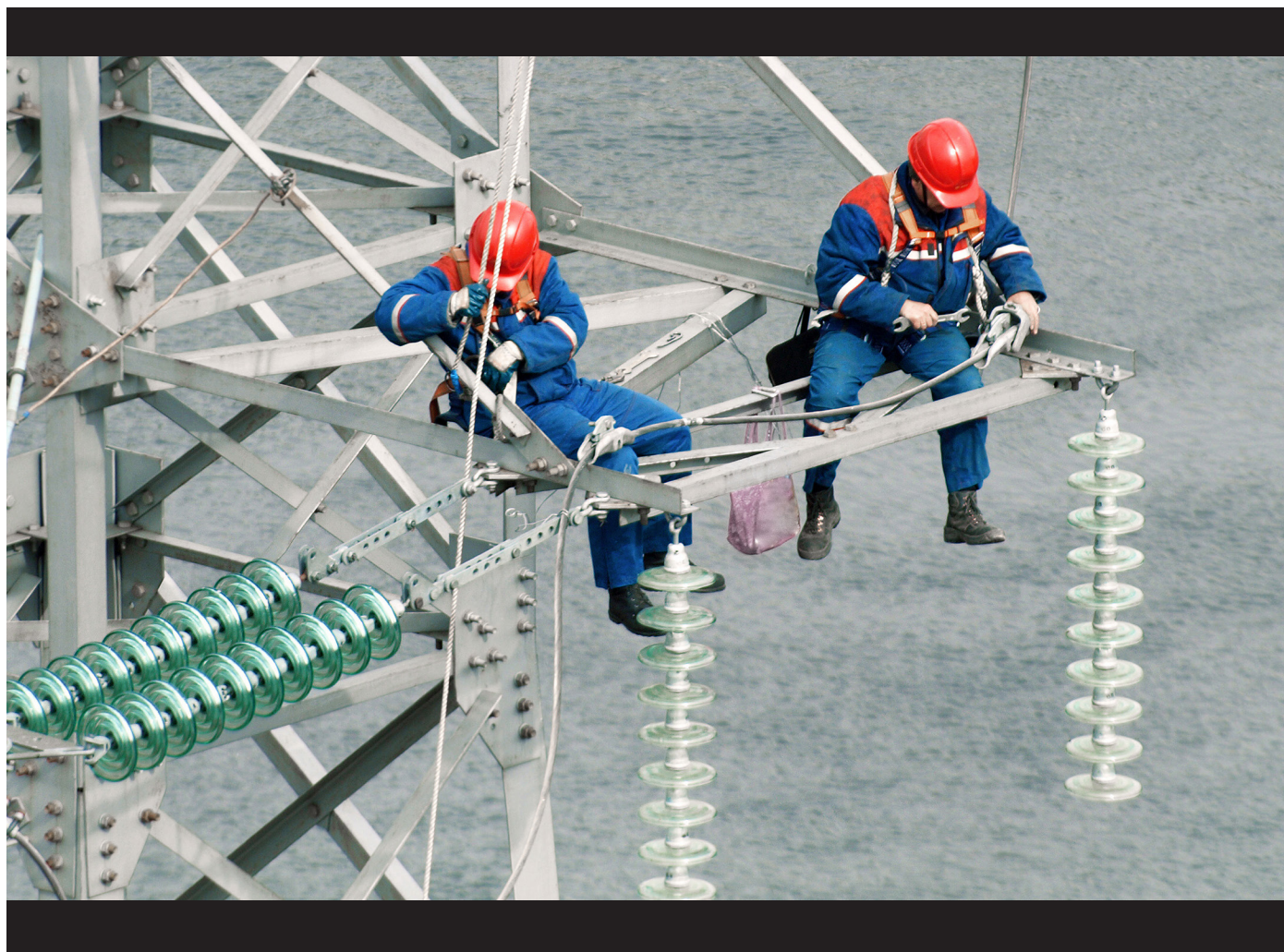


PROGRAM ON TECHNOLOGY INNOVATION: ASSESSING HUMAN PERFORMANCE AND BEHAVIORAL APPROACHES TO REDUCE SERIOUS INJURIES AND FATALITIES IN THE ELECTRIC POWER INDUSTRY

State of Knowledge and Practice White Paper





Program on Technology Innovation: Assessing Human Performance and Behavioral Approaches to Reduce Serious Injuries and Fatalities in the Electric Power Industry: State of Knowledge and Practice White Paper

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Summary

Injury rates in the electric utility industry have steadily declined over the past 20 years as reported by EPRI's Occupational Health and Safety Database [1]. However, the rates of Serious Injuries and Fatalities (SIFs) have remained relatively constant. EPRI members are working to improve these results in multiple ways, including improved Human Performance (HP) practices. This project sought to ascertain if research opportunities may exist within HP practices to improve safety outcomes within this industry.

There were two objectives of this project. The first was to identify lessons learned, new theories and practices, and opportunities and past successful applications from other industrial sectors (including fleets, industry, airlines, medical/health care, and emergency services), research institutes, consultants, and electric utilities. The second objective was to identify knowledge and practice gaps in the electric power industry based on the research and to recommend research questions that could provide opportunities for additional research by EPRI or other organizations.

Through interviews and literature reviews conducted from Fall 2017 through Spring 2018, this project report supplies a "state of knowledge" of both theoretical constructs and practical applications of applying Human Performance and/or behavior principles to reduce SIFs, and also provides a summary of research opportunities that EPRI or other organizations may address.

Introduction

According to EPRI's Occupational Health and Safety Database, injury rates in the electric utility industry have steadily declined over the past twenty years. The rates of Serious Injuries and Fatalities (SIFs), however, have essentially remained unchanged, with an uptick in fatalities recently reported [1]. The EPRI database defines SIFs as an event resulting in five or more full-time equivalent lost workdays. It is important to note, however, that there is no standard, agreed-upon definition for SIFs in any industry, including the electric power industry.

Although EPRI members have continued to work to improve these results, the industry is seeking to use Human Performance and Behavioral approaches (HP/B) to reduce SIFs. For the purposes of this research, Human Performance is defined as a series of behaviors executed to accomplish specific results.

Research Objectives

The objectives of this research were to: assess Human Performance behavior approaches that could help reduce SIFs; provide a "state of knowledge" look at both theoretical constructs and practical applications of applying Human Performance and/or behavior principles to reduce serious injuries and fatalities (SIFs); and summarize opportunities that EPRI could consider for future research.

This report also provides background for an EPRI "research workshop" being held October 23-25, 2018 where the EPRI Program 62 (P62) Human Performance Working Group, subject matter experts and external stakeholders will review current practices, research gaps and opportunities for future research and development. The results of the workshop will be summarized in an EPRI report. EPRI anticipates using these identified opportunities to initiate new projects in 2019.



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Project Approach

In February 2017, members of EPRI's Occupational Health and Safety Program (P62) requested that EPRI identify research opportunities to advance the practice and underlying knowledgebase using Human Performance and behavioral approaches. This project, funded through EPRI's Technology Innovation Program, sought to:

- Identify lessons learned, new theories and practices, and opportunities and past successful applications from electric utilities as well as other industrial sectors (including fleets, industry, airlines, medical/health care, and emergency services), research institutes, and consultants, and through a literature review.
- Identify knowledge and practice gaps in the electric power industry and identify opportunities to address these gaps through EPRI collaborative research and innovation.

The project approach involved interviewing 21 subject matter experts and practitioners from electric utilities, universities, regulatory agencies, and organizations that support the railroad, chemical production, aviation, natural gas, and fire-fighting industries, as well as Human Performance consultants who work across various industries. The objectives of these interviews were to compile effective Human Performance approaches to reduce serious injuries and fatalities, identify opportunities for improvements, and gather ideas for potential research opportunities.

The interview questions focused on:

- Defining Human Performance as applied to reducing SIFs.
- Ascertaining whether the interviewee's organization had an HP program or gathering insights on how HP is practiced or should be practiced.
- Gathering information on how organizations address various safety-related issues.
- The impacts of implementing HP.
- Opportunities for implementing HP to reduce SIFs.
- Identifying opportunities for research to improve HP effectiveness in reducing SIFs.

Interviewees were also asked for suggestions about publications that the research team should review as part of the literature review. The full list of interview questions are provided at the end of this white paper.

Following the interviews, literature reviews were conducted to provide additional background and insights. Publications reviewed included books, journals and peer-lit/grey-lit articles and research papers, workshop and conference proceedings and other sources.

Human Performance Overview

Definition of Human Performance

Human Performance is defined as "a series of behaviors executed to accomplish specific results." Simply put, Human Performance equals Behavior plus Results [2].

A Human Performance approach drives the way people think about and perform their work. By providing processes and tools, it helps them have a better awareness of potential consequences and risks and also enables getting a task done right the first time in a safe manner that produces reliable and timely results. A Human Performance approach also empowers all employees in an organization regardless of their position or tenure to contribute equally to the safety and excellence of the organization. [3].

Human Performance is also referred to as Human Performance Improvement and more recently as Human and Organizational Performance (HOP) [4].

Relationship Between Human Performance and Safety

Some of the interviewees indicated they did not have an HP program at their company but had a safety program that encompassed many elements of an HP program. Although safety is one of the outcomes of using the Human Performance philosophy, it is only one element, along with quality, reliability and efficiency.

History of Human Performance

Human Factors Research

For many years, solutions to workers' concerns in various industries have been founded in "Human Factors" engineering research, one of the disciplines included in Human Performance. Human Factors engineering focuses on improving how people interact with machines by attempting to improve the user interface, keeping the needs of the user in mind.

An example of Human Factors research can be found in the United States Air Force. In 1947, Paul Fitts, an America Air Force Colonel, was studying accident records from World War II and found that pilots in the cockpits of airplanes were repeatedly grasping the wrong controls. These incidents were referred to as "pilot errors." Fitts recognized that the cockpit take-off and landing controls were both identically shaped and in close proximity to each other. The controls had been designed and placed to make them easy to engineer and manufacture. The design did not take into account that



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pilots needed to identify and choose the correct control in cockpits that were often dark or dimly lit and in high-stress situations that required split-second decisions and reactions.

The simple yet resourceful solution to change the shape and location of the controls came from recognizing the need to design with the pilot in mind, and helped to end a dangerous, costly problem. In addition, the military put procedures and checklists in place and trained their personnel on the use of these tools [2].

Human Performance in the Electric Power Industry

The energy industry's interest in and use of Human Performance Improvement concepts began years later. EPRI published its first report on "human factors" in 1978. Following the Three Mile Island event in 1982, the Institute of Nuclear Power Operations (INPO) began taking a leading role in Human Performance. INPO's research and practical applications were made available in their course references and manuals [5].

The Department of Energy (DOE) had a long-standing relationship with INPO, and in 2001, contracted with INPO for access to their Human Performance materials. In 2009, these materials were released into the public domain. Today, DOE STANDARD *Human Performance Improvement Handbook Volume 1: Concepts and Principles* [2] and DOE STANDARD *Human Performance Improvement Handbook Volume 2: Human Performance Tools for Individuals, Work Teams and Management* [6] are both available free of charge on the internet.

The nuclear power industry has recognized managing Human Performance as a proactive approach to be used by their managers to improve the operation of their facilities, rather than as a reactive measure to be used after an event occurs.

Principles of Human Performance

Thought leaders subscribe to these principles or fundamental truths of Human Performance [2]:

- People are fallible, and even the best people make mistakes.
- Error-likely situations are predictable, manageable, and preventable.
- Individual behavior is influenced by organizational processes and values.
- People achieve high levels of performance due to encouragement and reinforcement received from leaders, peers, and subordinates.
- Events can be avoided through an understanding of the reasons mistakes occur and application of the lessons learned from past events.

These principles are building blocks that need to form the foundation of an organization's values, integrated into their practices and used to develop their processes. Organizations that promote the principles of Human Performance are working to ensure that their workers have better results and less unwanted outcomes.

Defining and Characterizing Errors

Error has been defined by the Department of Energy, as "an action that unintentionally departs from an expected behavior" [2], or in other words, something you didn't intend to do. Errors result in unwanted outcomes, including serious injuries or fatalities, damage, or mission interruption.

Errors are usually classified according to three categories based on what a person is doing when the error happens (their "performance mode"):

- **Skill-based** errors are due to inattention and occur infrequently while performing tasks that are automatic or pre-programmed.
- **Rule-based** errors are due to misinterpretation in a situation where a person needs to use an "if – then" thought process.
- **Knowledge-based** errors are due to having an inaccurate mental model or picture, usually when dealing with an unfamiliar situation [7]. Figure 1 shows the types of error and their corresponding performance mode.

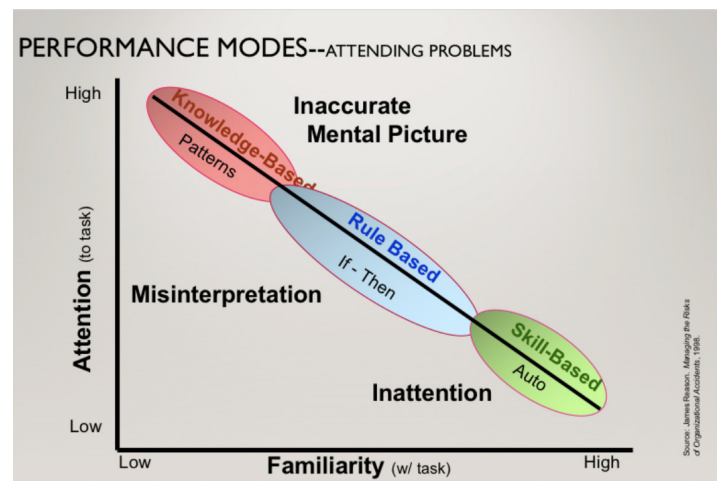


Figure 1 – Performance Modes

For example, experienced drivers commuting to and from work each day is a skill-based performance. They are very familiar with the route and often arrive at the end of the journey without a vivid memory of their trip. Their actions are automatic and even with very little attention paid to the task, they are able to perform it without error 9,999 times out of 10,000 [7].



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The vast majority of errors are unintentional, and to paraphrase the first principle of Human Performance, we are all fallible and will make mistakes. Therefore, it makes sense to focus on reducing the consequences of errors rather than fixating on reducing the errors themselves. Within HP practice, more attention should be paid to managing unwanted outcomes, not assigning blame to the individuals who committed the errors.

The Swiss Cheese Model

In *Managing the Risks of Organizational Accidents* [8], James Reason notes “You cannot change the human condition, but you can change the conditions in which humans work.”

In an article published in the *British Medical Journal* in 2000, Reason described an approach he developed to system accidents called the Swiss Cheese Model [9]. In this model, every system in an organization that carries some level of risk is addressed with a layer of defense. Figure 2 shows The Swiss Cheese Model. The holes in the slices of swiss cheese represent weaknesses in various parts of a system. Failures occur when there is not a defense in place to provide protection from a particular hazard, representing a “hole” in the swiss cheese. The hazard, represented by the arrow, is able to pass through all the holes, resulting in an accident or loss.

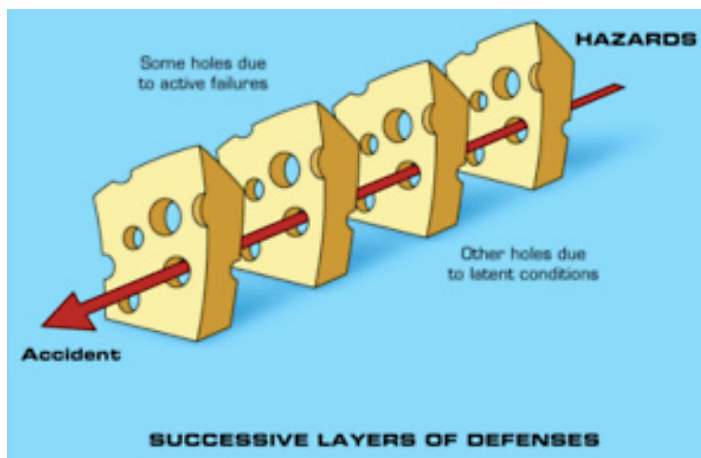


Figure 2 – The Swiss Cheese Model, James Reason, “Human error: models and management,” *British Medical Journal* [9].

Human Performance in Multiple Industries

Programmatic Approach vs. Systematic Approach

The interviewees had diverse opinions about the best way to incorporate Human Performance into an organization. Some indicated that a separate HP program could help reduce SIFs. Many others,

however, felt that a HP approach can only be effective in the larger context of an organization’s overall culture. Based on this second and more prevalent view, this white paper focuses on the drivers and elements of a Human Performance approach at the systematic level, with the main component being developing a “safety culture.”

Drivers for Developing a Human Performance Approach and Safety Culture

Risk Management

According to several thought leaders, the key driver for developing a Human Performance approach and safety culture is risk management. The National Safety Council defines risk as “a measure of the probability and severity of adverse effects [10].” One researcher noted that identifying risks and hazards, attempting to eliminate risk and determining an acceptable level of risk can lead to fewer incidents. A challenge to risk management, however, is that individuals may see risks differently.

Preventing worker injuries and equipment damage — both of which are costly in terms of dollars and lost productivity — is obviously a key component of risk management for any organization.

Companies may be motivated to develop a Human Performance approach and safety culture due to an event at their own organization or at an organization similar to theirs in the same industry. In many cases this event could be a “near-miss” or could have resulted in a SIF. A near-miss can be defined as any situation that could have resulted in undesirable consequences but did not, ranging from minor breaches in controls to incidents in which all the available safeguards were defeated, but no actual losses were sustained [2]. In the context of this research, a near-miss is often a situation in which a potential SIF was narrowly averted.

The Value of “Near-Misses”

Several interviewees discussed the value of near misses as a learning experience. In many cases, these events would not have become known if an employee had not reported them. In *Pre-Accident Investigations: An Introduction to Organizational Safety* [11], the author recounted an incident where a worker accidentally drilled a hole in the side of a pressurized propane tank, which fortunately did not result in a catastrophic failure of the tank or any injuries. The worker chose to disclose his error to his supervisor. The facility at which this near-miss occurred did not have separate storage areas or disposal methods for various types of tanks. In addition, the company did not provide training on disposal methods for tanks or training and supervision for employees who were not familiar with the tanks.



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When viewed through the lens of The Swiss Cheese Model, this company did not have the layers of defense necessary to prevent such an event. Since the worker disclosed the near miss, it provides an opportunity for the employer to reevaluate their safety processes.

The aviation and fire-fighting industries have implemented programs examining near misses and have found them to be valuable. These programs look beyond the actual outcome — which in the case of a near miss is rarely serious — and instead focus on the underlying causes of the near miss and look for ways to improve processes to avoid what could be a much more dangerous and costly event in the future.

A More Systematic Approach

Organizations may also be motivated by a realization — ideally at the executive or senior management level — that their company needs to take a more systematic look at how safety is addressed throughout the organization. This often leads to implementing a Human Performance approach that focuses on developing or strengthening the company's “safety culture.”

Developing a Human Performance and Safety Culture

Why Develop a Safety Culture?

An entire report could be written on this subject, and this white paper assumes that organizations interested in reducing serious injuries and fatalities will accept that adopting a positive safety culture is one way to meet that goal. A convincing argument for developing a safety culture is provided in The Campbell Institute's 2014 report, *Risk Perception: Theories, Strategies, and Next Steps* [10]. This report cites two studies. The first, by Fleming & Buchan in 2002, concluded that “workers employed by an organization with a positive safety culture — an environment with high emphasis on safe work procedures and commitment to employee health and safety — were less likely to take risks than workers employed by an organization without a positive safety culture.” Another study (Garcia et al., 2004) found that “workers exposed themselves to more risks and were less likely to comply with safety rules when they rated the safety climate of their organization poorly.”

What is a Safety Culture?

There is no one definition of a safety culture. The interviews and literature review conducted for this project identified a few definitions of a safety culture that seem especially relevant to reducing serious injuries and fatalities in the electric power industry.

Four Safety Culture Subcomponents

A popular view of safety culture identifies four critical subcomponents:

- A **Reporting Culture** that allows for easy collection of information in a confidential, non-punitive manner to allow for rapid and useful feedback.
- A **Flexible Culture** that allows control to be in the hands of the experts performing the task.
- A **Learning Culture** where there is a willingness to draw the right conclusion and implement major reforms when necessary.
- A **Just Culture** where an atmosphere of trust exists to encourage individuals to provide information.

These four subcomponents interact to create an **informed culture**, where those in charge of managing and operating systems have up-to-date and accurate information on all the factors that determine the safety of the system as a whole. An informed culture also has an underlying atmosphere of trust in which individuals are encouraged to learn through sharing information and experiences. An informed culture can be equated with a safety culture [8].

Several thought leaders agreed that the best way to create a just culture is through managing risk.

Three Types of Organizational Cultures

In *Managing the Risks of Organizational Accidents* [8], James Reason refers to Westrum's three types of culture in organizations:

- **Pathological**, where the messengers are shot.
- **Bureaucratic**, where messengers are listened to only if they are permitted to share their message or experience.
- **Generative**, where messengers are trained and rewarded for sharing their messages.

It is reasonable to assume that a “generative” culture is also an “informed” culture, which in turn, facilitates a safety culture.

Other Views of a Safety Culture

Some thought leaders say that a safety culture is the product of goal-directed interactions between how people feel, what people do and the organization. In addition, they say that organizations should place 80% of their safety improvement efforts on changing the situation to optimize desired behaviors by developing safety structures and systems that will influence workers' safety-related behaviors.

Another HP thought leader suggested a targeted approach in which the organizational culture focuses on understanding and managing risks, rather than just on safety.



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The need for an organization to assess its overall culture before attempting to develop a safety culture was another theme that emerged from this research, as was the idea that a safety culture is not a destination to be arrived at but rather a journey in which there is always room for improvement.

How Does an Organization Develop or Strengthen a Safety Culture?

The research conducted for this project yielded five key elements of an effective safety culture:

- Executive leadership that actively promotes a safety culture.
- An organizational reporting structure for Human Performance and safety personnel that encourages communication and collaboration.
- Focus on fixing the system, not the worker, with an emphasis on designing for safety.
- Help the workers be part of the solution through open communication, providing training and tools and especially by encouraging them to report safety issues.
- Use metrics as part of reporting and to track progress against goals.

Each of these elements is discussed below.

Executive Leadership

An organization's culture is driven by and a reflection of its leaders. Several interviewees stressed that executive leadership was crucial to developing a Human Performance program. A key element mentioned was transparency. When a company develops a new initiative or process that affects how workers perform tasks, explaining the reasons and benefits gives leaders the opportunity to talk about why the initiative or process is needed and the benefits to the company and its employees. In addition, this approach demonstrates that management and employees are collaborating to improve the organization, with workers being key stakeholders and contributors. Creating a partnership between employees and management develops trust.

Several thought leaders stated that leadership style was an important factor in reducing serious injuries and fatalities. One interviewee remarked that a meta-analysis their company conducted on management styles showed that "Servant Leadership" had doubled the impact on improvements in safety. Servant leadership is a philosophy where the role of the leader is to serve the people, instead of the people working to serve the leader.

Organizational Reporting Structure

Many electric power companies have a structured safety organization and some also have Human Performance personnel. Several interviewees noted the importance of a company's reporting structure for these employees. They indicated that if Human Performance and Safety are separate departments, they should both report to the same leader at the top of the organization — such as the CEO or COO — to ensure that both departments have the resources they need to keep the programs in place. Other points made by interviewees were the importance of keeping senior leadership and those charged with leading Human Performance and safety programs well-aligned and that a direct reporting relationship to the CEO and/or Board of Directors (BOD) helps to avoid some of the political aspects of reporting relationships.

Fix the System, Not the Worker

When a serious injury or fatality or a near-miss event occurs, organizations need to make a decision. Do they "fix the worker" (which assumes the worker was solely responsible for the event) or do they "fix the system?" In *Pre-Accident Investigations: An Introduction to Organizational Safety* [11], Todd Conklin states that fixing the worker gives the impression that a problem has been fixed, but probably doesn't address the underlying issue. In *Better Questions* [12], Conklin notes that the pressure to fix a problem is often stronger than the pressure to learn about it, but that unless an organization take the time to explore the root cause of an event, they are unlikely to improve systems or processes to help ensure a similar event will not happen in the future. Conklin encourages engaging workers in both learning about the problem and creating solutions, as most events are information rich and allow for considerable learning. He also states that although interest by the company's leadership in an event can be valuable, it's even more valuable to involve the workers because that's where the real learning takes place. He recommends that exploring an event should focus on the context before the event as well as the potential consequences to have the greatest impact.

A key element in "fixing the system" is **designing for safety**. Design can take place in any phase of the lifecycle of a process or piece of equipment. One interviewee discussed a "Design for Safety" class they taught. The goal of the class was to design equipment and processes from an Occupational Health and Safety perspective, with a focus on minimizing errors and maximizing worker safety. Students had the opportunity to design the work environment, including how the work would be performed and who would perform it, and



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also to strategize on how to prioritize and address issues. While designing the products or equipment, students were instructed to keep in mind the characteristics of workers, including various degrees of risk taking, potential distractions, ignorance, lack of training, and overall human fallibility.

Precursor analysis is an approach developed by the Construction Industry Institute aimed at preventing high-impact, low-frequency (HILF) events in the construction industry [13]. It has been applied mainly for high-energy work and uses a specific formula for what qualifies as high energy work. Researchers analyzed more than 500 past injuries to determine a definition of high energy work. Work scenarios were considered high energy if the amount of energy, whether kinetic, potential, electrical or mechanical, was likely to cause a fatal or disabling injury. It is a proactive approach, which uses a mathematical formula to quantify the amount of energy in given tasks. This approach also considers the need to integrate this mathematical, engineering approach with the need to interact effectively with workers in the field. The author of this approach notes that behavioral observations of crews are good predictors of future performance, providing qualitative indicators that include the number of observations but also the quality of the observations. In addition, the author highlighted the need for transparency with workers to explain the process and its goals, which facilitates making the worker a stakeholder in the process.

On a more tactical level, two strategies for “fixing the system” are observing how the work is conducted and integrating safety into the workflow.

Work site or field visits where company leaders or managers **observe how work is being conducted** provides opportunities to ask workers for their insights into how they do their work and more importantly, how work processes could be improved. These field observations not only allow for observing the work but also establish rapport with those conducting the work and can facilitate building partnerships between employees and management. This approach is most effective if there is a higher ratio of positive, constructive feedback to instructional or corrective feedback. One way to ensure the observational approach is viewed positively by the workers being observed is through employee satisfaction surveys or other feedback mechanisms.

Some interviewees stressed that HP and safety must be **integrated into the workflow**. In this approach, day-to-day work is grounded in HP principles and planned and managed accordingly. One interviewee discussed the success of companies who use the strategy of

integrating Human Performance into everything they do so that it is basically the way they do business. This is similar to concepts used in lean manufacturing and quality systems that are built on developing trust between leaders and workers through leaders using HP or safety language when communicating with workers.

Make Workers Part of the Solution

The preceding discussion on “fixing the system” often mentioned involving the workers, which can also be summarized as a strategy of making workers part of the solution. This is a multi-faceted approach that includes:

- Involving workers at the front end of the design process.
- Communicating openly and frequently with workers.
- Encouraging workers to report safety issues through non-punitive reporting programs.

Each of these is discussed below.

Several subject matter experts and thought leaders noted the importance of **involving the worker at the front end of the design process** for systems, procedures, and equipment. This approach has multiple benefits. Not only can the worker's input benefit the design process, but the worker will gain a better understanding of how they will be affected by changes in the design of systems and equipment. The time and effort spent explaining why a change is being considered — whether in a design or in a procedure — helps the worker be a part of the solution. When workers are not involved in the process, they may not understand the reasons and benefits and may resist the change, which could result in errors or accidents.

Communicating openly and frequently with workers has been discussed already but bears repeating. A safety culture thrives in an environment in which a company's leadership and managers are committed to transparent, regular communication with workers, especially when a new system, process, or piece of equipment is being developed and deployed. Communication is crucial to building trust and making employees feel they are stakeholders, rather than just workers who are doing what they're told without always understanding the underlying reasons for changes in the way they do their work.

A strong safety culture is based on two-way communication between leadership and managers and the workers who perform front-line tasks. A key component of successful two-way communication is **encouraging workers to report safety issues through non-punitive reporting programs**. This ties directly back to two of the four sub-components of a safety culture discussed earlier: **reporting culture** and **just culture**.



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Many thought leaders agree that encouraging workers to report safety issues through non-punitive reporting programs works to build buy-in and trust among employees. Leadership must demonstrate and honor the non-punitive system consistently. It is critical that workers are able to report incidents such as “near misses” and other factors that could contribute to accidents and injuries and that an organization’s leaders view this reporting as “gifts” that can help an organization learn and improve [11].

Non-punitive reporting programs help companies understand how work is performed and also help to identify issues that would remain unknown unless reported. Several industries, including aviation and fire-fighting, have had success in creating and using “non-punitive near-miss” reporting programs that focus on finding solutions rather than assigning blame. Some programs look at “near misses” as potential SIFs, where the potential for a fatality was present. They then respond to the “potential outcome” or “potential for harm” as if an event actually occurred. Also noted was the benefit of looking at “what went right,” and seeking out “pockets of excellence.” Looking at what is working well provides the opportunity to review successes (instead of always looking at what went wrong) and may also offer learning opportunities that can apply to other situations and help facilitate a safety culture.

The fire service is an example of where the front-line workers (in this case, fire fighters) provided information to their leadership on specific conditions they were encountering in burning buildings. According to the interviewee, the fire service has a stigma around making mistakes and discussing them. However, the interviewee noted, when fire fighters came forward and reported on operational factors — including weather and building materials — that impacted their jobs, it resulted in training on how fire reacts with building materials. High amounts of hydrocarbons and plastics in today’s building and housing materials are highly flammable, and basically turn into gasoline, thus feeding the fires. This knowledge changed how fires are fought and ultimately reduced the number of Line of Duty deaths.

Metrics and Reporting

Organizations seeking to reduce serious injuries and fatalities will most likely set goals to meet this objective. Metrics help quantify progress against goals. The interviews and literature review conducted for this project identified one list of potential safety metrics, many observations on metrics and how they are used, information on leading vs. lagging indicators for metrics, and several challenges associated with metrics.

Potential Safety Metrics

A subject matter expert in safety and Human Performance recommends the following safety metrics, which are listed in the order of importance indicated by the interviewee:

- A measure for visibility of leadership, such as the amount of time spent in the field, observing workers.
- Measuring the percentage of observations that show safe behaviors being used.
- Rate of corrective actions completed.

General Observations on Metrics and How They Are Used

- Several thought leaders pointed out that there are certain things organizations normally “have to measure” due to regulatory or business requirements. Some feel that near misses and close calls are reported as a function of how much workers trust their leadership and that that getting real information has more to do with trust and relationship building than has to do with recordkeeping computer systems and accounting.
- One business leader noted, “a company might do most of the things most of the time. The goal is to do all of them intentionally and do them all of the time. A good record may not be a record of excellence but persistent luck. Deming said to plan, do, check and act. Safety Culture is a journey; there is always room for improvement.”
- Several interviewees noted that looking at recovery and resilience seems to be a more reasonable, systematic approach. This approach is used by many High Reliability Organizations (HROs). (HROs will be discussed in detail later in this white paper.) HROs have metrics but do not oversimplify operations to meet certain goals. These organizations recognize that events are not linear, and that they need to understand context and the workers’ perspective. In *5 Traits of Highly Reliable Organizations: How to Hardwire Each in Your Organization* [14], Molly Gamble stated, “Leaders constantly look at data, benchmarks and other performance metrics. But to prevent simplification, leaders should constantly seek information that challenges their current beliefs as to why problems exist.” They recognize that they must be willing to challenge long-held beliefs.
- One utility noted that they have a Serious Injury and Fatality (SIF) report, which is an “add-on” to their OSHA reporting. SIFs are tracked as a percentage of OSHA recordables. Their SIF rate has declined, except for a brief rise in 2016. They also perform briefings for “high risk activities.”
- Some companies collect, tabulate and categorize near-misses or “good catches” in the hope that these reports may help create awareness of and prevent potential events. Other companies use “days without an event,” which has been popular in the nuclear industry.



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- One interviewee noted that metrics in industries that tend to be heavily engineering-based, like utilities, are usually created for two primary groups of individuals: 1) managers, who “manage” to metrics and 2) engineers, who use metrics to reduce “degrees of freedom” to solve problems. The interviewee suggested that it may be useful for these groups to consider collaborating to ensure they understand the approach each is taking. This same interviewee also noted that when it comes to safety research, there are often too many factors to consider, thus there is a need to isolate and measure what can be measured, such as increasing an individual’s skills for recognizing hazards, and then measure the effect of the increased skill.

Leading vs. Lagging Indicators

Simply put, leading indicators are those that predict performance and lagging indicators are those that measure past performance. The utility industry relies primarily on lagging indicators, partly due to regulatory reporting requirements but also because the processes for gathering this information are most likely already in place. An example of a lagging indicator is OSHA injury incident rates.

Some safety and Human Performance professionals indicated they believe there is no such thing as a set of leading indicators that can help safety professionals predict the future. As evidence of this they point out that if these data (leading indicators) existed, someone would have found it and companies would all be using these numbers and methods [11].

In 2015, the Campbell Institute published *Practical Guide to Leading Indicators: Metrics, Case Studies & Strategies* [15]. The first phase of their research including examining the use of leading indicators to improve environmental, health and safety (EHS) performance. This research revealed that a broad consensus existed among EHS leaders at their member organizations that only focusing on lagging metrics is not as effective in promoting continuous improvement as using leading indicators to anticipate and prevent injuries and incidents. They defined three types of leading indicators in their study:

- **Operations-based** leading indicators are relevant to infrastructure, machinery, and operations and are potentially site-specific, including Prevention through Design and Risk Assessments.
- **Systems-based** leading indicators relate to management of EHS systems and typically roll up from the facility level to the regional or corporate level, including Safety Perception Surveys and Hazard Analysis.
- **Behavior-based** leading indicators measure behavior and actions of individuals or groups in the workplace, including employee engagement and participation and area observations and walkarounds.

Challenges with Using Metrics

Conversations with many Human Performance practitioners indicated that using metrics to measure the success of the various Human Performance approaches to reducing SIFs is challenging. Even individuals at executive leadership levels admit to “struggling” with metrics and tend to agree that there is no “silver bullet.” They note that most initiatives do not exist in a vacuum, so it’s difficult to accurately correlate Human Performance or safety initiatives with reduced SIFs.

In an article in the journal *Professional Safety* entitled “Measuring Safety: A Call for a New Approach [16],” authors Phillip Hurst and Quincey Jones note that “regardless of the metric used, there remains the possibility of conceptual confusion about the definition of key terms. Definitional variability is a measurement killer and must be discussed frequently.” For example, everyone does not use the same definition for a “near-miss.” They recommend creating measurement systems that inspire employees and reflect the curiosity of leaders, rather than systems that create confusion. They note that measurement systems must reveal why information is requested, how data are used, and what changes might result from the data being collected. “Management gurus in the near future will emphasize qualitative as well as quantitative safety analysis. They will speak to the importance of conceptually analyzing the key concepts of a safety measurement system, such as *injury* or *near miss*. New techniques will be promulgated to close the definitional variance that exists in organizational cultures.”

Many programs have a “getting to zero” or “Zero Accidents” goal. This is a difficult concept when the focus is on increased production, making it difficult to “count” the lack of events. One suggestion is to count the things that can be controlled, such as the number of defenses that are put in place, such as Corrective Actions or Good Catches. Several interviewees noted that there is more than one way to “get to zero,” including not reporting incidents. If a company wants a “zero” incident record, they may reward employees accordingly, whether it’s a safety sticker for a hardhat or a group celebration. Many workers have heard “inspirational” speeches from upper management about the number of days without an incident. Although there is nothing wrong with praising employees for not having an incident, if a safety culture is not in place that also values reporting, an organization runs the risk of workers not reporting those incidents that do occur.

Other interviewees comment that metrics need to be kept in context to avoid “losing the faith of the organization.” For example, since the electric grid is not designed to tolerate wildfires, it doesn’t make sense to measure system equipment lost in these fires.



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Examples of HP Programs

The interviews and literature review yielded several examples of industries or organizations that have effective HP or safety programs. In the electric power industry, some utilities have effective safety and/or HP programs, but there is not a standardized approach. The North American Transmission Forum has an HP model and the American Chemistry Council has a “Responsible Care” program. In addition, several industry organizations require or recommend Safety Management Systems. The research also uncovered several mentions of High Reliability Organizations that have well-developed HP or safety programs. Each of these is discussed below.

Electric Power Industry

A successful program for reducing SIFs at an electric utility used a targeted Systems Engineering approach that recognized the human interface. The utility saw the need to shift its culture to understand risk and all the ways that people get injured. They determined several ways that individuals are injured, including human error, at risk behavior and reckless behavior [17].

The International Atomic Energy Agency (IAEA) report *Managing Human Performance to Improve Nuclear Facility Operation* [18] notes that the Human Performance Improvement model is a framework to improve job, process and organization performance. This framework uses an integrated approach based on the concept that individual behaviors and processes can only be as good as the organizational structure that supports them. Figure 3 is a graphical representation of Table 1 in the IAEA report.



Figure 3 – Levels of Organizational Improvement

North American Transmission Forum

The North American Transmission Forum (NATF) Human Performance Practices Group Core Team has drafted their own model, or

“roadmap” for NATF member companies to follow when establishing a Human Performance program [19]. Interviewees noted that the NATF HP Roadmap shows ways to improve operation of the bulk electric system by the prevention, detection and correction of human errors and “latent organizational weaknesses” that may lead to events with unwanted consequences. Latent organizational weaknesses refers to undetected deficiencies in organizational processes, equipment, or values that create job-site conditions that either provoke error or degrade the integrity of controls. Leadership sponsorship and engagement to provide support from the top, targeted marketing to employees, a formal process for reporting, and metrics to measure effectiveness are included as essential program elements. NATF members have access to the NATF HP Roadmap visual aid and an accompanying document that provides guidance for why, what, and how the various milestones along the way can be reached.

American Chemistry Council

Some industries have had success from mandating safety or Human Performance programs. Several years after the 1984 Bhopal Disaster – a gas leak incident that resulted in over half a million people being exposed to a highly toxic gas – the American Chemistry Council (ACC) adopted the “Responsible Care” program in the United States. Participation in the program is a condition of membership in ACC. Members have made CEO-level commitments to uphold the program elements. ACC members pledge to improve environmental, health, safety and security (EHS&S) performance for facilities, processes and products throughout the entire operating system. Member companies also commit to transparent reporting and submit to mandatory audits to ensure their commitment. Records indicate that they have reduced their recordable injury and illness incidence rates by 81% since 1990, making significant progress toward their overall industry goal of no accidents, injuries or harm to human health [20].

Industry Organizations Requiring or Recommending Safety Management Systems

Several industry organizations either require their member companies to have Safety Management Systems (SMS) in place or recommend they be used as guidelines, including the American Petroleum Institute (API), the American Board of Shipping (ABS) and the Federal Aviation Administration (FAA). Some of the systems follow models like DuPont’s 22-Element Safety Model which includes risk management and a safety culture [21]. These programs must be implemented by the companies themselves, rather than by governments or third parties. Governments may help develop recommendations and may audit results, but need to distance themselves from the implementation process.



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High Reliability Organizations

High-reliability organizations (HROs) — also known as *highly-reliable organizations* — were mentioned by several interviewees and also surfaced in the literature review. In addition to there being more than one name for HROs, there is not a standard definition for HROs. What is known is that the concept of HROs first arose in the medical industry and has now made its way into several other industries, including nuclear power, aviation and fire-fighting. Below are two views on HROs that emerged from the literature review.

In *Managing the Risks of Organizational Accidents* [8], James Reason states that HROs have the following characteristics: they are large, internally dynamic and intermittently intensely interactive; they perform complex, exacting tasks under considerable time pressure; and most relevant to this discussion, they have very low error rates and an almost complete absence of catastrophic failures over a number of years. Reason also notes that HRO decision making patterns encourage the reporting of errors, identify flaws in standard operating procedures, nominate and validate changes, practice error avoidance without rigidity and engage in mutual monitoring, without loss of trust in those performing tasks.

In *5 Traits of Highly Reliable Organizations: How to Hardwire Each in Your Organization* [14], Gamble listed the following traits as being central to the effectiveness of HROs:

- HROs are sensitive to operations at both the leadership and worker level. They are always aware of how processes and systems affect the organization.
- HROs are reluctant to accept simple explanations for problems and are always open to learning.
- HROs have a preoccupation with failure. All employees — regardless of their position in the organization — are encouraged to think of ways their work processes might break down.
- HROs defer to expertise. Leaders listen to the people with the strongest knowledge of tasks, even if these individuals don't have the most seniority.
- HROs are resilient. They are prepared to respond to failures and find new solutions.

Flight deck crews on aircraft carriers and wilderness firefighters are good examples of HROs. In addition to the characteristics discussed above, these organizations have “resources-in-reserve” to help recover from errors quickly. Ensuring there are resources available when unexpected incidents occur is also a key component of designing for safety.

Key Takeaways and Illustrative Case Studies

The research identified several important drivers for developing a successful Human Performance approach, and also revealed that a “safety culture” was the most important factor in helping to reduce serious injuries and fatalities. Interviewees and the literature reviewed indicate some key components of a safety culture, various approaches companies can take for developing a safety culture and several examples of HP programs and/or a safety culture. This section summarizes key takeaways and also includes six case studies that illustrate some of these major ideas.

Drivers

A primary driver for developing a Human Performance approach and safety culture is **risk management**. The research revealed there is not a common perception of the risk involved in various activities and tasks and that organizations approach risk management in many ways.

A significant event — whether or not it results in a serious injury or fatality — will almost always cause an organization to examine its safety practices. But the research indicated that **there could be significant benefits from examining “near-miss” and near-fatality incidents**. Several interviewees noted that near misses provide learning opportunities, but only if the organizational culture encourages workers to report these incidents, rather than penalizing them for any mistakes that were made.

Case Study 1 tells the story of a utility that had a low rate of recordable injuries in one year but saw a sudden increase in potential fatalities the following year. This company used these near-misses as a way to improve its safety culture.

Components of a Safety Culture

The majority of information gleaned from the interviews and literature search related to the importance of organizations having a safety culture. The research indicated there is not a uniform definition of a safety culture but there were a few key themes that emerged. Perhaps the most important was that an organization needs to have an **informed culture** that facilitates a safety culture. Characteristics of an informed culture include: safety information being collected in a confidential, non-punitive manner (**reporting culture**); allowing those experts performing tasks to have control over how the work is performed (**flexible culture**); an environment that allows examination of work processes and the willingness to implement change (**learning culture**); and an environment that facilitates trust and encourages workers to provide information on processes needing improvement and near-misses without fear of reprisal (**just culture**).



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CASE STUDY 1

UTILITY FACED INCREASE IN “NEAR” FATALITY INCIDENTS

Challenge: A utility with low recordable injury rates in 2008 suddenly had a dramatic increase in “near” fatalities the following year.

Solution: Company leadership realized they needed to look at their operational processes and decided to seek guidance from other industries.

Results: The company moved to an approach that examined activities and tasks from the worker’s perspective, which uncovered other potential safety issues. Near misses provided opportunities to not only address the immediate safety concern but also to examine safety from a process perspective that focuses on how workers perform tasks.

CASE STUDY 2

FRA RT&D TAKES LEAD IN IMPLEMENTING SAFETY CULTURE INITIATIVES

Challenge: Several railroad companies have piloted safety culture initiatives but there was no coordinated approach at an industry level.

Solution: FRA RT&D is evaluating these programs, initially focusing on BNSF Railways, the largest freight railroad network in the U.S. BNSF has implemented several safety initiatives. As part of its Approaching Others About Safety (AO) initiative, it trained nearly 30,000 employees how to more effectively communicate with their colleagues about safety. BNSF has reported significant progress in reducing reportable injuries and incidents as a result of its safety culture initiatives.

Results: FRA RT&D is partnering with the U.S. Department of Transportation Volpe Center to conduct an evaluation of BNSF’s safety culture initiatives and analyze lessons learned so they can provide guidance on developing safety culture initiatives to other railroad companies and to the industry as a whole [22].

Developing a Safety Culture

This research identified five key elements of a safety culture:

- Leadership that actively promotes a safety culture.
- An organizational reporting structure that encourages collaboration between HP and safety personnel.
- A focus on fixing the system, not the worker, with an emphasis on designing for safety.
- Helping workers be part of the solution.
- Using metrics for reporting and tracking progress against goals.

In addition, an overarching and key theme is that a safety culture is not a destination to be arrived at, but a journey of continuous improvement.

Leadership

Leadership sets the tone and guides the course for an organization, whether an industry organization or an individual company. Leaders that promote transparency and trust provide a natural foundation for a safety culture.

Case Study 2 tells the story of how the Federal Railroad Administration Office of Research, Technology and Development (FRA RT&D) demonstrated leadership to begin improving the industry’s safety culture.

Organizational Reporting Structure

Key takeaways related to organizational reporting structure are that if a company has both an HP and Safety department, they should report to the same executive and the organizations should be well-aligned, and that having these departments and/or the executive in charge of them report directly to the CEO and the Board of Directors helps avoid political aspects of reporting relationships.

Fix the System, Not the Worker

Todd Conklin is the author of two of the publications cited during this research. His view, which was echoed by several interviewees and other literature sources, was that only “fixing the worker” does not address underlying safety issues and tends to place blame, neither of which facilitates a safety culture. Only by addressing the root causes of an incident can an organization examine and improve systems or processes that will improve its safety culture. Conklin also encourages engaging the workers in both learning about the problem and creating solutions, as most events are information rich and allow for considerable learning. Not every event needs fixing, rather it depends on the value for the organization. Learning should be focused on the context before the event, or consequence, which he says is the only place you can have an impact [12].



CASE STUDY 3

FIRE DEPARTMENT LEARNS HOW TO “THINK DIFFERENTLY”

Challenge: A fire department in a small rural community did not have enough staff or equipment to deal with the number of fires occurring in the community. The budget did not allow for additional staff or equipment..

Solution: When they examined the nature of most of the fires, they found that many of the buildings that caught fire did not have sprinkler systems. They partnered with local lawmakers to enact legislation requiring sprinkler systems in tenable spaces.

Results: Losses from fires decreased, even though sometimes there was water damage in the buildings. This would not have been possible if the fire department hadn’t looked for a way to “fix the system.”

CASE STUDY 4

UPS REDUCES LEFT-HAND TURNS

Challenge: For a long time, UPS planned its routes based on the assumption that the most direct route was optimal. An examination of data related to accidents, fuel use, and the time required for trips revealed that left turns across traffic had higher risks for accidents and wasted time and fuel as drivers waited for breaks in oncoming traffic.

Solution: UPS instructed its drivers to keep left-hand turns to a minimum.

Results: UPS estimates it’s saved 10 million gallons of fuel, avoided 20,000 tons of carbon dioxide emissions and delivered 350,000 more packages a year. Although there is no way to count accidents that didn’t occur, it’s reasonable to assume they also improved the safety of their workers since over 50% of accidents at intersections are the result of left-hand turns [23].

Central themes related to “fixing the system” included designing for safety, observing how the work is conducted, and integrating safety into the workflow. All of these themes are based on the idea of developing or modifying business and work processes in a way that maximizes safety and minimizes the potential for serious injuries and fatalities.

Case Study 3 tells the story of how a fire department learned to “think differently” about certain types of fires and were able to “fix the system” to reduce damage from fires as well as potential injuries.

Case Study 4 relates how the United Parcel Service (UPS) looked at underlying data and made a simple process change –eliminating left turns wherever possible – as a way to “fix the system.”

Make Workers Part of the Solution

Involving workers in developing or improving work processes makes them stakeholders in the process rather than individuals who merely comply with a new process they may not understand or for which the benefits are not apparent. Three key themes emerged from the research on this subject and are central to achieving a safety culture.

- Involve workers at the front end of the design process, which can result in better processes as well as engaged workers.
- Communicate openly and frequently with workers as transparently as possible, especially when introducing anything new, whether it’s a process or a piece of equipment.

- Encourage workers to report safety issues through non-punitive reporting programs.

These programs help companies understand how work is performed and help to identify issues that would remain unknown if they were not reported. They also build trust and buy-in with workers.

Case Study 5 relates how Honeywell implemented a new reporting system to identify potential safety issues, including near-misses.

Case Study 6 demonstrates how proper training on carbon monoxide poisoning made first responders and fire fighters better able to provide appropriate medical care while also protecting their health and the health of their coworkers.

Metrics and Reporting

Metrics help quantify and track progress against goals. The research revealed there is a clear case for using metrics, but also that there are many potential safety metrics and many ways to use them, as well as many challenges. One of the key challenges was identifying leading indicators that can help predict performance. Most organizations use lagging indicators that report on past performance.



CASE STUDY 5

HONEYWELL'S "SAFETY OBSERVATIONS" SYSTEM

Challenge: Honeywell had a reporting system in place to identify safety issues, but only managers and supervisors could use it and it only allowed reporting in English although Honeywell has operations in many countries. Honeywell wanted to improve company safety and realized they needed a more sophisticated system to handle near miss and hazard reporting.

Solution: Honeywell implemented a new Safety Observation System that is directly accessible to all employees and available in nearly 20 languages. Employees are encouraged to report not only near misses and incidents, but also any unsafe behaviors and conditions.

Results: Over 82,000 safety observations were reported in 2013 across Honeywell's Building Solutions business unit. The number of recordable injuries dropped from 108 in 2010 to 54 in 2013 and the number of safety observations increased nearly 100% during the same time period [15].

CASE STUDY 6

FIRST RESPONDERS AND FIRE FIGHTERS LEARN VALUE OF NEW TOOLS

Challenge: First responders and fire fighters were instructed to include carbon monoxide alarms in their emergency kits but didn't receive information on the benefits of doing so and therefore were reluctant to use them.

Solution: Additional training was provided on the dangers of carbon monoxide poisoning. On more than one occasion, first responders and fire fighters thought they were dealing with a stroke victim, but the symptoms of carbon monoxide poisoning are similar to those of a stroke. These workers also learned that since carbon monoxide is an odorless, colorless gas that can render someone unconscious very quickly, they were risking their own health as well as the health of the victims they were treating.

Results: Providing training on carbon monoxide poisoning helped make first responders and fire fighters more effectively able to provide medical treatment and also helped protect their own health and the health of their co-workers.

Knowledge Gaps and Potential HP Research Opportunities to Reduce SIFs

In conclusion, several key themes emerged on how human performance approaches can contribute to reduction of serious injuries and fatalities. These themes included:

- Recognize that even the best systems have gaps or places where defenses are not in place to protect from a particular hazard, and thus incidents occur (The Swiss Cheese Model).
- Cultivate an informed safety culture around four elements: just culture, flexible culture, reporting culture, and a learning culture, where, for example, "near misses" become opportunities to design for safety and to continuously improve processes. A safety culture is a journey, not a destination.
- Create a common ground for understanding how risk is perceived in organizations.
- Foster leadership that promotes transparency and trust and a well-aligned organizational structure. This provides a natural foundation for a safety culture.
- Allow workers to develop solutions and improve processes, rather than trying to "fix the worker."

Learnings from this project point to opportunities for advancing Human Performance solutions to reduce SIFs through application and practice, and for continued learning through research. EPRI embarked on this project to ascertain if research opportunities existed where EPRI with its members could advance applications of HP to reduce SIFs.

Thought leaders, subject matter experts, and practitioners in Human Performance from various industries interviewed for this project identified a number of gaps in knowledge and practice and recommended potential opportunities for research to be conducted to find solutions to close these gaps. These individuals concentrated on what they have found, in their experience, to be effective Human Performance approaches to reduce serious injuries and fatalities and to identify where they feel that opportunities for improvements exist.

Gap: Current American National Standards Institute (ANSI) standard industry classifications used in reporting to OSHA do not clearly differentiate the severity of injuries; minor injuries add to a company's incident rate.

Research Question: Would changing the ANSI standard definitions have an impact on injury rates?

Gap: There is a lack of data on the characteristics of companies with low SIF rates vs. high SIF rates. For example, the role of management techniques, human factors considerations and work environment.



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Research Questions: Do such data exist? If so, how were these data measured and quantified? How is the data being used? If not, what would be needed to determine if an association/ correlation exists?

Gap: There is a lack of data on the effect of a company's culture and organizational structure on its safety performance, including the role of administrative functions such as human resources and finance.

Research Questions: Do such data exist? If so, how were these data measured and quantified? How is the data being used? If not, what would be needed to determine if a correlation or association exists?

Gap: Retaining and recruiting workers is a major issue for the utility industry. There is a lack of data on the effect a company's safety performance and safety culture has on retaining and recruiting workers.

Research Question: Is there a correlation between a company's safety performance and their ability to retain and recruit workers?

Gap: Worker input is not consistently sought when designing equipment and work processes.

Research Questions: Does involving workers improve the design? Does it reduce SIFs? What best practices exist for "designing for safety?" What other best practices could be implemented?

Gap: There is a lack of data on the effect of improving communication with workers performing tasks.

Research Questions: Do such data exist? What techniques have been successfully implemented?

Gap: Precursor analysis is a newer tool to provide predictive analytics to identify potential fatalities.

Research Questions: How many utilities use precursor analysis, if any? What effect has it had on reducing SIFs, if any?

Gap: Military and first responders use the "Emergency Response/ Military model," where one person focuses on the task, the second person observes and assists, and the third person provides oversight and scans for peripheral issues, threats or other distractions. It is unclear if the electric utility industry is using this model.

Research Questions: Are utilities using this model? What value could this provide to the utility industry? Are there any drawbacks? What could constitute advanced Situational Awareness and Communication training in the electric utility environment?

Gap: It is unclear if utilities are using a Human Performance program approach that focuses on Prevention, Detection and Correction. Human Performance Program documentation does not exist for all companies for comparison purposes.

Research Question: Does a balanced approach to Human Performance programs that focuses on the critical, irreversible tasks that workers perform improve the SIF rate?

Gap: Many companies use decision making models. These could be potentially helpful for benchmarking and continuous improvement for utilities, but information on the effectiveness of these models may not be readily available or shared on a regular basis.

Research Question: Is there a way to determine if a focus on risk and reward can lead to better decision making?

Next Steps

These knowledge gaps and research opportunities are intended to foster further discussion within the EPRI community to identify potential projects beginning in 2019. EPRI also welcomes suggestions from the broader human performance professional and research community.

For more information and dialogue, readers of this white paper may contact: Eric H. Bauman, Program Manager-Occupational Health and Safety, Energy and Environment Sector, at ebauman@epri.com or EPRI's Customer Assistance Center at askepri@epri.com.

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Interview Questions

1. How do you define Human Performance as applied to reducing SIFs (how would you define HP in this context?)
2. Do you have an HP program, and how is HP practiced in your organization? (For practitioners), or How should HP be practiced in organizations, or how are organizations practicing HP? (If consultant or academic).
 - a. Do you have a HP program? How long have you had it?
 - b. How or should HP programs be structured in your organization? What are the key components?
 - c. Did your organization implement HP before there is a “burning platform”? Or how did you obtain management and staff “buy-in” and budget to support HP implementation?
3. Apart from but related to HP, is your organization addressing safety related issues, such as...?
 - a. Fatigue management (for example, revising shift work scheduling, heat stress)
 - b. Do you have initiatives to “build in safety by design” in instrumentation, facilities designs, equipment, tools?
 - c. Did you amend or build any systems of safety or leading indicators reporting?
 - d. Other?
4. We are interested in the impacts of implementing the HP program in your organization:
 - a. Impacts on building trust and morale?
 - b. Breakthrough moments and/or Success stories you can share?
 - c. Impacts on overall injury rates or types of injuries?
 - d. Impacts on SIFs frequency or severity or types?
 - e. Impacts on reliability measures?
 - f. Impacts on physical and/or cyber security?
 - g. Anything else?
5. What do you see as opportunities for more effective implementation of HP programs and reduction of SIFs?
 - a. Structure of the HP? - what would you change, if anything in the HP program you described above?
 - b. Implementation of HP? – what would you change in how you implement HP?
 - c. Organizational barriers (such as budget, staffing, overcoming resistance, training)?
 - d. Use of measures/metrics – lagging indicators, “discovery clock” to report and track positive measures, like near-misses, corrective actions completed, etc.?
 - e. Designing for safety (for example, reducing hazards by design of projects, equipment, tools, work sites, control room design)?
 - f. Structured observation programs?
 - g. Addressing fatigue?
 - h. Work processes?
 - i. Technology? Please specify.
 - j. Other?
6. In the previous question, we asked if you see opportunities to make HP more effective. Besides benchmarking, do you have any ideas of potential opportunities for R&D to improve HP effectiveness in reducing SIFs?
 - a. Metrics? Predictive analytics?
 - b. Training?
 - c. Processes?
 - d. Structure of the programs themselves?
 - e. Addressing fatigue?
 - f. Designing for Safety?
 - g. Other?
7. Is there anything else you would like to share with us?
8. Do you have any suggestions for journal articles or other publications that we should read as part of this project?

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