
<td>.016</td>
<td>.013</td>
<td>.016</td>
<td>.039</td>
</tr>
<tr>
<td>L4</td>
<td>.539</td>
<td>.259</td>
<td>.539</td>
<td>.037</td>
</tr>
<tr>
<td>SP5</td>
<td>.539</td>
<td>.259</td>
<td>.539</td>
<td>1.000</td>
</tr>
<tr>
<td>SP6</td>
<td>.546</td>
<td>.266</td>
<td>.546</td>
<td>.590</td>
</tr>
<tr>
<td>SP7</td>
<td>1.000</td>
<td>.511</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>SP8</td>
<td>.024</td>
<td>.033</td>
<td>.024</td>
<td>.010</td>
</tr>
<tr>
<td>CF9</td>
<td>.014</td>
<td>.009</td>
<td>.014</td>
<td>.010</td>
</tr>
<tr>
<td>CF10</td>
<td>.130</td>
<td>.022</td>
<td>.130</td>
<td>.027</td>
</tr>
<tr>
<td>CF11</td>
<td>1.000</td>
<td>.511</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>CF12</td>
<td>.277</td>
<td>.052</td>
<td>.277</td>
<td>.069</td>
</tr>
<tr>
<td>M13</td>
<td>.539</td>
<td>1.000</td>
<td>.539</td>
<td>1.000</td>
</tr>
<tr>
<td>M14</td>
<td>.564</td>
<td>.266</td>
<td>.546</td>
<td>.590</td>
</tr>
<tr>
<td>M15</td>
<td>.266</td>
<td>.351</td>
<td>.133</td>
<td>.361</td>
</tr>
<tr>
<td>M16</td>
<td>1.000</td>
<td>.333</td>
<td>.333</td>
<td>1.000</td>
</tr>
<tr>
<td>W17</td>
<td>.052</td>
<td>.080</td>
<td>.052</td>
<td>.680</td>
</tr>
<tr>
<td>W18</td>
<td>.005</td>
<td>.003</td>
<td>.003</td>
<td>.003</td>
</tr>
<tr>
<td>W19</td>
<td>.007</td>
<td>.099</td>
<td>.007</td>
<td>.027</td>
</tr>
<tr>
<td>W20</td>
<td>1.000</td>
<td>.511</td>
<td>.446</td>
<td>.217</td>
</tr>
<tr>
<td>PM21</td>
<td>.539</td>
<td>.259</td>
<td>1.000</td>
<td>.317</td>
</tr>
<tr>
<td>PM22</td>
<td>.277</td>
<td>.052</td>
<td>.277</td>
<td>.371</td>
</tr>
<tr>
<td>PM23</td>
<td>.539</td>
<td>.259</td>
<td>.539</td>
<td>.317</td>
</tr>
<tr>
<td>PM24</td>
<td>.539</td>
<td>.259</td>
<td>.539</td>
<td>.317</td>
</tr>
</tbody>
</table>

Significant p-values are highlighted in yellow. The results from this analysis suggest that questions L3, SP8, CF9, W18 and W19 are linked to Business Results with statistical significance. The charts in Figure VI-1 and Figure VI-2 show that when these predictors are answered No, the vast majority of companies answered No to the Business Results questions as well. However, when the answer to these predictors was Yes, some of the Business Results questions were answered predominately Yes, and some of the Business Results questions were answered Yes a higher proportion of the time. A possible conclusion is that Yes answers to the predictor questions do not necessarily guarantee a Yes answer to the Business Results questions, but you cannot achieve Yes answers to the Business Results questions unless you answer Yes to the predictor questions. For example, question SP8 is,
Figure VI-1. Relationships between Survey Responses for Predictor Questions and Business Results Questions.
Figure VI-2. Relationships between Survey Responses for Predictor Questions and Business Results Questions. (cont’d)
Regression Analysis

In order to understand the potential contribution of each of the categories from the IH/OH-based Baldrige assessment on Business Results, a metric was calculated to create a single numeric response for each of the six categories. This metric measured the average number of yes responses for each dimension by each organization.

Each category – Leadership; Strategic Planning; Customer Focus; Measurement Analysis and Knowledge Management; Workforce Focus; and Process Management - was measured in the survey by four yes or no questions. The number of yes answers was counted for each organization that responded for the dimension measured, and the proportion of yes answers was calculated

- As an example:
  - L1=yes, L2=yes, L3=no, L4=yes: \( L = \frac{3}{4} = 0.75 \)
  - L1=no, L2=no, L3=no, L4=no: \( L = 0 \)
  - L1=yes, L2=yes, L3=yes, L4=yes: \( L = 1 \)

Seven new metrics were created:

- \( L \) = proportion of yes answers for each of the 4 Leadership questions
- \( SP \) = proportion of yes answers for each of the 4 Strategic Planning questions
- \( CF \) = proportion of yes answers for each of the 4 Customer Focus questions
- \( M \) = proportion of yes answers for each of the 4 Measurement, Analysis and Knowledge Transfer questions
- \( W \) = proportion of yes answers for each of the 4 Workforce Focus questions
- \( PM \) = proportion of yes answers for each of the 4 Process Management questions
- \( BR \) = proportion of yes answers for each of the 4 Business Results questions

The relationship between each of the Baldrige categories and Business Results is shown in Figure 4. Figure 3 is presented to illustrate the relationships observed in the survey.

The data point highlighted in the blue circle is organization 7, which answered yes to 1 of the 4 Business Results questions, and yes to 2 of the 4 Leadership questions.

The data points highlighted in the red circle are organization 3, 18 and 22, which each answered yes to 4 of the 4 Business Results questions, and yes to 4 of the 4 Leadership questions.

Figure VI-3. Illustration of Survey Relationships.
Figure VI-4. Relationships of Proportion of Yes Responses of Business Results Questions to Proportion of Yes Responses to from Predictors
It appears that organizations that answered No to the dimensions measured also answered No to the Business Results responses, and organizations that answered Yes to the dimensions, had varied Business Results responses.

In order to evaluate the influence that each of the categories had on Business Results, a regression analysis was performed. Each dimension was used to predict Business Results using a quadratic fit. In addition to testing whether the regression was statistically significant, prediction limits—which represent a range that a single new observation is likely to fall given specified settings of the predictor (the specific dimension in the analysis)—were constructed for the strategy. An examination of the prediction limits for each of the analyses show that even though there is a statistical relationship, “knowing” the level of support expressed does not definitively yield the Business Results response.

Results follow.

![Fitted Line Plot](image)

**Figure VI-5. Business Results (BR) as a function of Leadership (L)**

$$\text{BR} = 0.0891 - 0.8430 \cdot L + 0.8430 \cdot L^2$$

The regression was statistically significant:

- Linear component: \( p = .001 \)
- Quadratic Component: \( p = .043 \)
Figure VI-6. Business Results (BR) as a function of Strategic Planning (SP)

\[ BR = 0.1559 - 1.540 \times SP + 1.973 \times SP^2 \]

The regression was statistically significant:

- Linear component: \( p = 0.020 \)
- Quadratic Component: \( p = 0.004 \)
Figure VI-7. Business Results (BR) as a function of Customer Focus (CF)

\[ BR = 0.2024 - 1.44 \times CF + 1.588 \times CF^2 \]

The regression was statistically significant:
- Linear component: \( p = .000 \)
- Quadratic Component: \( p = .009 \)

Business Results (BR) as a function of Measurement, Analysis and Knowledge Management

In this regression, there were no predictors that were statistically significant:
- Linear component: \( p = .191 \)
- Quadratic Component: \( p = .665 \)
Figure VI-8. Business Results (BR) as a function of Workforce Focus (W)

\[ BR = 0.1793 - 0.8538 \times W + 1.514 \times W^2 \]

The regression was statistically significant:

Linear component: \( p = .000 \)

Quadratic Component: \( p = .005 \)
Figure VI-9. Business Results (BR) as a function of Process Management (PM)

\[ BR = -.0324 + .4630 \times PM \]

In this regression, only the linear component was statistically significant:
- Linear component: \( p = .042 \)
- Quadratic Component: \( p = .146 \)
Analysis of Variance

An Analysis of Variance was conducted that tested whether the proportion of Yes answers to BR questions was the same for each level of the proportions of Yes answers for each of the six categories measured in the survey. Results from those analyses follow:

Business Results as a function of Leadership (L)

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>4</td>
<td>1.7016</td>
<td>0.4254</td>
<td>5.77</td>
<td>0.003</td>
</tr>
<tr>
<td>Error</td>
<td>19</td>
<td>1.4000</td>
<td>0.0737</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>23</td>
<td>3.1016</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Individual 95% CIs For Mean Based on Pooled StDev

<table>
<thead>
<tr>
<th>Level</th>
<th>N</th>
<th>Mean</th>
<th>StDev</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>1</td>
<td>0.0000</td>
<td>*</td>
</tr>
<tr>
<td>0.25</td>
<td>3</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>0.50</td>
<td>2</td>
<td>0.1250</td>
<td>0.1768</td>
</tr>
<tr>
<td>0.75</td>
<td>8</td>
<td>0.1875</td>
<td>0.2912</td>
</tr>
<tr>
<td>1.00</td>
<td>10</td>
<td>0.6500</td>
<td>0.2934</td>
</tr>
</tbody>
</table>

This analysis shows that when companies answered yes to all 4 of the Leadership questions, there was a higher proportion of yes answers to Business Results questions than when 3 questions were answered yes, and when 1 was answered yes.

Business Results as a function of Strategic Planning (SP)

<table>
<thead>
<tr>
<th>Source</th>
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<th>MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP</td>
<td>3</td>
<td>1.6658</td>
<td>0.5553</td>
<td>7.73</td>
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<tr>
<td>Error</td>
<td>20</td>
<td>1.4358</td>
<td>0.0718</td>
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<td></td>
</tr>
<tr>
<td>Total</td>
<td>23</td>
<td>3.1016</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Individual 95% CIs For Mean Based on Pooled StDev

<table>
<thead>
<tr>
<th>Level</th>
<th>N</th>
<th>Mean</th>
<th>StDev</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>2</td>
<td>0.1250</td>
<td>0.1768</td>
</tr>
<tr>
<td>0.50</td>
<td>1</td>
<td>0.2500</td>
<td>*</td>
</tr>
<tr>
<td>0.75</td>
<td>9</td>
<td>0.0556</td>
<td>0.1667</td>
</tr>
<tr>
<td>1.00</td>
<td>12</td>
<td>0.6042</td>
<td>0.3278</td>
</tr>
</tbody>
</table>

This analysis shows that when companies answered yes to all 4 of the Strategic Planning questions, there was a higher proportion of yes answers to Business Results questions than when 3 questions were answered yes.
Business Results as a function of Customer Focus (CF)

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
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<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>CF</td>
<td>4</td>
<td>2.014</td>
<td>0.503</td>
<td>8.80</td>
<td>0.000</td>
</tr>
<tr>
<td>Error</td>
<td>19</td>
<td>1.087</td>
<td>0.057</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>23</td>
<td>3.101</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Individual 95% CIs For Mean Based on Pooled StDev

<table>
<thead>
<tr>
<th>Level</th>
<th>N</th>
<th>Mean</th>
<th>StDev</th>
<th></th>
<th></th>
<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>1</td>
<td>0.250</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>0.25</td>
<td>2</td>
<td>0.000</td>
<td>0.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.50</td>
<td>7</td>
<td>0.000</td>
<td>0.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.75</td>
<td>3</td>
<td>0.333</td>
<td>0.144</td>
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<tr>
<td>1.00</td>
<td>11</td>
<td>0.636</td>
<td>0.323</td>
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</tr>
</tbody>
</table>

This analysis shows that when companies answered yes to all 4 of the Customer Focus questions, there was a higher proportion of yes answers to Business Results questions than when 2 questions were answered yes.

Business Results as a function of Measurement, Analysis and Knowledge Management (M)

<table>
<thead>
<tr>
<th>Source</th>
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<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>3</td>
<td>0.303</td>
<td>0.101</td>
<td>0.72</td>
<td>0.550</td>
</tr>
<tr>
<td>Error</td>
<td>20</td>
<td>2.798</td>
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<tr>
<td>Total</td>
<td>23</td>
<td>3.102</td>
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<td></td>
<td></td>
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</tbody>
</table>

Individual 95% CIs For Mean Based on Pooled StDev

<table>
<thead>
<tr>
<th>Level</th>
<th>N</th>
<th>Mean</th>
<th>StDev</th>
<th></th>
<th></th>
<th></th>
<th></th>
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<tbody>
<tr>
<td>0.00</td>
<td>2</td>
<td>0.125</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>0.75</td>
<td>8</td>
<td>0.312</td>
<td>0.347</td>
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<td>1.00</td>
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</table>

This analysis showed no difference in Business Results answers when Measurement, Analysis, and Knowledge Management questions varied.
This analysis shows that when companies answered Yes to all 4 of the Workforce Focus questions, there was a higher proportion of Yes answers to Business Results questions than when 3, 2, 1 or 0 questions were answered Yes. It also shows that when 3 Workforce Focus questions were answered Yes, the proportion of Yes answers to Business Results questions were higher than when 2 or 1 Workforce Focus questions were answered Yes.

This analysis showed no difference in Business Results answers when Process Management Questions varied.
Conclusions

It is difficult to demonstrate with statistical rigor, with the limited data available, that a single Baldrige category of Leadership; Strategic Planning; Customer Focus; Measurement, Analysis, and Knowledge Management; Workforce Focus; or Process Management influences Business Results. However, there were specific questions in some categories (the predictors listed below) that did appear to influence Business Results responses. When these predictors were answered No, Business Results responses were predominately No. Only when these predictor questions were answered Yes was there a reasonable chance of Yes answers to the Business Results questions. There were no statistically significant correlations between Process Management responses and improved Business Results, or Measurement Analysis and Knowledge Management responses and improved Business Results. Although this is true when looked at in the light of IH/OH programs, it may be different if other programs, such as machine maintenance, budget planning, or business development were analyzed.

Predictors

Leadership
   Do senior leaders regard a productive IH/OH program as a competitive advantage?

Strategic Planning
   Does your IH/OH program make performance improvement projections as part of the strategic or action planning process?

Customer Focus
   Do any company external customers require evidence of a specific level of IH/OH program performance or proficiency?

Workforce Focus
   Are IH/OH considerations included as part of employee (including leadership) development?
   Does your company use IH/OH programs as a tool to recruit, hire and retain employees?

Response

Business Results
   Is IH/OH program performance objectively linked to product or service cost reductions?
   Is IH/OH program performance objectively linked to increases in employee productivity?
   Is IH/OH program performance objectively linked to customer satisfaction with safer products or services?
   Does your company use IH/OH achievements (e.g. dust, toxin, mold elimination) as evidence of being corporately responsible?

Yes answers to the Business Results questions mean the respondents indicated that, for their companies, IH/OH program performance is objectively linked to cost reductions in products or services, increases in employee productivity, and customers being satisfied
with safer products or services. As well, IH/OH program achievements are used as evidence of being corporately responsible.

The executive summary for this section states that it appears that companies that pay particular attention to IH programs and practices through leadership, strategic planning processes, and customer and workforce focus are more likely to see improved business results than those companies that do not. More specifically, only when the five predictors were answered Yes was there a reasonable chance of improved Business Results.

So what is the study’s suggestion for the IH/OH program managers if they want to demonstrate their program’s value to the company and the profession?

Based on this study, a Malcolm Baldrige Award Examiner could suggest the following with confidence.

Ensure that Senior Leaders regard a productive IH/OH program as a competitive advantage. Sustaining success is most generally supported at the top. This means that we could expect to see IH/OH program metrics in proposals submitted for contract work or in publications to stockholders and other stakeholders. Senior leaders in this context include the head of an organization and their direct reports.

During the strategic planning process, the IH/OH programs should develop performance improvement projections as part of their action planning activities. This may tend to solidify commitment to their achievement.

Listen to your customers. One might expect that when a company regards its productive IH/OH programs as a competitive advantage, that its external customers (or at least some of them) also value IH/OH program performance or proficiency. Expect improved business results when customers expect higher levels of IH/OH program performance.

Use productive IH/OH programs as a tool to recruit, hire and retain employees, as well as a tool for employee development. Among all the Baldrige Categories, Workforce Focus was most highly correlated with improved Business Results. Hiring employees that value productive IH/OH programs can strengthen a workforce already exhibiting a culture with a focus on productive industrial hygiene and occupational health.

**Recommendations**

As with many studies, additional research with larger sample sizes (even if the same survey instrument is used) would yield stronger correlations and possibly cause and effect relationships. With only 24 respondents this study was able to show results with statistical significance, yet half of the survey questions had to be set aside due to the absence of responses for these questions.

It may also be of value to correlate the six criteria categories to other types of business results such as stock value, stock market stability, and company growth. Examining in
detail the demographics of certain industries and the responses to the questions on the instrument used for this study may show stronger correlations for specific industries such as chemical, service, or manufacturing.
Appendix A: Survey I

ORC Worldwide
Industrial Hygiene Program Study

ORC has been awarded a contract by the American Industrial Hygiene Association to conduct a research study to determine the value that the industrial hygiene/occupational hygiene profession (IH) brings to the business world. Currently there are limited data demonstrating the relationship between comprehensive IH programs and improvements in worker health and positive business results. Where such data exist, they are most often focused on employee safety/accident prevention and not the prevention of short-term and long-term illnesses through the improvement of working conditions and process design that IH professionals address. Because of this data gap IH professionals have a difficult task of proving that investments in related staffing and programs can contribute to business value and success.

The greatest asset of ORC is its member companies and their willingness and desire to share information to advance both their individual business interests and the overall profession of occupational safety and health.

For Phase I of the research project ORC is using the attached survey to get a broad measure of the types of IH programs that companies have developed and manage. The survey will gather data on company demographics and IH program elements while seeking to understand what, if any, outcome data have been captured by companies. This survey is designed to learn in broad terms the amount of outcome data that companies have collected and how accessible those data are for use in correlating the relationship between IH program elements and business outcomes.

Companies that have comprehensive IH management systems and robust outcome data will be invited to participate in a more detailed Phase II study which will seek develop a strategy to calculate the value of IH investments. Please note, this survey is solely on IH rather than safety. Therefore, so far as possible, please base your responses on your IH programs and their associated costs and benefits.

ORC asks that you complete the attached IH screening survey by COB January 5, 2007. The data received in Phase I of the study will be summarized, blinded and made available to participants. Also, please indicate on the survey form if your organization would specifically be interested in participating in the Phase II study. Thank you for your willingness to participate in this important project for the industrial hygiene/occupational hygiene profession. Please address any questions you may have to Steve Newell, Dee Woodhull or Scott Madar at 202-293-2980.
Appendix A: Survey I

Value of Industrial Hygiene/Occupational Hygiene Programs Survey

Note: In completing this survey, we ask you to provide data for your corporation as a whole and for your “best” site/operation. When selecting a “best site”, please select a site/operation that is:

1. One of your best sites/operations in terms of IH-related management systems, compliance, and innovation
2. Is most likely to have data on employee health status and business outcomes that have been influenced by IH programs

Section I – Site Identification, Demographics and Organization

1. Company:
2. Contact Name:
3. Contact Phone Number
4. Contact E-mail Address
5. Staffing and Facilities:
   a. Total Number of Global Employees
      i. Total number of Manufacturing/Operations employees
      ii. Total number of Sales and/or Service employees
      iii. Total number of Corporate or Division staff employees
      iv. Total number of R&D employees
   b. Total Number of Global Manufacturing/Operations, Sales, Administrative, and R&D Sites
      v. Manufacturing/Operations
      vi. Sales and/or Service
      vii. Administrative
      viii. R&D
6. Industry Sector:
   a. Company primary NAICS code(s). Please list up to five.
   b. Best IH Program Site NAICS code(s).
7. Organization:
   a. Number of Industrial Hygienists (Global FTEs)
      i. Corporate
      ii. Best IH Program Site
      # Certified

Note: Certified in the practice of IH in the country they are employed and not necessarily by the ABIH
Appendix A: Survey I

b. Industrial Hygiene Reporting Structure – three reporting levels

Example

<table>
<thead>
<tr>
<th>Corporate</th>
<th>Best Program Site (typical)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Corporate Industrial Hygienist</td>
<td>Plant Industrial Hygienist</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Is there a functional or reporting relationship between IH resources at the site level to IH resources at the Corporate level?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functional □   Reporting □   Both □</td>
</tr>
</tbody>
</table>

187
Appendix A: Survey I

Section II – IH Management Systems and Program Elements

8. IH Management Systems – Please check off the IH/OH management system elements used by your corporation and by your “best IH program site:”

<table>
<thead>
<tr>
<th>IH Management System</th>
<th>Best Practice Site</th>
<th>Corporation</th>
</tr>
</thead>
<tbody>
<tr>
<td>i. IH Policy</td>
<td>y/n</td>
<td>y/n</td>
</tr>
<tr>
<td>ii. Leadership responsibility and authority</td>
<td></td>
<td></td>
</tr>
<tr>
<td>iii. Employee participation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>iv. Planning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>v. Hazard identification, assessment, and control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>vi. Incident investigation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>vii. Design review and management of change</td>
<td></td>
<td></td>
</tr>
<tr>
<td>viii. Purchasing review</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ix. Contractor IH policy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>x. Emergency preparedness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>xi. Education, training, awareness, and competence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>xii. Communication</td>
<td></td>
<td></td>
</tr>
<tr>
<td>xiii. Records management</td>
<td></td>
<td></td>
</tr>
<tr>
<td>xiv. Auditing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>xv. Management review</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

9. Does your company engage in any of the following recognized management systems or processes: (please circle all that apply)

   a. Six Sigma
   b. Lean
   c. Malcolm Baldrige Award
   d. ISO 9000
   e. ISO 14001
   f. OHSAS 18001
   g. ANSI Z-10
   h. OSHA VPP
   i. Others (please specify)
10. IH Program Element Evaluation

<table>
<thead>
<tr>
<th>IH Program Element</th>
<th>What percentage of total program time is spent on this area? (%)</th>
<th>Have cost or improvement studies been conducted on this program? (Yes or no)</th>
<th>What are the program goals? (Check all that apply)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Compliance</td>
<td>Loss Avoidance</td>
</tr>
<tr>
<td>Risk Assessment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemical Exposure monitoring</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noise Assessment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ergonomics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ionizing and/or non-ionizing radiation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk Prioritization</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk Control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk Elimination</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Substitution of less hazardous materials operations, processes, or equipment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engineering Controls</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warnings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Administrative Controls</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiratory Protection</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Personal Protective Equipment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix A: Survey I

11. Has your company implemented a comprehensive Industrial Hygiene Exposure Monitoring Strategy?

12. Does your company maintain a Health Monitoring System database with the following capabilities (yes or no): (Again – what is the definition of a health monitoring system?)

13. Is this the Employee Periodic Medical Surveillance Program?) If yes, then does the HMS include the following:
   a. Comprehensive health surveillance data on exposed employees Y/N
   b. Comprehensive health surveillance data on all employees Y/N
   c. Comprehensive industrial hygiene exposure data for all employee exposure groups Y/N
   d. Linkage to complete employee personal information Y/N
   e. Generation of specific data elements on specific employee groups Y/N
   f. Generation of specific data elements on IH exposure groups Y/N
   g. Generation of specific data elements on medical surveillance outcomes Y/N

14. Has your company conducted health studies using the Health Monitoring System? Y/N
Appendix A: Survey I

15. Please describe the metrics that are used to gauge progress in the key IH program areas indicated at your best site and at the corporate level.

<table>
<thead>
<tr>
<th>IH Program Element</th>
<th>Describe IH leading metrics in use (Best Site; Corporate)</th>
<th>Describe IH trailing metrics in use (Best Site; Corporate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>i. Risk Assessment</td>
<td>i. Risk Assessment</td>
<td>i. Risk Assessment</td>
</tr>
<tr>
<td>ii. Chemical Exposure monitoring</td>
<td>ii. Chemical Exposure monitoring</td>
<td>ii. Chemical Exposure monitoring</td>
</tr>
<tr>
<td>iii. Noise Assessment</td>
<td>iii. Noise Assessment</td>
<td>iii. Noise Assessment</td>
</tr>
<tr>
<td>v. Ionizing and/or non-ionizing radiation</td>
<td>v. Ionizing and/or non-ionizing radiation</td>
<td>v. Ionizing and/or non-ionizing radiation</td>
</tr>
<tr>
<td>vi. Risk Prioritization</td>
<td>vi. Risk Prioritization</td>
<td>vi. Risk Prioritization</td>
</tr>
<tr>
<td>vii. Risk Control</td>
<td>vii. Risk Control</td>
<td>vii. Risk Control</td>
</tr>
<tr>
<td>viii. Risk Elimination</td>
<td>viii. Risk Elimination</td>
<td>viii. Risk Elimination</td>
</tr>
<tr>
<td>ix. Substitution of less hazardous materials operations, processes, or equipment</td>
<td>ix. Substitution of less hazardous materials operations, processes, or equipment</td>
<td>ix. Substitution of less hazardous materials operations, processes, or equipment</td>
</tr>
<tr>
<td>x. Engineering Controls</td>
<td>x. Engineering Controls</td>
<td>x. Engineering Controls</td>
</tr>
<tr>
<td>xi. Warnings</td>
<td>xi. Warnings</td>
<td>xi. Warnings</td>
</tr>
<tr>
<td>xii. Administrative Controls</td>
<td>xii. Administrative Controls</td>
<td>xii. Administrative Controls</td>
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<td>xiii. Respiratory Protection</td>
<td>xiii. Respiratory Protection</td>
<td>xiii. Respiratory Protection</td>
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<td>xiv. Other Personal Protective Equipment</td>
<td>xiv. Other Personal Protective Equipment</td>
<td>xiv. Other Personal Protective Equipment</td>
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<tr>
<td>xv. Other</td>
<td>xv. Other</td>
<td>xv. Other</td>
</tr>
</tbody>
</table>
Appendix A: Survey I

Section III – IH Related Cost and Outcome Data

16. Cost related outcome data. For each statement below, please input the letter corresponding to the appropriate statement

   a. The data exist and are releasable for study with strict confidentiality and blinded
   b. Data exist and are not releasable for study, or
   c. The data do not exist

<table>
<thead>
<tr>
<th>Best Site</th>
<th>Corporate</th>
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<tbody>
<tr>
<td>a, b or c</td>
<td>a, b or c</td>
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</table>

   a. Annual IH program costs
   b. By IH program element
   c. Workers’ Compensation Loss Data
   d. Other occupational health related losses – skin diseases, respiratory diseases, diseases from toxic exposures, diseases from physical agents
   e. Non-occupational health-related losses
   f. Health and environmental remediation costs
   g. Long-term occupational health liability costs

17. Health and exposure-related outcome data. For each statement below, please input the letter corresponding to the appropriate statement

   a. The data exists and are releasable for study with strict confidentiality and blinded, or
   b. The data exist but are not releasable.
   c. The data do not exist

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<td>a, b or c</td>
<td>a, b or c</td>
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</table>

   a. Employee Exposure Monitoring Data
   b. Medical surveillance data
   c. Health monitoring data
   d. Workplace injury and illness data (OSHA, first aid)

18. Human Resources Outcome Data and Costs. For each statement below, please input the letter corresponding to the appropriate statement

   a. The data exists and is releasable for study with strict confidentiality and blinded, or
   b. The data does not exist but is not releasable for use in the IH value study.
   c. The data does not exist

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<tbody>
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<td>a, b or c</td>
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</table>

   a. Absenteeism Data
   b. Hiring Costs – Full-time and replacement workers
   c. Hiring Costs – Part-time and temporary replacement workers
   d. Business and Financial Metrics – Production & Material Costs
   d. Business and Financial Metrics – Payroll and labor costs
Appendix A: Survey I

e. Business and Financial Metrics – Cost of poor quality/other quality metrics
f. Business and Financial Metrics – The value of process improvements associated with IH Programs
g. Business and Financial Metrics – Productivity improvements associated with improving IH processes
h. Business and Financial Metrics -

19. Legal Metrics and Costs

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<td>a. (OSHA) Compliance Citations</td>
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<td>a, b or c</td>
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<tr>
<td>b. Type and Costs of Legal Judgments</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Type and Costs of Legal Settlements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. IH Related Sarbanes-Oxley disclosures</td>
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<td></td>
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</table>

3. IH Business Case Analysis

a. Has your company conducted business case analysis for IH projects and/or programs? (Yes or no)

b. If so, what types of projects/programs were included in the analyses?

c. What financial metrics were used as part of the analysis?

d. Was the business case presented to management? (Yes or no)

e. If so, at what levels (check all that apply)
   i. Board of Directors
   ii. Senior Executive management (corporate)
   iii. Middle management (business unit)
   iv. First-line management (plant or field)
   v. Supervisory

f. Describe the level of effectiveness of the business case in producing the expected results:
Appendix A: Survey I

Section IV – Phase II Study Participation

My company is interested in further participating in Phase II of the Value of the IH Profession Study:

Yes: □   No □.

Interested companies will be contacted by an ORC Consultant by mid-December.

Thank for your participation in Phase I of the Value of the IH Profession Project.
Appendix B: List of Companies Responding to Survey I

1. Barr Laboratories, Inc.
2. Baxter Healthcare Corporation
3. BP America Inc.
4. Cabot
5. CITGO Petroleum Corporation
6. Colgate-Palmolive Company
7. Comcast Corporation
8. Consolidated Edison Company of NY
9. Constellation Energy
10. Corning Incorporated
11. Dade Behring Inc.
12. DaimlerChrysler Corporation
13. Disneyland Resort
14. Dow Chemical Company, The
15. Eastman Chemical Company
16. Eaton Corporation
17. Edwards Lifesciences LLC
18. Eli Lilly and Company
19. Entergy Services Inc.
20. Exxon Mobil
21. Ford Motor Company
22. Genentech, Inc.
23. General Motors Corporation
24. GlaxoSmithKline
25. Goodrich
26. Harris Corporation
27. Henkel Corporation
28. Hercules Incorporated
29. Hospira
30. Ingersoll-Rand Company
31. International Paper Company
32. International Truck and Engine Corporation
33. ITT Industries, Inc.
34. Lawrence Livermore National Laboratory
35. Mars Incorporated
36. Phelps Dodge Corporation
37. Philip Morris, USA
38. Praxair, Inc.
39. Saint-Gobain Containers
40. Sunoco, Inc.
41. Textron, Inc.
42. The Hershey Company
43. TRW Automotive
44. Tyco Healthcare-Mallinckrodt Division
45. United Technologies Corporation
46. Verizon
Appendix C: Participating Companies

1. Altairnano
2. Barr Laboratories, Inc.
3. BASF
4. BP America Inc.
5. Consolidated Edison Company of NY
6. DaimlerChrysler
7. Dow Chemical Company
9. Eastman Chemical Company
10. Eaton Corporation
11. Eli Lilly and Company
12. Exxon Mobil
13. General Motors Corporation
14. GlaxoSmithKline
15. Hospira
16. International Paper Company
17. International Truck and Engine Corporation
18. Pfizer, Inc.
19. Praxair, Inc.
20. Textron, Inc.
21. United Technologies Corporation
22. Verizon
### Appendix D: Industrial Hygiene Metrics

#### Risk Assessment Metrics

<table>
<thead>
<tr>
<th>Leading - Best IH Program Site</th>
<th>Trailing - Best IH Program Site</th>
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<tbody>
<tr>
<td>% Risk Assessment complete</td>
<td>Injury reduction</td>
</tr>
<tr>
<td>Audits scores</td>
<td>% Overexposure</td>
</tr>
<tr>
<td>Field time</td>
<td>Reviews &amp; assessments</td>
</tr>
<tr>
<td>Web-based compliance training</td>
<td>% Chemicals assessed vs. scheduled</td>
</tr>
<tr>
<td>Qualitative Exposure Assessment (QEA)</td>
<td>DART</td>
</tr>
<tr>
<td>Process Hazard Analyses completed vs. scheduled</td>
<td>Fleet accident rate</td>
</tr>
<tr>
<td>Risk Priority Number (RPN)</td>
<td>QEA MM</td>
</tr>
<tr>
<td>IH Assessments to corporate</td>
<td>Audit scores</td>
</tr>
<tr>
<td>Sampling plan completed</td>
<td>Survey results</td>
</tr>
<tr>
<td>Job Hazard Analysis Development</td>
<td>Worker Comp. cases &amp; issues</td>
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<tr>
<td>Design reviews for new processes &amp; facilities</td>
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<tr>
<td>Management system scores</td>
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</table>

<table>
<thead>
<tr>
<th>Leading – Corporate</th>
<th>Trailing - Corporate</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Risk Assessment completed vs. scheduled</td>
<td>OSHA injury &amp; illness rates</td>
</tr>
<tr>
<td>% complete sampling plan</td>
<td>Injury reduction</td>
</tr>
<tr>
<td>Inspections/observations</td>
<td>Health-related incidents</td>
</tr>
<tr>
<td>Web-based compliance training</td>
<td>% overexposure</td>
</tr>
<tr>
<td>QEA</td>
<td>% of chemical exposures to be assessed</td>
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<tr>
<td>Project Hazard Assessments completed</td>
<td>DART</td>
</tr>
<tr>
<td>Risk Priority Rating</td>
<td>Fleet accident rate</td>
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<tr>
<td>Job Hazard Assessments (JHAs)</td>
<td>QEA Monitoring Module</td>
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<tr>
<td>Internal &amp; external audit results</td>
<td>Investigations to root cause</td>
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<tr>
<td>QEA before installation</td>
<td>Finding tracked to complete</td>
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<tr>
<td>Corrective/preventative actions completed on time</td>
<td>Accident trending</td>
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<tr>
<td>SOP’s updated</td>
<td>Number of samples below OEL, Action Level</td>
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<tr>
<td></td>
<td>Ergonomic reviews</td>
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<td>Testing upon installation &amp; use</td>
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### Chemical Exposure Monitoring Metrics

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<th>Leading - Best IH Program Site</th>
<th>Trailing.- Best IH Program Site</th>
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<tr>
<td>Data collection</td>
<td>Track symptoms reported</td>
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<tr>
<td>Execution of Annual Sampling Plan</td>
<td>OSHA Injury/Illness rates</td>
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<tr>
<td>QEA</td>
<td>Sampling due to complaints</td>
</tr>
<tr>
<td>Exposure Risk Priority Number (RPN)</td>
<td>QEA</td>
</tr>
<tr>
<td>Change management performance</td>
<td>Occupational illnesses</td>
</tr>
<tr>
<td>Chemical inventory</td>
<td>Report turnaround time</td>
</tr>
<tr>
<td>Completion of planned studies (%)</td>
<td>Histogram of exposure judgments</td>
</tr>
<tr>
<td>Hazardous Material Control Program implementation</td>
<td>Number of samples below OEL, Action Level</td>
</tr>
<tr>
<td>Annual notifications</td>
<td>Number of samples exceeding OEL, Action Level</td>
</tr>
<tr>
<td>Process change notifications</td>
<td>Auditing of programs based on incident review</td>
</tr>
<tr>
<td>Exposure Assessments completed</td>
<td>Reduction in employees exposed</td>
</tr>
<tr>
<td>IAQ levels w/acceptable ratings (%)</td>
<td>% assessments complete</td>
</tr>
<tr>
<td></td>
<td>Testing on installation &amp; use</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Leading – Corporate</th>
<th>Trailing - Corporate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audits</td>
<td>Assessments</td>
</tr>
<tr>
<td>Observation</td>
<td>OSHA injury &amp; illness rates</td>
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<tr>
<td>Collaboration</td>
<td>% Monitoring completed</td>
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<tr>
<td>PELs</td>
<td>QEA</td>
</tr>
<tr>
<td>QEA</td>
<td>Occupational illnesses</td>
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<tr>
<td>Exposure Risk Priority Number</td>
<td>Report turnaround time</td>
</tr>
<tr>
<td>Change management performance</td>
<td>Histogram of exposure judgments</td>
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<tr>
<td>Chemical inventory</td>
<td># of samples that exceed the AL</td>
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<tr>
<td>Monitoring results</td>
<td>Survey results</td>
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<tr>
<td>% Completion of planned studies</td>
<td>Auditing of effectiveness of programs based on incident review</td>
</tr>
<tr>
<td>Hazardous material control program implementation</td>
<td>Reduction in number of exposed employees</td>
</tr>
<tr>
<td>% completion of exposure monitoring plan</td>
<td>% qualitative and/or quantitative assessments completed</td>
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<tr>
<td>Exposure levels against ACGIH</td>
<td>Testing on installation &amp; use</td>
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<tr>
<td>IAQ levels w/acceptable ranges</td>
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## Radiation Metrics

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<td>NRC Exposure Guidelines</td>
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<td>QEA</td>
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<td>Number of scheduled activities completed on time</td>
<td>Dosimetry records</td>
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<td>Program Assessment completions</td>
<td>Incidents or Notices of Violation for ionizing radiation</td>
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<tr>
<td>Site surveys</td>
<td>Inspection result – non issue</td>
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<td>Training/awareness</td>
<td>Evaluation of leaks based on incident reviews</td>
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<td>Radiation safety &amp; dosimeter monitoring</td>
<td>Investigate radiation concerns</td>
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<table>
<thead>
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<th>Leading – Best IH Program Site</th>
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<td>Checklist completed</td>
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<tr>
<td>Inspections/observations</td>
<td>recordkeeping/OSHA</td>
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<tr>
<td>QEA completion</td>
<td>QEA</td>
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<tr>
<td>Completed wipe tests/required</td>
<td>Dosimetry records</td>
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<tr>
<td>Number of scheduled activities completed on time</td>
<td>Readings below PEL, TLV</td>
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<td>Audit findings</td>
<td>Incidents or Notices of Violation for ionizing radiation</td>
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<td>Assessment completion</td>
<td>Evaluation of exposures on dosimetry badges</td>
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<td>Training/awareness for employees</td>
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## Risk Prioritization Metrics

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<td>Hazard &amp; Risk Assessment (HRA) rankings</td>
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<td>Sampling plan completion</td>
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<tr>
<td>Risk analyses</td>
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<td>Matrix of health effects &amp; exposure risk</td>
<td>Audit performance</td>
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<td>Air sampling plan completion</td>
<td>Failure to achieve injury &amp; illness reduction</td>
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<tr>
<td>Aspects &amp; impacts risk mapping</td>
<td>Hazard and risk ratings</td>
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<td>Management meetings to identify risk mitigation</td>
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<td>Reduction in incidents</td>
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<td>Mgmt system audit score</td>
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<tr>
<td>Completion of annual action plans</td>
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<td>Compliance tasks in compliance mgt system</td>
<td>OSHA Injury &amp; illness rates</td>
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<td>Planning</td>
<td>QEA</td>
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<td>All jobs w/ risk prioritization reviewed w/employees</td>
<td>Top 3 injury &amp; illness reduction</td>
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<td>Actions based on incidents</td>
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<td>Annual risk review/prioritization</td>
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<td>Matrix of health effects &amp; exposure risk</td>
<td>Hazard &amp; risk ratings</td>
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<td>Air sampling plan completion</td>
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<tr>
<td>Engineer out risks</td>
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</tr>
<tr>
<td>Management meetings to ID how risks are mitigated</td>
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<td>Reduction in incidents</td>
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## Risk Control Metrics

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<tr>
<th>Leading – Corporate</th>
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<tr>
<td>% Overexposed</td>
<td>% overexposed</td>
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<tr>
<td>Communications</td>
<td>% samples above 50% OEL where control actions taken</td>
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<td>Engineering Controls &amp; Cost</td>
<td>Audit performance</td>
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<tr>
<td>Workplace Exposure Improvement Score (WEIS)</td>
<td>Completion of open items</td>
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<tr>
<td>Air sample plan completion</td>
<td>Response to incidents causing injury or Damage</td>
</tr>
<tr>
<td>Response time to open items</td>
<td>Controls implemented due to exposure</td>
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<td>Implementation of risk minimization programs</td>
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<td>Reduction of incidents</td>
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<tr>
<td>Controls implementation before exposure</td>
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<td>Management system audit score</td>
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<th>Trailing - Best IH Program Site</th>
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<tr>
<td>% Overexposed</td>
<td>Work order system to correct issues</td>
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<tr>
<td>Planning/training</td>
<td>% overexposed</td>
</tr>
<tr>
<td>Training/communications</td>
<td>Assessments</td>
</tr>
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<td>Workplace exposure improvement index/score [WEIS]</td>
<td>OSHA injury &amp; illness rates</td>
</tr>
<tr>
<td>Air sample plan completion</td>
<td>Audit performance</td>
</tr>
<tr>
<td>Implementation of risk minimization programs</td>
<td>Response to incidents causing injury or Damage</td>
</tr>
<tr>
<td>Reduction in incidents</td>
<td>Audits</td>
</tr>
<tr>
<td>Work order system to correct issues</td>
<td>Key Performance Indicators (KPIs)</td>
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<td>Work order system to correct issues</td>
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## Risk Elimination Metrics

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<td>Planning</td>
<td>OSHA injury &amp; illness rates</td>
</tr>
<tr>
<td>Number &amp; type of exposure control projects</td>
<td>Time to complete resolution</td>
</tr>
<tr>
<td>Design review, supplier &amp; equipment buyoff</td>
<td>Exposure – related illness</td>
</tr>
<tr>
<td>Chemical Reviews</td>
<td>Histogram of exposure judgments</td>
</tr>
<tr>
<td>Job Hazard Analysis</td>
<td>Incident reviews</td>
</tr>
<tr>
<td>Ops mtgs.</td>
<td>Cost determination &amp; reduction surveys</td>
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<td>Safety incident log</td>
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<tr>
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<th>Trailing - Corporate</th>
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</thead>
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<tr>
<td>Planning</td>
<td>Assessments</td>
</tr>
<tr>
<td>Workplace Exposure Improvement Score (WEIS)</td>
<td>OSHA injury &amp; illness rates</td>
</tr>
<tr>
<td>Number &amp; type of exposure control projects</td>
<td>Time to complete resolution</td>
</tr>
<tr>
<td>Design review, supplier and equip. buyoff</td>
<td>Injury &amp; Illness Trending</td>
</tr>
<tr>
<td>Hazards eliminated in design process</td>
<td>Histogram of exposure judgments</td>
</tr>
<tr>
<td>Incident reviews</td>
<td>Incident reviews</td>
</tr>
<tr>
<td>Leading – Best IH Program Site</td>
<td>Trailing - Best IH Program Site</td>
</tr>
<tr>
<td>-------------------------------------------------------------------</td>
<td>----------------------------------------------------------------</td>
</tr>
<tr>
<td>Planning</td>
<td>OSHA injury &amp; illness rates</td>
</tr>
<tr>
<td>Workplace Exposure Improvement Score (WEIS)</td>
<td>Time to complete resolution</td>
</tr>
<tr>
<td>Hazardous Material Control program implementation</td>
<td>Exposure-related illnesses/complaints</td>
</tr>
<tr>
<td>Evaluations prior to process change</td>
<td>Reduced purchase of hazardous materials</td>
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<tr>
<td>Formal chemical reviews</td>
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<td>Number of raw materials in use</td>
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<td>Trailing - Corporate</td>
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<td>Planning</td>
<td>Assessments</td>
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<tr>
<td>Hazard comparison</td>
<td>OSHA injury &amp; illness rates</td>
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<tr>
<td>Hazardous Material Control program implementation</td>
<td>Time to complete resolution</td>
</tr>
<tr>
<td>Material reviews prior to use</td>
<td>Injury &amp; Illness Trending</td>
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<tr>
<td></td>
<td>Reduced purchase of hazardous materials</td>
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<td>Trends in Inspection Results</td>
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## Engineering Control Metrics

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<tr>
<th>Leading - Best IH Program Site</th>
<th>Trailing - Best IH Program Site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completion of recommended controls</td>
<td>OSHA injury &amp; illness rates</td>
</tr>
<tr>
<td>Resurvey areas where controls added</td>
<td>Time to complete resolution</td>
</tr>
<tr>
<td>Planning</td>
<td>Exposure-related illnesses/complaints</td>
</tr>
<tr>
<td>Life safety systems, installation of engineering controls</td>
<td>Actions based on incidents</td>
</tr>
<tr>
<td>WEIS</td>
<td>Number of follow-ups after the fact</td>
</tr>
<tr>
<td>Process changes against process change evaluations</td>
<td></td>
</tr>
<tr>
<td>Reduction in exposure potential</td>
<td></td>
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<tr>
<td>Ventilation surveys performed/required</td>
<td></td>
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<tr>
<td>Preventative maintenance for effectiveness</td>
<td></td>
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<tr>
<td>Design review, supplier &amp; equipment buy-off</td>
<td></td>
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<tr>
<td>Number of planning documents reviewed &amp; formalized</td>
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<tr>
<th>Leading – Corporate</th>
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<tbody>
<tr>
<td>Planning</td>
<td>Assessments</td>
</tr>
<tr>
<td>Auditing</td>
<td>OSHA injury &amp; illness rates</td>
</tr>
<tr>
<td>WEIS</td>
<td>Time to complete resolution</td>
</tr>
<tr>
<td>Design review; supplier &amp; equipment buy-off</td>
<td>Exposure related illnesses/complaints</td>
</tr>
<tr>
<td>Action register</td>
<td>Actions based on incidents</td>
</tr>
<tr>
<td>Life safety systems—installation of engineering controls prior to tool installs</td>
<td>Engineering controls due to exposure</td>
</tr>
<tr>
<td>Engineering controls in design stage</td>
<td>Number of follow-ups after the fact</td>
</tr>
<tr>
<td>Reduction in exposure potential</td>
<td>Cost determination &amp; reduction surveys</td>
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</table>
### Warnings Metrics

<table>
<thead>
<tr>
<th>Leading - Best IH Program Site</th>
<th>Trailing - Best IH Program Site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning</td>
<td>OSHA injury &amp; illness rates</td>
</tr>
<tr>
<td>Training</td>
<td>Time to complete resolutions</td>
</tr>
<tr>
<td>Inspections</td>
<td>Actions based on incident reviews</td>
</tr>
<tr>
<td>Observations</td>
<td></td>
</tr>
<tr>
<td>Workplace Exposure Improvement</td>
<td></td>
</tr>
<tr>
<td>Score (WEIS)</td>
<td></td>
</tr>
<tr>
<td>Training completed vs. required</td>
<td></td>
</tr>
<tr>
<td>Design review; supplier &amp; equipment buy-off</td>
<td></td>
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<tr>
<td>Audit results</td>
<td></td>
</tr>
<tr>
<td>Determination of hazard warnings during planning of tool installations, hazard communication &amp; fabrication operations training</td>
<td></td>
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<tr>
<th>Leading – Corporate</th>
<th>Trailing - Corporate</th>
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<tr>
<td>Planning</td>
<td>Assessments</td>
</tr>
<tr>
<td>Auditing</td>
<td>OSHA injury &amp; illness rates</td>
</tr>
<tr>
<td>Workplace Exposure Improvement Score (WEIS)</td>
<td>Time to complete resolutions</td>
</tr>
<tr>
<td>Design review; supplier &amp; equipment buy-off</td>
<td>Actions based on incident reviews</td>
</tr>
<tr>
<td>Warnings in place at start of operations</td>
<td>Warnings implemented due to exposure</td>
</tr>
<tr>
<td></td>
<td>Cost determination &amp; reduction surveys</td>
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### Administrative Control Metrics

<table>
<thead>
<tr>
<th>Leading - Best IH Program Site</th>
<th>Trailing - Best IH Program Site</th>
</tr>
</thead>
<tbody>
<tr>
<td>WEIS</td>
<td>OSHA injury &amp; illness rates</td>
</tr>
<tr>
<td>Design reviews</td>
<td>Time to complete resolutions</td>
</tr>
<tr>
<td>Pre-planning</td>
<td>Exposure – related illnesses/complaints</td>
</tr>
<tr>
<td>Design to make controls unnec</td>
<td>Incident reviews</td>
</tr>
<tr>
<td>Reduction in exposure potential</td>
<td></td>
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<table>
<thead>
<tr>
<th>Leading – Corporate</th>
<th>Trailing - Corporate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design review</td>
<td>OSHA injury &amp; illness rates</td>
</tr>
<tr>
<td>Pre-planning</td>
<td>Time to complete resolutions</td>
</tr>
<tr>
<td>Design to make controls unnec</td>
<td>Compliance</td>
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<tr>
<td>Reduction in exp. pot.</td>
<td>Incident reviews</td>
</tr>
<tr>
<td></td>
<td>Controls implemented due to exposures</td>
</tr>
<tr>
<td></td>
<td>Cost determination &amp; reduction surveys</td>
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## Respiratory Protection Metrics

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<tr>
<th>Leading - Best IH Program Site</th>
<th>Trailing - Best IH Program Site</th>
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</thead>
<tbody>
<tr>
<td>Annual survey</td>
<td>OSHA injury &amp; illness rates</td>
</tr>
<tr>
<td>Track fit tests</td>
<td>Time to complete resolutions</td>
</tr>
<tr>
<td>Planning</td>
<td>Exposure – related illnesses/complaints</td>
</tr>
<tr>
<td>Training</td>
<td>Number of respiratory protection</td>
</tr>
<tr>
<td>Inspections</td>
<td>equipment wearers</td>
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<tr>
<td>Observations</td>
<td>Pulmonary Function Tests</td>
</tr>
<tr>
<td>WEIS</td>
<td>Incident review to determine program effectiveness</td>
</tr>
<tr>
<td>Fit tests performed vs. required</td>
<td>Employees turned away at crib</td>
</tr>
<tr>
<td>Hazardous Material Control Program implementation</td>
<td></td>
</tr>
<tr>
<td>Frequent monitoring of Action Level</td>
<td></td>
</tr>
<tr>
<td>PPE elimination</td>
<td></td>
</tr>
<tr>
<td>Percent using respiratory protection</td>
<td></td>
</tr>
<tr>
<td>Review of PPE matrix</td>
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<tr>
<th>Leading – Corporate</th>
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<tr>
<td>Planning</td>
<td>Assessments</td>
</tr>
<tr>
<td>Auditing</td>
<td>OSHA injury &amp; illness rates</td>
</tr>
<tr>
<td>WEIS</td>
<td>Time to complete resolution</td>
</tr>
<tr>
<td>Hazardous material control program implementation</td>
<td>Compliance</td>
</tr>
<tr>
<td>Audit</td>
<td>Incident review to determine program effectiveness</td>
</tr>
<tr>
<td>Monitoring requirements, training, etc.</td>
<td>Exposures where respiratory protection required</td>
</tr>
<tr>
<td>Review of PPE matrix</td>
<td>Cost determination &amp; reduction surveys</td>
</tr>
<tr>
<td>Annual survey</td>
<td>Number of respirator users</td>
</tr>
<tr>
<td></td>
<td>% training completed</td>
</tr>
<tr>
<td></td>
<td>% users validated</td>
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### Other PPE Metrics

<table>
<thead>
<tr>
<th>Leading - Best IH Program Site</th>
<th>Trailing - Best IH Program Site</th>
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</thead>
<tbody>
<tr>
<td>Standard Threshold Shifts for hearing protection control</td>
<td>OSHA injury &amp; illness rates</td>
</tr>
<tr>
<td>Planning</td>
<td>Time to complete resolution</td>
</tr>
<tr>
<td>Training</td>
<td>Exposure – related illnesses/complaints</td>
</tr>
<tr>
<td>Inspections</td>
<td>Medical testing</td>
</tr>
<tr>
<td>Observations</td>
<td>Compliance</td>
</tr>
<tr>
<td>WEIS</td>
<td>Incident review to determine program effectiveness</td>
</tr>
<tr>
<td>Hazardous Material Control Program implementation</td>
<td>% PPE Assessments completed</td>
</tr>
<tr>
<td>Failure of protective measures - determined by audits</td>
<td></td>
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<tr>
<td>PPE Elimination</td>
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<tr>
<td>% using</td>
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<tr>
<td>PPE matrix &amp; review of PPE needed</td>
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<tr>
<td>Hazardous Material Control Program implementation</td>
<td>Compliance</td>
</tr>
<tr>
<td>Audits</td>
<td>Incident review to determine program effectiveness</td>
</tr>
<tr>
<td>PPE matrix &amp; review of PPE needed</td>
<td>PPE requirements implemented due to exposure</td>
</tr>
<tr>
<td>PPE requirements established before exposure</td>
<td>Cost determination &amp; reduction surveys</td>
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## Other IH Metrics

<table>
<thead>
<tr>
<th>Leading - Best IH Program Site</th>
<th>Trailing.-. Best IH Program Site</th>
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<tbody>
<tr>
<td>Management involvement meetings</td>
<td></td>
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<tr>
<td>Training completion</td>
<td></td>
</tr>
<tr>
<td>Wellness – interventions &amp; Health Risk Assessments (HRAs)</td>
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</tr>
<tr>
<td>Number of findings tracked to closure</td>
<td></td>
</tr>
<tr>
<td>Management systems score</td>
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<table>
<thead>
<tr>
<th>Leading – Corporate</th>
<th>Trailing - Corporate</th>
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<tbody>
<tr>
<td>Wellness – interventions &amp; Health Risk Assessments (HRAs)</td>
<td>DART</td>
</tr>
<tr>
<td>Internal health &amp; safety audit scores</td>
<td>TRIR</td>
</tr>
<tr>
<td>Audits performed vs. scheduled</td>
<td>Reduce the number of samples that are &gt; 50% of OEL</td>
</tr>
<tr>
<td>Time to closure</td>
<td></td>
</tr>
<tr>
<td>Overdue recommendations</td>
<td></td>
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<tr>
<td>Management systems score</td>
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</tr>
<tr>
<td>Case Study Title</td>
<td>Page</td>
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Case Study Validation 1: MSDS Software Case

The ROHSEI case study determined the value of implementing MSDS software for the purpose of authoring, maintaining and distributing MSDSs in the workplace. There were three possible scenarios:

1. Industry accepted software run internally
2. Federal sector software run internally
3. Outsourced solution

The MSDS program incorporated six elements with defined costs for each step. The value of an MSDS program includes the financial benefits associated with reduction of risk and improvement of the business process. Incorporating these elements enabled a full accounting of how the investment in running an internal MSDS program could improve the business process.

The case study used “Design and Engineering Personnel Time” to calculate total operating costs within the data element “design and engineering” in the quantitative tool.

The case study used “EHS Personnel Time” to calculate what would be considered the total operating costs within the data element “IH and safety staff time spent on managing the risk” and within the data element “process/steps/motion” in the quantitative tool.

The case study used “EHS Supplies” to calculate total operating costs within the data element “IH Supplies” and “Maintenance costs” in the quantitative tool.

The case study used “Operational Personnel Time” to calculate total operating costs within the data element “Operational Personnel Time” in the quantitative tool.

The case study used “Training” to calculate total operating costs within the data elements “training and meetings” in the quantitative tool.

The company used “Vendors, Consultants and Contract Labor” to calculate total operating costs within the data elements “Vendors, Consultants and Contract Labor” in the quantitative tool.

The MSDS software case study indicated:

- The users had access to the data.
- The users understood the elements.
- The users understood the elements over time.
- Different users understood the elements.
- The users were able to calculate the value associated with the various project scenarios.
Case Study Validation 2: Integrated Health

The ROHSEI case study determined the value of implementing onsite occupational health clinics at every site for the purpose of decreasing off-site doctors’ office visits and reducing the cost of medical management of Workers’ Compensation and Short-Term Disability cases. The investment was intended to increase the overall productivity of employees and improve overall health.

The integrated health program incorporated three elements with defined costs for each step. The value of an integrated health program includes the financial benefits associated with reduction of risk, improvement of the business process and improved employee health. The incorporation of these elements enabled a full accounting of how investment in an internal integrated health care management program could improve the business process.

The case study used “Medical Costs and Insurance” to calculate the total cost of occupational illnesses and injuries within the data element “Average medical costs of occupational injury/illness cases associated with the hazard(s)” in the quantitative tool. Reduction in these costs was equated to improved employee health.

The case study used “Other Personnel Time” to calculate total operating costs within the data element “other personnel time spent on managing the risk” in the quantitative tool.

The case study used “Operational Personnel Time” to calculate the total operating costs within the data element “operational Personnel Time” in the quantitative tool.

The company used “Vendors, Consultants and Contract Labor” to calculate total operating costs within the data elements “Vendors, Consultants and Contract Labor” in the quantitative tool.

The Integrated Health case study indicated:

- The users had access to the data.
- The users understood the elements.
- The users understood the elements over time.
- Different users understood the elements.
- The users were able to calculate the value associated with the various project scenarios.
Case Study Validation 3: Noise Reduction

The ROHSEI case study determined the value of investment in engineering controls to reduce noise levels. By installing line braces and reinforcement structures, the company was able to minimize vibration and ultimately reduce noise levels. The noise reduction program incorporated 18 elements with defined costs for each step. The value of a noise reduction program includes the financial benefits associated with reduction of risk, improvement of the business process and improved employee health. The incorporation of these elements enabled a full accounting of the costs of investment in risk reduction and the resulting improvement in the business process to be included as part of the value calculation. The company took into account the following elements in the ROHSEI analysis:

1. Business Interruption Insurance
2. Design and Engineering Personnel Time
3. EHS Personnel Time
4. EHS Supplies
5. Emergency Response
6. Fines and Penalties
7. Legal Fees, Workers Comp & Settlements
8. Loss of Raw Materials, Product
9. Material Recovery
10. Material Substitution
11. Medical Costs and Insurance
12. Noise Reduction- Lost Sales
13. Operational Personnel Time
14. Operations and Maintenance
15. Other Personnel Time
16. Production Downtime
17. Property Damage Insurance
18. Vendors, Consultants and Contract Labor

The case study used “EHS Personnel Time” to calculate total operating costs within the data elements “IH and safety staff time spent on managing the risk” and “process/steps/motion” in the quantitative tool.

The case study used “Design and Engineering Personnel Time” to calculate total operating costs within the data element “design and engineering” in the quantitative tool.

The case study used “Legal Fees, Workers’ Compensation & Settlements” to calculate what would be considered the total non-medical costs of incidents within the data element “Internal and external legal fees, workers’ compensation and settlements” in the quantitative tool.

The case study used “Medical Costs and Insurance” to calculate total cost of occupational illnesses and injuries within the data element “Average medical costs of occupational injury/illness cases associated with the hazard(s)” in the quantitative tool.

The Noise Reduction case study indicated:

- The users had access to the data.
- The users understood the elements.
- The users understood the elements over time.
- Different users understood the elements.
- The users were able to calculate the value associated with the various project scenarios.
Case Study Validation 4: In-House Versus Contract Manufacturing

The ROHSEI case study examined the costs associated with two scenarios of manufacturing a new product in house versus using a contract manufacturer. The material to be manufactured had significant toxicity and would require specialized handling at either an internal or contract facility. The three scenarios considered were:

1. Manufacture in-house with PPE for operator protection
2. Manufacture in-house with engineering controls for operator protection
3. Manufacture at a third party contract manufacturing location

The analysis utilized seven elements to define the costs and benefits associated with each of the scenarios.

To manufacture in house, specialized equipment was required to be purchased and installed in order to contain the hazardous product and ensure an adequate level of employee protection. “Equipment Purchase” was the parameter used to account for the cost of the equipment. The company also captured the “Equipment Installation” to account for the cost of preparing the equipment for operation.

Once the equipment was ready for operation the company would conduct manufacturing trials where product was manufactured in the new process and validated as meeting acceptable quality standards. The cost of conducting the validation trials with its associated labor and material impacts was captured as “Internal Manufacturing Runs”.

Manufacturing conducted at a third party location would also require validation trials for which the company would be financially responsible. These costs were captured in the parameter “3rd Party Manufacturing Runs”.

The company also accounted for the additional cost of “Personal Protective Equipment” under the scenario that allowed for in-house manufacturing but with a less contained process, thus allowing higher levels of airborne exposure to employees.

In the contract manufacturing scenario the intermediate product would be manufactured off-site but would be shipped back to the owner for further processing. The company captured these costs as “Shipping” expenses.

The in-house versus contracting case study indicated:

- The user had or was able to develop or collect the data.
- The user understood or was able to create the data elements.
- The user understood the elements during the course of the study.
- Different project team participants understood the elements.
- The project team was able to calculate the value associated with the various project scenarios.
Case Study Validation 5: Need for Machine Replacement

The ROHSEI case evaluated the options associated with keeping, repairing or purchasing a type of production equipment. The study looked at the cost of the options but also considered the potential reduction in injuries associated with the existing equipment as a potential benefit associated with the final decision. Three scenarios were considered:

1. Continue to use the existing machines
2. Upgrade the existing equipment
3. Purchase new replacement equipment

The company identified the “Average Incident Cost” associated with accidents which had occurred on or around the existing equipment. They also estimated the potential reduction in the number of incidents associated with each of the three scenarios.

The new machines require fewer employees to operate the equipment and the company captured the associated employee costs as “Direct Labor”. Likewise each equipment scenario requires additional levels of maintenance and other support which the company calculated as “Indirect Labor”.

The reliability and maintainability of the equipment also varies by scenario. The case study used “Production Downtime” to capture the costs associated with the product activity that was lost due to the equipment being unavailable due to maintenance and repair.

The equipment in each scenario had differing rates of generating scrap. The case study used “Scrap Costs” to capture the cost of the amount of wasted product from the machines in each scenario.

Because of the accidents that have occurred on the equipment, the company has had to resort to using “Temporary Labor” to replace injured workers.

The Machine Replacement case study indicated:
- The users had access or were able to obtain or develop the necessary data.
- The users understood the data elements.
- The users understood the elements over time.
- The different members of the protect team understood the elements.
- The users were able to calculate the value of the elements associated with the various project scenarios.
The ROHSEI case study determined the value of using alternative means of containment compared to the use of personal protective equipment. There were three possible scenarios evaluated to ensure employee protection:

1. Continue the use of Personal Protective Equipment
2. Invest in a Flexible Containment System
3. Invest in Local Exhaust Ventilation

The company identified the elimination of the “Cost of Personal Protective Equipment” as a potential benefit of investment in engineering controls. The investment would result in both an improved business process and a reduced level of risk.

As part of the analysis of possible process changes, alternative methods of managing dust associated with potent compounds were evaluated. The parameters “Continuous Liner” and “Standard Drum Bag” were associated with operational steps in the various scenarios which described improvements in the business process.

By considering alternatives to the current operation, the study showed it would be possible to eliminate or significantly reduce the parameter “Cleaning Labor” which would result in an improvement in the business process.

A parameter “Flexible Enclosure” described the cost of the equipment associated with one scenario. It was designed to improve the business process.

The company identified that additional “Maintenance” was required by the containment projects. This cost was incorporated into the overall calculation of the investment required to implement the alternative.

The personal protective equipment versus containment case study indicated:

- The users had access or could acquire the data.
- The users understood the data elements.
- The users understood the data elements over time.
- Different users on the project team understood the elements.
- The project team was able to calculate the value contributed by the data elements.
Case Study Validation 7: Tyvek Recycling

The ROHSEI case study determined the value of recycling the company’s Tyvek suits and booties after use rather than outsourcing their destruction through incineration.

The Tyvek Recycling program incorporated two new elements with defined costs for each step. The value of a Tyvek recycling program includes the financial benefits associated with reduction of risk and improvement of the business process.

The case study used “Recycling” to calculate total operating costs within the data element “waste collection, disposal and recycling cost” in the quantitative tool.

The case study used “Waste Disposal” to calculate total operating costs within the data elements “Environmental Emissions” or “Hazardous waste management and treatment costs” or “waste collection, disposal and recycling costs” in the quantitative tool.

The Tyvek Recycling case study indicated:

- The users had access to the data.
- The users understood the elements.
- The users understood the elements over time.
- Different users understood the elements.
- The users were able to calculate the value associated with the various project scenarios.
Case Study Validation 8: Pharmaceutical Handling

The ROHSEI case study determined the value of installing material handling equipment in a pharmacy for the purpose of reducing the number of injuries and increasing productivity.

The Material Handling Program incorporated six elements with defined costs for each step. The value of a Material Handling Program includes the financial benefits associated with reduction of risk and improvement of the business process. The incorporation of these elements enabled a full accounting of the effect of investment in risk reduction on operating costs and the resulting improvement in the business process to be included as part of the value calculation.

The case study used “Legal Fees, Workers’ Compensation & Settlements” to calculate the total non-medical costs of incidents within the data element “Internal and external legal fees, workers’ compensation and settlements” in the quantitative tool.

The company used “EHS Personnel Time” to calculate what would be considered the total operating costs within the data element “IH and safety staff time spent on managing the risk” and within the data element “process/steps/motion” in the quantitative tool.

The company used “Lost Work (Sick) Time” to calculate total non-medical cost of incidents within the data element “Labor” in the quantitative tool.

The company used “Medical Costs and Insurance” to calculate total cost of occupational illnesses and injuries within the data element “Average medical costs of occupational injury/illness cases associated with the hazard(s)” in the quantitative tool.

The company used “Production Downtime” to calculate total operating costs within the data elements “Delay Time” in the quantitative tool.

The company used “Productivity” to calculate total operating costs within the data elements “Process Flow” in the quantitative tool. The incorporation of these elements showed how the business process could be improved with installation of material handling equipment.

The Pharmaceutical Handling case study indicated:

- The users had access to the data.
- The users understood the elements.
- The users understood the elements over time.
- Different users understood the elements.
- The users were able to calculate the value associated with the various project scenarios.
Case Study Validation 9: Emergency Spill Team

The ROHSEI case study determined the value of outsourcing labor rather than keeping an in-house team for the purpose of improving the company’s spill response within their manufacturing operations and laboratory activities. There were three possible scenarios:

1) Reducing the team to eight employees to cover the day shift only.
2) Reducing the team to four employees (a minimum of two employees required and two back-ups).
3) Outsourcing.

The analysis for the first two scenarios was completed in two ways - with in-house labor and outsourced labor.

The Emergency Spill Team Program incorporated eight elements with defined costs for each step. The value of the program includes the financial benefits associated with reduction of risk and improvement of the business process.

The case study used “Spill Response Labor” and “Payment for Spill Response” to calculate total non-medical cost of incidents within the data element “emergency response” in the quantitative tool.

The case study used “Hydrostatic Testing” to calculate total operating costs within the data elements “Operations and Maintenance Costs” and “Cost of ongoing preventive maintenance for IH purposes” in the quantitative tool.

The case study used “SCBA Air Switch Out” and “Spill Equipment Supplies” to calculate total operating costs within the data element “IH Supplies” and “Maintenance costs” in the quantitative tool.

The case study used “Medical Exam” to calculate total operating costs within the data element “Medical Surveillance Costs” in the quantitative tool.

The case study used “Training” to calculate total operating costs within the data elements “training and meetings” in the quantitative tool.

The MSDS Software case study indicated:
The users had access to the data.
The users understood the elements.
The users understood the elements over time.
Different users understood the elements.
The users were able to calculate the value associated with the various project scenarios.
Case Study Validation 10: Bottled Water

The ROHSEI case study determined the value of implementing a program for bottling water for emergency use in a shipyard for the purpose of reducing costs associated with purchasing bottled water. There were three possible scenarios:

1. Purchase bottled water
2. Bottle company water in building
3. Bottle company water in trailer

The Bottled Water Program incorporated seven elements with defined costs for each step. The value of the program includes the financial benefits associated with reduction of risk and improvement of the business process.

The company used “Bottled Water” to calculate total non-medical cost of incidents within the data element “Loss of Raw Materials or Product” in the quantitative tool.

The company used “Bottling Materials” and “Packaging Supplies” to calculate total operating costs within the data element “Maintenance Costs” in the quantitative tool.

The company used “Sanitation Supplies” to calculate total operating costs within the data element “IH Supplies” and “Maintenance costs” in the quantitative tool.

The company used “Trailer Rent” and “Trailer Setup” to calculate total capital costs within the data element “Equipment” in the quantitative tool.

The company used “Utilities and Piping” to calculate what would be considered the total capital costs within the data elements “Installation” in the quantitative tool.

The Bottled Water case study indicated:

- The users had access to the data.
- The users understood the elements.
- The users understood the elements over time.
- Different users understood the elements.
- The users were able to calculate the value associated with the various project scenarios.
Table E-1. AIHA Value of the Profession Data Element Analysis Matrix.

<table>
<thead>
<tr>
<th>QUANTITATIVE ELEMENTS</th>
<th>Risk Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>CASE STUDY: COMPANY B</td>
<td>DATA ELEMENTS</td>
</tr>
<tr>
<td>Health</td>
<td>Company B</td>
</tr>
<tr>
<td>Data Element Criterion</td>
<td></td>
</tr>
<tr>
<td>Total Cost of Occupational Illnesses or Injuries</td>
<td>Company B had incorporated the element by number/type and costs. However, there were no costs associated with occupational illnesses documented in this case study.</td>
</tr>
<tr>
<td>Case Study: Company B Health</td>
<td></td>
</tr>
<tr>
<td>Total Capital Costs</td>
<td></td>
</tr>
<tr>
<td>Total Operating Costs</td>
<td>Company B considered these costs to be one time charges for implementing the IH intervention.</td>
</tr>
<tr>
<td>Total Medical Surveillance Costs</td>
<td>Company B was able to determine the type of cost data necessary for the element according to time spent within operational (Non-IH) time, IH safety staff time, other time, and consultant time.</td>
</tr>
<tr>
<td>Total Other Costs Related to the Current Method of Managing the Risks</td>
<td>Company B provided capital costs incurred during the intervention.</td>
</tr>
<tr>
<td>Total Non-Medical Costs of Incidents</td>
<td>Company B provided operating cost data based on time spent within the various sub-elements. The sub-elements do not allow for double-counting, providing a consistent basis for data collection. Each category is defined so users will know what costs to include and exclude.</td>
</tr>
</tbody>
</table>
## AIHA Value of the Profession Data Element Analysis Matrix

### CASE STUDY: COMPANY C

<table>
<thead>
<tr>
<th>DATA ELEMENTS</th>
<th>QUANTITATIVE ELEMENTS</th>
<th>Health</th>
<th>Risk Management</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data Element Criterion</strong></td>
<td><strong>Total Cost of Occupational Illnesses or Injuries</strong></td>
<td><strong>Total Capital Costs</strong></td>
<td><strong>Total Operating Costs</strong></td>
</tr>
<tr>
<td>1. Is the element the right one for the model?</td>
<td>Company C incorporated the element by costs associated with medical staff and facilities for medical screenings and IH monitoring/testing.</td>
<td>Company C incorporated the element by capital costs.</td>
<td>Company C incorporated the element by expressing the changes in the various sub-elements. For example, pre-intervention capital costs were higher than post-intervention capital costs.</td>
</tr>
<tr>
<td>2. Are its key sub-elements listed correctly?</td>
<td>Company C considered number/type of illnesses however, data was not provided for further sub-elements. Medical costs were considered through processing and disorder fees.</td>
<td>Company C considered these costs to be routine expenses for ventilation equipment and installation.</td>
<td>Company C was able to distinguish between operational (Non-IH) time, IH safety staff time, other time, IH supplies and operations/maintenance. They were then able to show the differences between these sub-categories before, during and after the intervention.</td>
</tr>
<tr>
<td>3. Is it correctly named? Will the users know what it means?</td>
<td>Company C was able to determine the type of cost data that would belong within this element.</td>
<td>Company C was able to determine the type of cost data that would belong within this element.</td>
<td>Company C was able to determine the type of cost data necessary for the element.</td>
</tr>
<tr>
<td>4. Is it adequately defined, so that consistent answers will be given by different users?</td>
<td>Company C provided fact-based (consistent) data of costs associated with medical staff and facilities for medical screenings and IH monitoring/testing.</td>
<td>Company C provided cost data specific to this intervention analysis. However, fact-based, consistent cost data would be used for other types of analysis as well.</td>
<td>Company C provided operating cost data based on time spent within the various sub-elements. The sub-elements do not allow for double-counting, providing a consistent basis for data collection. Each category is defined so users will know what costs to include and exclude.</td>
</tr>
<tr>
<td>5. Will it be consistently interpreted over time?</td>
<td>Company C considered the elements to be sufficient for collecting data on occupational illness costs necessary for retrospective and prospective analysis.</td>
<td>Company C considered these costs to be the same type of elements and sub-elements that would be needed for retrospective and prospective analysis.</td>
<td>Company C considered operating costs to include the same type of elements and sub-elements that would be needed for retrospective and prospective analysis.</td>
</tr>
</tbody>
</table>
# QUANTITATIVE ELEMENTS

## CASE STUDY: COMPANY D

<table>
<thead>
<tr>
<th>Data Element Criterion</th>
<th>Total Cost of Occupational Illnesses or Injuries</th>
<th>Total Capital Costs</th>
<th>Total Operating Costs</th>
<th>Total Medical Surveillance Costs</th>
<th>Total Other Costs Related to the Current Method of Managing the Risks</th>
<th>Total Non-Medical Costs of Incidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Is the element the right one for the model?</td>
<td>Company D incorporated the element by number/type of ergonomic illnesses.</td>
<td>Company D incorporated the element by equipment costs.</td>
<td>Company D was able to distinguish between operational (Non-IH) time, IH safety staff time, and IH supplies. They were then able to show the differences between these sub-categories before and after the intervention.</td>
<td>Company D did not use this element for the analysis.</td>
<td>Company D did not use this element for the analysis.</td>
<td>Company D did not use this element for the analysis.</td>
</tr>
<tr>
<td>2. Are its key sub elements listed correctly?</td>
<td>Company D considered recordable ergo cases and costs per case.</td>
<td>Company D considered these costs to be routine expenses for the intervention.</td>
<td>Company D was able to determine the type of cost data necessary for the element.</td>
<td>Company D did not use this element for the analysis.</td>
<td>Company D did not use this element for the analysis.</td>
<td>Company D did not use this element for the analysis.</td>
</tr>
<tr>
<td>3. Is it correctly named? Will the users know what it means?</td>
<td>Company D was able to determine the type of cost data belonging in this element based on average cost and number of illness.</td>
<td>Company D was able to determine the type of cost data necessary for the element.</td>
<td>Company D was able to determine the type of cost data necessary for the element, according to time spent within operational (Non-IH) time, IH safety staff time, and IH supplies.</td>
<td>Company D did not use this element for the analysis.</td>
<td>Company D did not use this element for the analysis.</td>
<td>Company D did not use this element for the analysis.</td>
</tr>
<tr>
<td>4. Is it adequately defined, so that consistent answers will be given by different users?</td>
<td>Company D provided fact based (consistent) data of cost and number/type of illness.</td>
<td>Company D provided the same cost data for during and after the intervention.</td>
<td>Company D provided operating cost data based on time spent within the various sub-elements. The sub-elements do not allow for double-counting, providing a consistent basis for data collection. Each category is defined so users will know what costs to include and exclude.</td>
<td>Company D did not use this element for the analysis.</td>
<td>Company D did not use this element for the analysis.</td>
<td>Company D did not use this element for the analysis.</td>
</tr>
<tr>
<td>5. Will it be consistently interpreted over time?</td>
<td>Company D considered the elements to be sufficient for collecting data on occupational illness costs necessary for retrospective and prospective analysis.</td>
<td>Company D considered these costs to be the same type of elements and sub-elements that would be needed for retrospective and prospective analysis.</td>
<td>Company D considered operating costs to include the same type of elements and sub-elements that would be needed for retrospective and prospective analysis.</td>
<td>Company D did not use this element for the analysis.</td>
<td>Company D did not use this element for the analysis.</td>
<td>Company D did not use this element for the analysis.</td>
</tr>
<tr>
<td>QUANTITATIVE ELEMENTS</td>
<td>Health</td>
<td>CASE STUDY: COMPANY E</td>
<td>Risk Management</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------</td>
<td>--------</td>
<td>-----------------------</td>
<td>----------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data Element Criterion</td>
<td>Total Cost of Occupational Illnesses or Injuries</td>
<td>Total Capital Costs</td>
<td>Total Operating Costs</td>
<td>Total Medical Surveillance Costs</td>
<td>Total Other Costs Related to the Current Method of Managing the Risks</td>
<td>Total Non-Medical Costs of Incidents</td>
</tr>
<tr>
<td>1. Is the element the right one for the model?</td>
<td>Company E incorporated the element by number/type of illnesses and average costs of illnesses over 5 years.</td>
<td>Company E did not use this element for the analysis.</td>
<td>Company E incorporated the element by expressing the changes in the various sub-elements. For example, pre-intervention costs included monitoring, meeting, IH planning, design/engineering, maintenance/janitorial and operations/maintenance costs.</td>
<td>Company E incorporated the element by addressing annual cost of medical staff, facilities, supplies and IH monitoring/testing.</td>
<td>Company E did not use this element for the analysis.</td>
<td></td>
</tr>
<tr>
<td>2. Are its key sub-elements listed correctly?</td>
<td>Company E considered number/type of illnesses, average costs and the cost of medical staff and facilities for screening and IH monitoring/testing.</td>
<td>Company E did not use this element for the analysis.</td>
<td>Company E was able to distinguish between operational (Non-IH) time, IH safety staff time, other time, IH supplies, and operations/maintenance. Company E was then able to show the differences between these sub-categories before, during and after the intervention.</td>
<td>This element is a sub-element itself under Total Operating Costs, but has been culled out to show its importance in the analysis. Therefore, the criteria question is not relevant.</td>
<td>Company E did not use this element for the analysis.</td>
<td></td>
</tr>
<tr>
<td>3. Is it correctly named? Will the users know what it means?</td>
<td>Company E was able to determine the type of cost data that would belong within this element.</td>
<td>Company E did not use this element for the analysis.</td>
<td>Company E was able to determine the type of cost data necessary for the element, according to time spent within operational (Non-IH) time, IH safety staff time, other time, IH supplies and operations/maintenance.</td>
<td>Company E was able to determine the type of cost data necessary for the element.</td>
<td>Company E did not use this element for the analysis.</td>
<td></td>
</tr>
<tr>
<td>4. Is it adequately defined, so that consistent answers will be given by different users?</td>
<td>Company E provided fact based (consistent) data of costs associated with number/type of illnesses and medical costs. Users will collect fact-based data.</td>
<td>Company E did not use this element for the analysis.</td>
<td>Company E provided operating cost data based on time spent within the various sub-elements. The sub-elements do not allow for double-counting, providing a consistent basis for data collection. Each category is defined so users will know what costs to include and exclude.</td>
<td>Company E provided medical surveillance cost data based on operating costs.</td>
<td>Company E did not use this element for the analysis.</td>
<td></td>
</tr>
<tr>
<td>5. Will it be consistently interpreted over time?</td>
<td>Company E considered the elements to be sufficient for collecting data on occupational illness costs necessary for retrospective and prospective analysis.</td>
<td>Company E did not use this element for the analysis.</td>
<td>Company E considered operating costs to include the same type of elements and sub-elements that would be needed for retrospective and prospective analysis.</td>
<td>Company E considered medical surveillance costs to include the same type of elements that would be needed for retrospective and prospective analysis.</td>
<td>Company E did not use this element for the analysis.</td>
<td></td>
</tr>
<tr>
<td>Data Element Criterion</td>
<td>Total Cost of Occupational Illnesses &amp; Injuries</td>
<td>Total Capital Costs</td>
<td>Total Operating Costs</td>
<td>Total Medical Surveillance Costs</td>
<td>Total Other Costs Related to the Current Method of Managing the Risks</td>
<td>Total Non-Medical Costs of Incidents</td>
</tr>
<tr>
<td>------------------------</td>
<td>-----------------------------------------------</td>
<td>---------------------</td>
<td>----------------------</td>
<td>---------------------------------</td>
<td>---------------------------------------------------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>1. Is the element the right one for the model?</td>
<td>Yes - one Company F intervention requires capital investment</td>
<td>Yes - total operating cost is key parameter of developing total cost of the intervention</td>
<td>Element was populated in the case study</td>
<td>Company F did not identify any costs associated with this data element</td>
<td>Company F did not identify any costs associated with this data element</td>
<td></td>
</tr>
<tr>
<td>2. Are its key sub elements listed correctly?</td>
<td>Yes - sub-elements capture the various parameters that make up the total operating costs</td>
<td>Yes - sub-elements captured provided information included in the study</td>
<td>Sub-elements were not consistently captured</td>
<td>Company F did not identify any costs associated with this data element</td>
<td>Company F did not identify any costs associated with this data element</td>
<td></td>
</tr>
<tr>
<td>3. Is it correctly named? Will the users know what it means?</td>
<td>Yes - readily understood by users. Basic financial language was used by organizations</td>
<td>Yes - Company F IH's understood what was intended by the parameter</td>
<td>Yes - data element was properly named</td>
<td>Company F did not identify any costs associated with this data element</td>
<td>Company F did not identify any costs associated with this data element</td>
<td></td>
</tr>
<tr>
<td>4. Is it adequately defined, so that consistent answers will be given by different users?</td>
<td>Adequately defined. Requires capital costs to be captured for each intervention considered</td>
<td>The sub-elements are defined and instructions assisted with getting consistent answers regarding the interventions</td>
<td>The data element was properly defined and consistent data was provided</td>
<td>Company F did not identify any costs associated with this data element</td>
<td>Company F did not identify any costs associated with this data element</td>
<td></td>
</tr>
<tr>
<td>5. Will it be consistently interpreted over time?</td>
<td>Yes - consistent financial business language</td>
<td>Company F was able to develop data to conduct analysis of 5 year period.</td>
<td>Company F developed developed retrospective data and projected to several scenarios</td>
<td>Company F did not identify any costs associated with this data element</td>
<td>Company F did not identify any costs associated with this data element</td>
<td></td>
</tr>
<tr>
<td>6. Will it provide consistent data over time?</td>
<td>Yes - capital expenditure data will be consistently captured over time</td>
<td>Company F data appeared to be consistent over the period of the study</td>
<td>Company F was able to provide consistent data over time</td>
<td>Company F did not identify any costs associated with this data element</td>
<td>Company F did not identify any costs associated with this data element</td>
<td></td>
</tr>
<tr>
<td>7. Do companies have the data to support it?</td>
<td>Capital expenditure data is routinely developed in organizations</td>
<td>Company F was able to obtain sufficient data to construct a retrospective analysis of the intervention options</td>
<td>Company F had the data to support actual and future costs</td>
<td>Company F did not identify any costs associated with this data element</td>
<td>Company F did not identify any costs associated with this data element</td>
<td></td>
</tr>
<tr>
<td>8. Will the IH be able to access the data?</td>
<td>Yes - IH's will likely be part of the data collection process</td>
<td>Company F IH's either had the data or were able to reconstruct the data from company records and personnel.</td>
<td>Company F IH's were able to access medical surveillance costs</td>
<td>Company F did not identify any costs associated with this data element</td>
<td>Company F did not identify any costs associated with this data element</td>
<td></td>
</tr>
</tbody>
</table>
## CASE STUDY: COMPANY G

### DATA ELEMENTS

<table>
<thead>
<tr>
<th>Data Element Criterion</th>
<th>Health</th>
<th>Risk Management</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Cost of Occupational Illnesses or Injuries</strong></td>
<td><strong>Total Capital Costs</strong></td>
<td><strong>Total Operating Costs</strong></td>
</tr>
<tr>
<td>1. Is the element the right one for the model?</td>
<td>There was a cost associated with experiencing both short term and long term hearing shifts</td>
<td>Operating costs reflect both costs incurred by operating staff and budgets as well as associated IH costs</td>
</tr>
<tr>
<td>2. Are its key sub elements listed correctly?</td>
<td>Cost of incidents must be calculated separately from template and entered</td>
<td>Data was available to populate the sub elements</td>
</tr>
<tr>
<td>3. Is it correctly named?</td>
<td>Company G understood what information was required</td>
<td>The company understood what was required in the data element</td>
</tr>
<tr>
<td>4. Is it adequately defined, so that consistent answers will be given by different users?</td>
<td>Clearer definition is required since a range of costs could be considered</td>
<td>The instructions were adequate to consistently collect the data</td>
</tr>
<tr>
<td>5. Will it be consistently interpreted over time?</td>
<td>Yes - with proper instruction</td>
<td>The data element worked well for collecting data retrospectively over a several year period.</td>
</tr>
<tr>
<td>6. Will it provide consistent data over time?</td>
<td>Yes - with proper instruction</td>
<td>The data was consistent over 3 scenarios that varied over time.</td>
</tr>
<tr>
<td>7. Do companies have the data to support it?</td>
<td>Company had invoices from vendors to describe testing costs</td>
<td>Company G had some very good data to support the analysis. Other data which involved internal personnel time and costs had to be retrospectively constructed.</td>
</tr>
<tr>
<td>8. Will the IH be able to access the data?</td>
<td>IH's managed the process and had access to data</td>
<td>The IH had access to the necessary data or was able to provide reasonable estimates</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Total Medical Surveillance Costs</strong></th>
<th><strong>Total Other Costs Related to the Current Method of Managing the Risks</strong></th>
<th><strong>Total Non-Medical Costs of Incidents</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Capital Costs</strong></td>
<td>The costs associated with audiometric testing and follow-up medical evaluations were included in this data element</td>
<td>This element collected data on fines and penalties which was important to the model</td>
</tr>
<tr>
<td><strong>Total Operating Costs</strong></td>
<td>The capital costs were well understood</td>
<td>There were no non-medical incidents to judge effectiveness of data element</td>
</tr>
<tr>
<td><strong>Total Other Costs Related to the Current Method of Managing the Risks</strong></td>
<td>The company understood what was intended to be captured in this data element</td>
<td>There were no non-medical incidents to judge effectiveness of data element</td>
</tr>
<tr>
<td><strong>Total Non-Medical Costs of Incidents</strong></td>
<td>Company G staff understood the costs associated with the fines and penalties element</td>
<td>There were no non-medical incidents to judge effectiveness of data element</td>
</tr>
</tbody>
</table>

### AIHA Value of the Profession Data Element Analysis Matrix

<table>
<thead>
<tr>
<th>Data Element</th>
<th>Health</th>
<th>Risk Management</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Cost of Incidents</strong></td>
<td><strong>Total Capital Costs</strong></td>
<td><strong>Total Operating Costs</strong></td>
</tr>
<tr>
<td><strong>Surveillance Costs</strong></td>
<td>The data was consistent over time</td>
<td>The data associated with fines and penalties will be consistently interpreted over time</td>
</tr>
<tr>
<td><strong>Total Medical Costs</strong></td>
<td>The data element collected data on fines and penalties</td>
<td>Similar answers would have been provided across users and scenarios</td>
</tr>
<tr>
<td><strong>Total Other Costs Related to the Current Method of Managing the Risks</strong></td>
<td>The capital costs were well understood</td>
<td>There were no non-medical incidents to judge effectiveness of data element</td>
</tr>
<tr>
<td><strong>Total Non-Medical Costs of Incidents</strong></td>
<td>The company understood what was required in the data element</td>
<td>There were no non-medical incidents to judge effectiveness of data element</td>
</tr>
</tbody>
</table>

### Data Collection

- **COMPANY G**
  - The company had very specific data on fines and penalties.
  - The company had some very good data to support the analysis. Other data which involved internal personnel time and costs had to be retrospectively constructed.
  - The IH had access to the necessary data or was able to provide reasonable estimates.
  - The IH managed the data for the company and thus had full access to the data.

### Data Analysis

- There were no non-medical incidents to judge effectiveness of data element.
## QUANTITATIVE ELEMENT
### CASE STUDY: COMPANY H
#### Health Data Element Criterion

<table>
<thead>
<tr>
<th>Total Cost of Occupational Illnesses or Injuries</th>
<th>Total Capital Costs</th>
<th>Total Operating Costs</th>
<th>Total Medical Surveillance Costs</th>
<th>Total Other Costs Related to the Current Method of Managing the Risks</th>
<th>Total Non-Medical Costs of Incidents</th>
</tr>
</thead>
</table>

### 1. Is the element the right one for the model?
- Company H did not identify any costs associated with the element.
- Company H incorporated the element by containment equipment.
- Company H was able to express the changes in various sub-elements. For example, pre-intervention costs included PPE, which were reduced post-intervention.

### 2. Are its key sub-elements listed correctly?
- Company H did not identify any costs associated with the element.
- Company H considered these costs to be routine expenses for containment.
- Company H was able to distinguish between operational personnel time, PPE costs, EHS supply costs, and disposable bag costs. They were then able to show the differences between these sub-categories before, during and after the intervention.

### 3. Is it correctly named? Will the users know what it means?
- Company H did not identify any costs associated with the element.
- Company H was able to determine the type of cost data necessary for the element.
- Company H was able to determine the type of cost data necessary for the element.

### 4. Is it adequately defined, so that consistent answers will be given by different users?
- Company H did not identify any costs associated with the element.
- Company H provided the same cost data for before and during the intervention.
- Company H provided operating cost data based on various sub-elements. The sub-elements do not allow for double-counting, providing a consistent basis for data collection. Each category is defined so users will know what costs to include and exclude.

### 5. Will it be consistently interpreted over time?
- Company H did not identify any costs associated with the element.
- Company H considered these costs to be the same type of elements that would be needed for retrospective and prospective analysis.
- Company H considered operating costs to include the same type of elements and sub-elements that would be needed for retrospective and prospective analysis.
### Quantitative Element

<table>
<thead>
<tr>
<th>CASE STUDY: COMPANY I</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data Element Criterion</strong></td>
</tr>
<tr>
<td>Total Cost of Occupational Illnesses or Injuries</td>
</tr>
<tr>
<td>1. Is the element the right one for the model?</td>
</tr>
<tr>
<td>2. Are its key sub-elements listed correctly?</td>
</tr>
<tr>
<td>3. Is it correctly named? Will the users know what it means?</td>
</tr>
<tr>
<td>4. Is it adequately defined, so that consistent answers will be given by different users?</td>
</tr>
<tr>
<td>5. Will it be consistently interpreted over time?</td>
</tr>
<tr>
<td>6. Will it provide consistent data over time?</td>
</tr>
<tr>
<td>7. Do companies have the data to support it?</td>
</tr>
<tr>
<td>QUANTITATIVE ELEMENT</td>
</tr>
<tr>
<td>----------------------</td>
</tr>
<tr>
<td>Data Element Criterion</td>
</tr>
<tr>
<td>1. Is the element the right one for the model?</td>
</tr>
<tr>
<td>2. Are its key sub-elements listed correctly?</td>
</tr>
<tr>
<td>3. Is it correctly named? Will the users know what it means?</td>
</tr>
<tr>
<td>4. Is it adequately defined, so that consistent answers will be given by different users?</td>
</tr>
<tr>
<td>5. Will it be consistently interpreted over time?</td>
</tr>
<tr>
<td>Data Element Criterion</td>
</tr>
<tr>
<td>-------------------------</td>
</tr>
<tr>
<td>Total Capital Costs</td>
</tr>
<tr>
<td>Total Operating Costs</td>
</tr>
<tr>
<td>Total Medical Surveillance Costs</td>
</tr>
<tr>
<td>Total Other Costs Related to the Current Method of Managing the Risks</td>
</tr>
<tr>
<td>Total Non-Medical Costs of Incidents</td>
</tr>
</tbody>
</table>

1. Is the element the right one for the model?
   - Company K did not use this element for the analysis.

2. Are its key sub-elements listed correctly?
   - Company K did not use this element for the analysis.

3. Is it correctly named? Will the users know what it means?
   - Company K was able to distinguish between operational (Non-IH) time, IH safety staff time, and IH supplies. They were then able to show the differences between these sub-categories before, during and after the intervention.

4. Is it adequately defined, so that consistent answers will be given by different users?
   - Company K provided operating cost data based on time spent within the various sub-elements. The sub-elements do not allow for double-counting, providing a common basis for data collection. Each category is defined so users will know what costs to include and exclude.

5. Will it be consistently interpreted over time?
   - Company K considered operating costs to include the same type of elements that would be needed for retrospective and prospective analysis.
References


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