A Systematic Approach to SAFETY PERFORMANCE

By John F. Kowalski and John C. Summers

IN TODAY'S BUSINESS WORLD, success necessitates meeting more than the required minimum standards (regulations). Safety performance is about individuals, leaders and the organization working together using safety (human) performance fundamentals and tools to protect personnel, property and the place (environment).

Safety has come a long way since the 1970s. For years, traditional safety focused on separating individual pieces of the process to obtain results. A systemic approach to safety performance is fundamentally different from traditional safety in that it focuses on the safety process.

A high performing organization is grounded on five fundamental safety performance principles:

1) People make errors.
2) Organizational values and programs influence behaviors.
3) Behaviors are influenced by what is encouraged and reinforced.
4) Errors and risk can be reduced through the use of safety performance tools.
5) Events can be eliminated through the use of defenses.

Senge (2006) defines system thinking as "a way of thinking about, and a language for describing and understanding, the forces and interrelationships that shape the behavior of systems."

Systems thinking focuses on how people interact with the others in a system, "a set of elements that interact to produce behavior" (Aronson, 1996). Systems thinking expands its view to take into account increasingly larger numbers of behavior interactions (organization, leader, individual) in a system (the process) that produces desired results.

Each individual plays a key role in working together as part of the organization to achieve the desired safe results. The behavioral aspects include those by the individual as well as those supported and reinforced by the organization.

In all cases, individuals, leaders and the organization should consistently strive for high safety performance standards. An aspect that plays a key part in what safety behaviors are employed is the culture and subcultures of the organization. Simply stated, culture can be considered as "the way we do things around here."

To establish a proper perspective, consider that, according to Bureau of Labor Statistics (BLS, 2018a; b) data, the rate of fatalities in the U.S. has almost leveled off (with a recent slight increase) while the rate of nonfatal injuries has steadily declined. Why do significant events, including injuries, continue to occur even though lower-level incident rates are declining? Some may answer that lower-level incidents are not being reported. Why could this be occurring? Possible reasons include:

- rewarding the consequence (i.e., low incident rates), which indirectly encourages nonreporting;
- creating a punishment atmosphere when lower-level events are reported;
- not encouraging the reporting of lower-level incidents and near-hits.

Leaders in many organizations tend to reward and recognize job results (production) and frequently overlook or take for granted the prevention behaviors necessary to safely complete the job. Additionally, production results are visible and establish natural feedback, whereas prevention behaviors get no natural feedback. For example, you wear a hard hat and safety glasses and shoes all day in a hot, humid environment. At the end of the workday, nothing happened. So, you might say, "I am really glad I wore this hard hat, safety glasses and shoes; they caused me to sweat more, I probably lost some additional hair, and nothing happened that demonstrated these were needed."

We often associate safety with the OSHA incident rate or days without a lost-time incident. With this premise, the organization could (and sometimes does) conclude that no OSHA recordables means no problems.

In some organizations, after an incident (event) the primary focus is on identifying what the person did or did not do that caused the event. Additionally, the cause is frequently identified as an "unsafe behavior" and opportunities for improvement focus on the individual. Dekker (2014) offers:

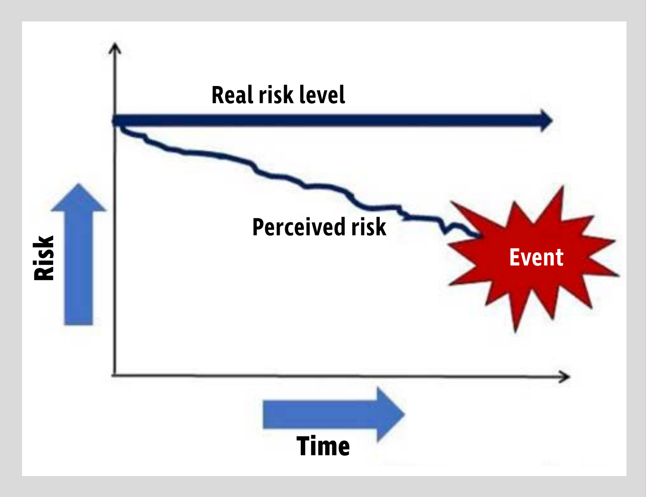
> Do you try to understand why it made sense to do what s/he did? The worker probably did not come to

KEY TAKEAWAYS

- **This article provides a systematic thinking approach using human and organizational performance fundamentals and analysis techniques to improve safety performance. The techniques described apply to individuals, leaders and the overall organization.**
- **The authors present a six-part model based on the philosophy that to reduce errors and eliminate events of consequence, adequate human performance tools and defenses must be in place.**
- **The theory aspects are presented, as well as several real-life examples from various industries where applying the correct actions or methods leads to improved, consistent results.**

FIGURE 1
SAFETY PERFORMANCE PROCESS

FIGURE 2
NORMALIZED DEVIANCE



work to do a bad job. If what s/he did made sense to him/her, it probably makes sense to others as well. That points to systemic conditions to examine.

If an assumption is made that individuals come to work to do their jobs, not to get hurt, then digging a little deeper to identify organizational factors that influence individual behaviors is warranted. In the worst possible scenario, the person performed the correct action, and a hidden (latent) flaw or problem existed, leading to the event. All the individual behavioral change actions in the world will not improve this condition.

Peeling back the layers can lead to more important questions (and answers):

•What about the behaviors of the leaders?

•Does the investigation include review of the work situation that existed when the event or injury occurred?

•Does it include supervisor and manager follow-up to identify how they may have influenced (or did not influence) on-the-job behaviors?

•Does the investigation include reviewing preparations for job performance, what job previews, hazard analysis, walk downs or prejob briefings occurred before work commenced?

•What previous operating experience, if any, existed before this performance?

•What was the focus of the job brief?

Often, the focus before and during the task is on what it takes to get the job done. High-reliability organizations also focus on what to avoid while achieving success. A site vice president at a nuclear power plant in northwest Ohio has great words to consider when briefing workers: "We have all the time necessary to perform the job correctly the first time, we just don't have any time to waste."

Safety Performance Process

Safety performance combines industrial safety, human performance and organizational performance into one process to protect people, the property (plant) and place (environment).

The safety performance process has six key elements starting with organizational behaviors and rotating clockwise toward safe results (Figure 1). Simple-to-use programs, processes and procedures, and hazard risk analysis are vital parts of the safety performance process. However, they alone do not guarantee success. To be effective, the alignment of behaviors of the organization, leaders and individuals is needed. Each aspect of the safety performance process is outlined here.

Organizational Behaviors

Safety starts with the culture of the organization. Safety performance is management-sponsored and leadership-driven by the collective behaviors of the company, from the board of directors to the workers in the field.

After providing human performance training at a power station in western Pennsylvania, training feedback was solicited from trainees, some of whom provided negative feedback. A meeting was held to discuss the subject material. During the meeting, the attendees huddled around one individual, a seasoned worker and an informal leader who the workers respected. Attendees commented that they liked the training, but that their supervisors would not let them use the human performance techniques.

In the days that followed, after being asked several times to help lead the human performance effort, the informal leader finally agreed to help. With his leadership, the program thrived. Workers became involved with the process and made several suggestions to improve it. Workers also started to coach each other and apply safety performance tools more consistently. A key result was that errors decreased.

Every organization has leaders like this informal leader at all levels of the organization. It is critical to identify and engage these leaders to improve safety performance.

While interacting with hundreds of companies and thousands of employees, the authors have often been asked, "How can we reduce errors?" After analyzing hundreds of consequential events, a few common themes usually appeared. First, individuals were not consistently applying appropriate error prevention tools. Second, and more importantly, defenses to protect against errors were either flawed or missing. On further investigation, the authors frequently identified an organizational weakness. If a program was in place to reduce errors and ensure defenses, it was inconsistently applied. Worst case, there was no program, no systematic approach, to protect individuals and the organization.

The authors frequently recommended consistently using appropriate safety performance tools and verifying that at least one defense is in place in the event that an error occurs.

Just like other programs and processes, the safety program must be predicated on the fact that people are not perfect; they are human and will make errors.

For several reasons, sometimes the best workers make the most grievous errors. We typically give the best workers the most important, time-restricted tasks. We assign them the most complicated tasks, recognizing that they are our heroes who "get the job done." This reinforces to the workforce the importance of "getting it done." Unfortunately, this can unduly influence a work group about the importance of getting the job done versus getting the job done safely. A simple example: A maintenance manager at a large western Pennsylvania electrical generating facility with approximately 1,000 employees created a three-statement philosophy: "1) Be safe; 2) do it right; 3) git'r done."

Interviews approximately 6 months after this was implemented with personnel from the maintenance organization indicated that every person, when asked for the maintenance philosophy, answered "git'r done." After additional questioning, personnel would frequently add that there was a safety part to this philosophy also. As an example, suppose a high-performing maintenance technician is doing a time-critical task by himself at 2:00 a.m. and the job requires brief work in the overhead (that had not been staged for). Which of the following pathways will the technician likely take?

1) Stop, call the supervisor and wait for a ladder to be delivered (but the job is to be completed by 2:30 a.m. or the plant must shut down).

2) Walk to the ladder storage area (a brisk 10-minute walk) and get a ladder.

3) "Git'r done" by climbing on the handrail (without fall protection as it is not staged) adjust the valve, spending less than 2 minutes performing an unsafe act.

Used properly, safety performance fundamentals and tools are a good defense, fighting the normalization of deviance that can exist in the culture. This term was a result of analyzing NASA incidents.

Figure 2 is a pictorial explanation of normalization of deviance. As an example, when less than 100% of safety devices exist, a heightened sense of uneasiness exists across the organization. As personnel initially perform work with this type environment, respect is strong for performing actions associated with the missing barriers. Depending on the time element of how long workers must live with the missing barriers, the risk perception of the threat diminishes. People drift away from consistent use of procedures and processes that were designed to maintain defense-in-depth and prevent vulnerability to an event.

The NASA Space Shuttle *Columbia* disaster is a good example of normalization of deviance. On Feb. 1, 2003, *Columbia* disintegrated upon reentering Earth's atmosphere, killing all seven crew members. Investigations revealed that NASA's organizational culture and decision-making processes had been key contributing factors to the incident, with the agency violating its own safety rules (CAIB, 2003).

For example, one design requirement stipulated that no foam shall be released during shuttle liftoff and flight. In 107 shuttle launches, foam breaking loose had been identified on every mission, and analyzed away (mostly via paper calculations) as a challenge. Since the start of the shuttle program, NASA managers had known that foam was a problem.

Specific to the *Columbia* mission, NASA managers also disregarded warnings from engineers who identified that a large piece of foam struck the orbiter wing shortly after takeoff. NASA leadership denied three requests for in-orbit pictures by Department of Defense satellite photography (to assess damage potential) during shuttle flight pass by.

Organizational behaviors key messages: Safety performance initiatives begin at the highest levels of the organization. Humans make errors and organizational focus either reduces or increases errors.

Programs, Processes, Procedures & Training

Management provides the programs, processes and procedures necessary to achieve safe job performance. A high-performing organization has simple, easy-to-understand programs, processes and procedures with effective training programs.

The foundation for success of highly reliable organizations is not based on meeting minimum requirements but rather is based on best safety practices. As an example, a nuclear site had a loss of all power March 20, 1990 (U.S. NRC, 1990). Although the nuclear fuel was down to its last safety barrier, natural circulation cooling, for about 18 hours, the senior executive identified at the start of the event that all Nuclear Regulatory Commission requirements were met. In follow-up speeches and seminars, the executive used this example as a reason to stay above requirements, because that is only the minimum level of safety protection.

Leadership implements and reinforces use of the programs and processes to set up jobsite conditions for safe job performance. In all cases, safety must be integrated into procedures with the desired safe behavior reinforced on a continuing basis.

Educating the organization and providing an effective training program is a key building block for success. This effort must involve workers and supervisors from development to implementation. Dynamic hands-on learning exercises are preferred so trainees can visualize the desired safe behavior.

Following is an example from another nuclear site. The challenge was to create an interactive and dynamic learning center in which people can demonstrate proper safe work practices and use of safety performance tools. The purpose was to simulate jobsite conditions with various industrial and radiological issues that challenged the students.

Training is staffed by qualified instructors, but the discussions in the center are facilitated by subject matter experts from the line organization. This grassroots approach drives ownership of safety and human performance from the lowest level of the organization. The center has been a great benefit to the workers. Most enjoy the hands-on approach, the open discussions of safe work practices and the use of safety performance tools.

Preparations to perform a task are just as important as the task itself. The work planning process sets up the job for safe performance. Job planning includes a job safety analysis specific to the task to be performed.

The work planning process frequently includes the following:
- precautions and limitations;
- energy source controls (lockout/tagout);
- confined space considerations;
- job accessibility (scaffold/personnel lifts);
- PPE;
- fire prevention;
- special considerations;
- procedures/work instructions;

TABLE 1
DETERMINE POTENTIAL CONSEQUENCE

Consequence value	Potential consequence (most probable result of unabated hazard)
5	**Catastrophic:** Serious injury or fatality (SIF). Hazards exist that if left unabated would most likely result in a fatality or disabling injury (e.g., unprotected fall hazard, exposed high-voltage conductor, unguarded equipment/tools; exposure to chemicals).
4	**Critical:** Potential SIF. Hazards exist that if left unabated the most likely consequence would be life altering.
3	**OSHA-recordable injury (non-SIF):** Hazards exist that if left unabated the most likely consequence would be an injury requiring medical treatment beyond first aid (e.g., a person lifts extremely heavy or awkward load that could likely result in sutures, medical prescription, physical therapy, restricted work or lost time).
2	**Medical case:** Hazards exist that if left unabated the most likely consequence would be an injury that would require medical care. Examples include non-OSHA-recordable medical treatment (e.g., tetanus shot).
1	**Minor injury/near-hit:** Hazards exist that if left unabated could result in an injury that would be very minor in nature and would not require first aid.

TABLE 2
DETERMINE PROBABILITY

Probability value	Likelihood	Probability that a sequence of events will result in injury
5	Frequent	Injury has occurred from hazard exposure
4	Probable	Injury possible, not unusual; has even 50-50 chance each hazard exposure
3	Occasional	Injury would result from an unusual sequence or coincidence
2	Remote	Injury has never happened after many years of exposure, but is possible
1	Improbable	Injury practically impossible (has never happened)

TABLE 3
DETERMINE FREQUENCY OF EXPOSURE

Exposure value	Likelihood	Exposure frequency (how often personnel are exposed to the hazard)
5	Frequent	Continuous (or many times daily)
4	Probable	Frequent (about once daily)
3	Occasional	Occasional (once per week to once per month)
2	Remote	Unusual (once per quarter)
1	Improbable	Rare (has been known to occur)

- critical steps or actions that can cause immediate irreversible harm to people, property (equipment) or the place (environment);
- tools and equipment;
- chemical control (safety data sheets);
- past learning experiences.

During job preparation, a task preview is performed by the workers to ensure that the task can be performed as planned in a safe manner. During the walk down, adjustments are made as necessary. Subject matter experts provide procedures and work instructions needed to perform the job safely. This includes the industrial safety manual, written to meet OSHA regulations.

Procedures and work instructions provide the safe work practices that include the warnings, cautions and notes, and identify whether any critical steps are necessary for safe task performance. Strict compliance with procedures and work instructions is needed for safety. People put themselves at increased risk for error with the possibility of injury if they do not follow procedures and work instructions. When these procedures and work instructions are faulted, workers must stop and correct the deficiencies.

Programs, processes, procedures and training key messages: The quality of programs, processes, procedures with consistent adherence reduces the risk of error. All levels of the organization are trained to recognize at-risk conditions and behaviors as well as how to correct, coach and reinforce desired behavior.

Hazard Risk Analysis

Jobsite conditions are an advertisement of safety standards. Although everyone says they have high expectations, existing standards dictate the minimum acceptable conditions and behaviors. Remember that everyone's first impression is what they see. When a work area is clean and neat, there is positiveness to the work environment. Good jobsite conditions encourage work to be performed in a safe and organized manner. Poor jobsite conditions can create an unnecessary hazard.

Presence of safe jobsite conditions means having a safe place for materials, tools and equipment, and arranging things to help create safe working conditions. An example of this is a NASCAR or Winston Cup garage. The work area is well lit and clean, and tools are stored in an organized and neat manner. This promotes efficient, error-free rebuilds and repair. Much is the same for other businesses; time and errors cost money.

Every job performed involves some level of hazards and risk. Once the risk is clear, appropriate defenses can be applied to reduce the risk to an acceptable level. All work activities require some amount of control, oversight and management involvement. As the risk increases, the need for control and oversight increases. A risk analysis process identifies where additional controls, barriers and oversight are needed to either reduce the likelihood of an error or to minimize the consequences of an event should an error occur. Hazard and risk analysis provides a basic understanding of:

- hazard identification;
- risk assessment;
- hazard mitigation controls and risk reduction.

One risk strategy used by several nuclear utilities is prevention, detection and correction. Risk analysis efforts work best

FIGURE 3
DETERMINE A RISK SCORE FOR EACH HAZARD

Risk (R) = probability (P) x exposure (E) x consequence (C)

Likelihood				Consequence (C): Minor injury/ near-hit	Medical case	OSHA-recordable (non-SIF)	Critical (potential SIF)	Catastrophic (SIF)
	Probability (P)	Exposure frequency (E)	Score	1	2	3	4	5
Frequent	Injury has occurred for hazard exposure: 5	Continuous (or many times daily): 5	25	25	50	75	100	125
Probable	Injury possible, not unusual; has even 50-50 chance each hazard exposure: 4	Frequent (about once daily): 4	16	16	32	48	64	80
Occasional	Injury would result from an unusual sequence or coincidence: 3	Occasional (once per week to once per month): 3	9	9	18	27	36	45
Remote	Injury has never happened after many years of exposure, but is possible: 2	Unusual (once per quarter): 2	4	4	8	12	16	20
Improbable	Injury practically impossible (has never happened): 1	Rare (has been known to occur): 1	1	1	2	3	4	5

when prevention aspects are identified and applied. But no one can think of all the what-ifs, so an effort to analyze potential detection and correction actions is needed. Best performance occurs when the prevention actions achieve success, but a prepared organization is ready to implement correction and detection actions to a reasonable level.

There are hazards associated with every activity performed. Typical job hazards include:
- chemicals or dust;
- unwanted energy;
- overexertion;
- gravity;
- configuration;
- mechanical;
- environment.

Some hazards such as housekeeping and tripping hazards can and should be fixed as they are found. Fixing hazards on the spot emphasizes the importance of safety and takes advantage of a safety leadership opportunity.

Hazards by themselves do not cause injuries. Contact with hazards through energy transfer can cause harm to people, the environment or the plant. The energy can be kinetic, potential, thermal, electrical, elastic, gravitational, magnetic, radiant, sound, nuclear or mechanical. If the energy can be eliminated, then there would be no injury or illness.

Once all hazards are identified, the risk of harm to personnel, property or the environment is computed as follows: risk (R) = consequence (C) x exposure (E) x probability (P).

The potential consequences of task performance with exposure to the hazards can be:

TABLE 4
LEVELS OF RISK

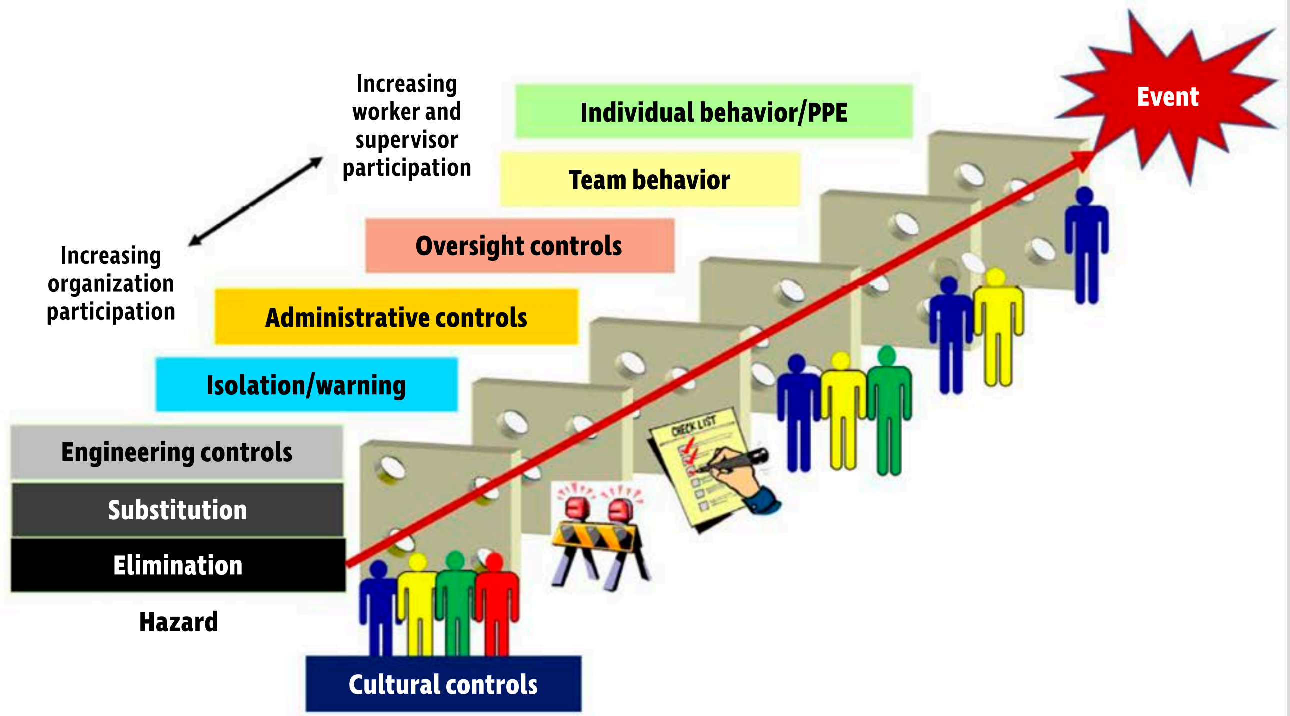
Risk score	Risk priority	Risk rating
80 or higher	1 - High	Not acceptable
50 to 79	2 - Serious	Manageable with administrative controls
11 to 49	3 - Medium	Tolerable with administrative controls
10 or lower	4 - Low	Acceptable

- catastrophic: serious injury or fatality (SIF);
- critical: potential SIF;
- OSHA-recordable (non-SIF);
- medical case;
- minor injury/near-hit.

A consequence/probability matrix can be developed to rank risks, sources of risk and risk treatment based on the level of risk (ANSI/ASSP Z690.3-2011). To develop a consequence/probability matrix, first determine the potential consequence (C) of the hazard if it is unabated using Table 1. Next, determine the probability (P) a sequence of events will result in injury using Table 2. Determine the frequency of exposure (E) to the hazard using Table 3. Finally, determine a risk score for each hazard using the chart in Figure 3.

FIGURE 4

HIERARCHY OF CONTROLS: MULTILAYER APPROACH TO HAZARD MITIGATION



Note. Adapted from *Managing the Risks of Organizational Accidents* (1st ed.), by J. Reason, 1997, Aldershot, England: Ashgate.

Based on the risk score, there are four levels of risk (Table 4): green (lowest), yellow, orange and red (highest). Most tasks performed are either green or yellow risks. Risks in the red levels must not be performed without appropriate management approval.

•Green risk levels 1 to 9: Frequently performed activities that resulted in events of minor or negligible consequences (i.e., injury requiring first-aid treatment, near-hit environmental or process safety event).

•Yellow risk levels 6 to 12: Occasionally performed activities with exposure typically less than 1 hour that resulted in events of moderate consequences (i.e., injury requiring medical treatment, minor environmental event or process safety event).

•Orange risk levels 13 to 18: Remotely performed activities (fewer than two times a day or less than a few hours a month) that have the potential to result in a significant injury, environmental or process event.

•Red risk levels 19 to 25: Infrequently performed activities that could result or recently resulted in an SIF, environmental or process event.

Example: Removal of a fire protection system. The risk analysis classifies the evolution as a yellow risk score.

•Approval is required by management.

•Preparation: Work documents that should be reviewed include the continuous use procedure to shut down the fire protection system, any reference use procedures developed to cover an abnormal condition during shutdown of the system and any applicable past experience when this was performed before.

•Prejob briefing: Supervisor oversees the prejob briefing. Discussion includes asking "What is the worst thing that could happen?" Ensure that hazard controls are addressed before the start of work.

•Oversight: Supervisor will oversee any critical steps or key actions.

A multilayer approach can be used to mitigate the hazard: eliminate or reduce exposure. As shown in Figure 4, like the Swiss cheese model used by Reason (1997), hazards (harm to people, the plant or the environment) would need to pass through several layers of defenses to become an event.

Unfortunately, there are small to large flaws (holes in the Swiss cheese model) that increase the potential for an event of consequence. Increased worker and supervisor wariness (a healthy uneasiness) is needed at the work site. The elimination or reduction in hazards necessitates increased organization participation.

Cultural, leadership, administrative and engineering controls are the strongest hazard mitigation controls. Cultural controls require management sponsorship and leadership support of the overall risk management process. Administrative processes ensure that programs and quality procedures are in place. Engineering controls are hard or physical defenses such as interlocks or safety barriers existing or put into place for protection.

When a hazard is identified, the highest level of control must be applied, commensurate with the risk level. Lower value controls may be used in the interim until long-term controls are implemented. Additional controls, barriers and oversight are needed to either reduce the likelihood of an error or to minimize the consequences of an event should an error occur.

Kahneman (2011) introduces two systems of thinking. System 1 is fast, automatic and emotional (unconscious thinking). System 2 is slow, deliberate, systematic and rational thinking. Safety performance tools (i.e., job hazard analysis adherence, job brief, safety minute, and self- and peer-checks) are a form of System 2 thinking to deliberately focus a worker's attention on safe behaviors before performing a task.

TABLE 5
HIERARCHY OF HAZARD MITIGATION CONTROLS & RISK REDUCTION

Hazard mitigation control	Description	Examples	Risk reduction
Cultural controls	The assumptions, values, beliefs, and attitudes and related leadership practices that encourage both high standards of performance or mediocrity, open or closed communication, and high or low standards of performance.	Personnel in excellent organizations practice safe work practices and error-prevention rigorously, regardless of their perception of a task's risk and simplicity, how routine it is and how competent the performer. The integrity of this control depends on the respect they have for each other and their pride in the organization.	Sponsors and supports overall risk management process
Engineering controls	Redesign equipment or process that automatically reduces risk.	•Redesign system or process •Physical interlocks •Improve material handling process	Eliminates or reduces consequence by one level
Elimination	Remove the hazard from the area or workplace.	•Remove hazard (e.g., pinch point) •Reduce human interaction •Repair damaged equipment	Eliminates consequence
Substitution	Replace with a less hazardous material or process or equipment.	•Safer travel path •Substitute less hazardous chemical •Automatic versus manual tools	Reduces consequence by one level
Isolation	Isolate the hazard from the person.	•Guards/stops •Presence-sensing device •Fencing along a walkway	Reduces likelihood up to 70%
Warning	Visible or audible warning systems improving awareness.	•Alarms •Signs or labels •Barriers	Reduces likelihood up to 30%
Administrative controls	Policies, procedures, practices and training to control risk.	•Procedures (e.g., JHAs, permits) •Training •Work management	Reduces likelihood up to 30%
Oversight controls	Verifies safety margins, integrity of programs, procedures, processes and quality of performance.	•Planning •Risk management •Safety meetings •Observations and coaching	Reduces likelihood up to 10%
Team behavior	Team awareness of hazards and mitigation measures and PPE to be used.	•Prejob briefing •Effective communications •Peer check	Reduces likelihood up to 10%
Individual behavior/PPE	Individual awareness of hazard, mitigation measures and PPE to minimize risk.	•PPE •Self-check •Work instruction/procedure use and compliance •Stop when unsure	Reduces likelihood up to 10%

Most events are initiated while performing repetitive, perceived as routine low-risk green activities. Team and individual behaviors were added to the hierarchy of hazard mitigation controls and risk reduction (Table 5) to include safety performance tools as the last line of defense from an event (Figure 5, p. 50).

Depending on the level of risk, the application of a defense (e.g., job hazard analysis) and the use of safety performance tools can reduce the risk of a given task. Following is an example of risk reduction with associated calculations.

Using a portable grinder to cut pipe would be perceived as a low-risk task. However, many people have been injured, some seriously, while using a portable grinder. Using the risk matrix (Figure 3, p. 47), risk is calculated to be 27 (yellow) [probability (3) x exposure (3) x consequence (3)]. Using the hazard mitigation controls and risk reduction chart, job hazard analysis (JHA), oversight, prejob brief, safety minute and PPE would reduce the risk to from 27 to 12.3 (54%):

Initial risk = likelihood x consequence = 9 x 3 = 27

Likelihood (3 x 3 = 9)		**Consequence**
Probability (P)	**Exposure (E)**	OSHA-recordable (non-SIF)
Injury would result from an unusual sequence or coincidence **3**	Occasional (once per week to once per month) **3**	**3**

Risk reductions from the hierarchy of hazard mitigation controls and risk reduction table (Table 5):

•JHA -30% likelihood; risk = 6.3 x 3 = 18.9;
•oversight -10% likelihood; risk = 5.7 x 3 = 17.1;
•prejob brief -10% likelihood; risk = 5.1 x 3 = 15.3;
•safety minute -10% likelihood; risk = 4.6 x 3 = 13.8;
•PPE -10% likelihood; risk = 4.1 x 3 = 12.3.

In this case, the risk was reduced from 27 to 12.3 (54%) by having and adhering to the job safety analysis, followed by safety performance tools. Substituting a different method to cut the pipe (e.g., band saw or pipe cutter) could further reduce the risk.

A risk matrix can also be used to aid the decision-making process when considering hazard/risk mitigation controls to determine whether the risk is acceptable. Safety committees typically have a list of items that need to be improved. Some refer to it as a top 10 list. Most items on the list typically involve improving jobsite conditions. Items on the list would include conditions that require maintenance to restore as designed safe conditions. Some items suggest new systems or process changes.

Using a hazard risk analysis approach, we can determine hazards and risk as well as the effectiveness of existing and proposed risk mitigation controls. A five-step process can be used:

1) Identify the hazard(s).

2) Determine existing risk without hazard/risk mitigation controls.

3) Determine risk reduction with existing hazard/risk mitigation controls.

4) Evaluate proposed additional or modified hazard/risk mitigation controls.

5) Quantify risk reduction with additional hazard/risk mitigation controls.

Using this approach, an organization can quantify risk reduction as a result of recommendations or suggestions to improve jobsite conditions. One can determine risk associated with existing jobsite conditions and controls, and controls with proposed additional or modified jobsite conditions and controls to determine return on investment.

Hazard risk analysis key messages: Every job performed involves some level of hazards and risk. Safety performance tools reduce the likelihood of human error.

Team Behaviors

Teamwork is determined by how people are treated by team members, both by the supervisor and by peers. If both the supervisor and the group make fair decisions, people will have positive attitudes toward the supervisor (trust) and the group commitment leading to better team functioning.

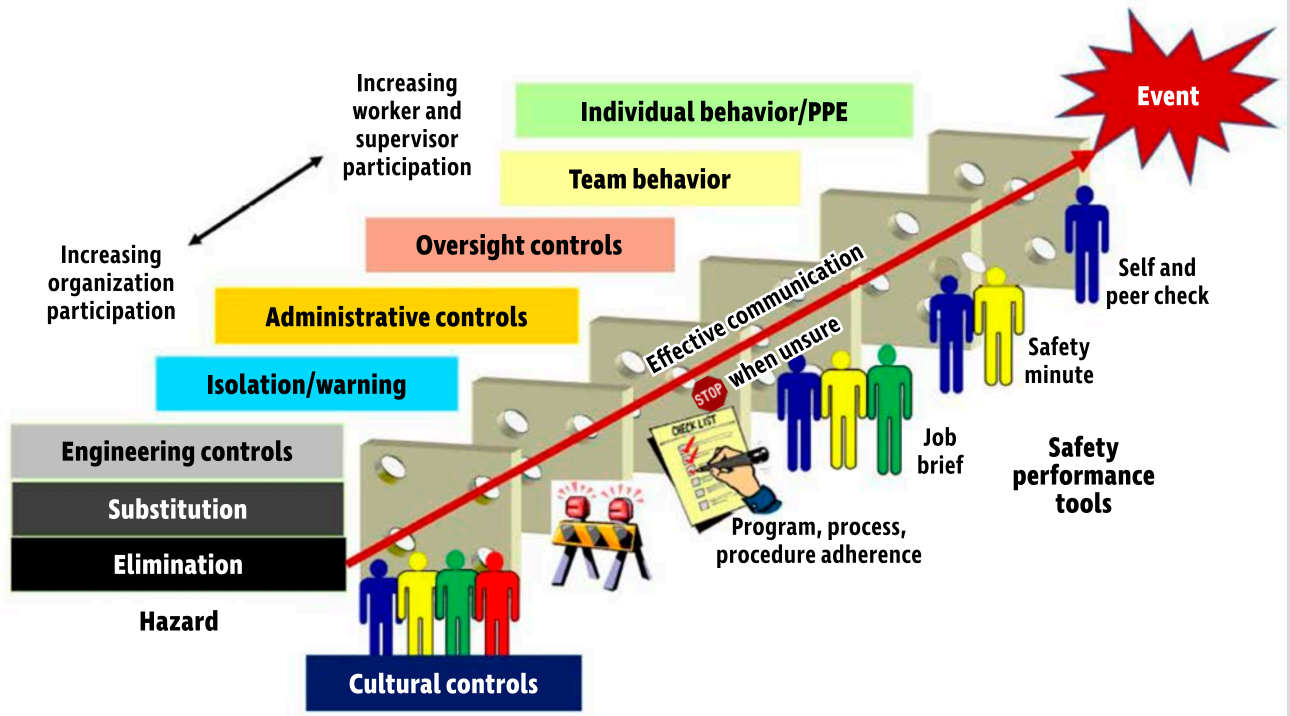
Trust is related to how well the team functions. Team members in a high-performing team build trust, and team members readily identify themselves with the team. Team identification leads to team trust resulting in cooperation.

Teamwork determines how effectively people get work done. How people are treated sets the stage for how safety is perceived to be valued by the organization, the culture for raising safety issues, and the likelihood that people will talk with each other about safety.

Team behavior key message: Crucial conversations occur at all levels of the organization, resulting in consistent alignment of the culture.

FIGURE 5

HIERARCHY OF CONTROLS INCLUDING SAFETY PERFORMANCE TOOLS AS LAST LINE OF DEFENSE



Note. Adapted from *Managing the Risks of Organizational Accidents* (1st ed.), by J. Reason, 1997, Aldershot, England: Ashgate.

Individual Behaviors

Individuals bring their knowledge and skills to the workplace. Their behaviors were molded through their biases and filters through years of experience. Individuals are also influenced by the culture of the organization. It is up to leadership to establish high standards to meet the organization's goals.

Individual behavior key message: Individual behavior is influenced by organizational culture and what is encouraged and reinforced. Safety performance tools used daily promotes situational awareness and hazard recognition.

Safety Performance Tools

Safety performance tools promote good situational awareness. Situational awareness is having an accurate understanding of our surroundings: where we are, what happened, what is happening, what is changing and what could happen.

The military defines situational awareness as the ability to identify, process and comprehend the critical elements of information about what is happening to the team with regard to a mission. More simply, it is being aware of what is going on around you.

Safety performance tools are proven techniques promoting good situational awareness on a daily basis. Similar to PPE, safety performance tools reduce errors that can lead to events including injuries. The likelihood (risk) of errors can be reduced by 10% through proper use of safety performance tools.

From the job brief to self and peer checks, the tools influence team and individual behaviors to reduce risk and perform the job safely. Every task performed starts with a prejob brief, followed by a safety minute, program, process and procedure adherence, and self and peer checks, and ends with a postjob brief. Throughout the job, personnel effectively communicate and stop when unsure.

Job Briefing

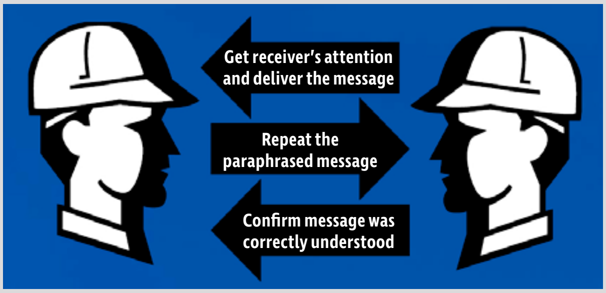
The most important teamwork tool used for successful work outcome is the job briefing: pre- and postjob. The prejob brief sets the stage for safe job performance. It is a huddle-up of all the players involved with the job to discuss how the work is to be performed. Fundamentally, it is a meeting to discuss what it will take to succeed, and what must be avoided (to preclude failure).

Workers should have the opportunity to participate in the development of prejob briefing checklists. As required by OSHA before each job, the person in charge conducts a job briefing with all workers that covers, at a minimum, hazards associated with the work, procedures to be used, any special precautions, control of energy sources, PPE required and environmental controls.

The most effective prejob brief is performed in a reverse manner from the workers to the supervisor. Having workers engaged in the job brief ensures that roles and responsibilities are determined for safe job performance. When a worker takes the leadership role for conducting a job brief, it establishes an understanding of the task with engagement, ownership and teamwork. For jobs of higher risk or infrequently performed tasks, the supervisor would take a more active leadership role in conducting the briefing.

The postjob brief provides the opportunity to discuss what went well and learning opportunities for future performance. Capturing the experience of job performance is vital for future safe performance.

FIGURE 6
THREE-PART COMMUNICATION



Safety Minute

Before starting work at the jobsite, when distracted or returning after a break, workers take a safety minute to establish situational awareness and recognition of job hazards.

After arriving at the jobsite, take time to establish situational awareness (takes about a minute). A walkaround or lookaround is used to verify that jobsite conditions and all other assumptions made at the prejob brief are correct, and to verify that work is ready to proceed.

Companies have various versions of this concept: 2-minute rule, 2-minute drill, "take 2 for safety" or a safety minute. A typical safety minute may contain the following:

Explore: Look up, down and around asking:
- Is this the right unit/component?
- What are the hazards?
- Review hazard/risk controls discussed at prejob brief.
- What's the worst thing that can happen and why won't it? What else can happen?
- Are signs/barriers in place?
- Stop and seek help if unsure.

Program, Process & Procedure Adherence

Rule-based errors can be prevented by adhering to written programs, processes and procedures (e.g., permits and work instructions, such as work packages and clearance instructions, that support creating and maintaining a safe work environment). When working in a rule-based environment it is key to seek direction (vs. acting on assumptions) when faced with uncertainty.

Place-keeping is extremely important when performing procedure/work instructions. A frequent type used is the circle/slash method to ensure that the procedure or instruction is performed properly. This is also beneficial for when personnel are distracted or interrupted. The method is:

1) Circle the step number to start the action.
2) Read the step.
3) Perform the action required.
4) Slash through the circle after completing the step.

Also, place-keep notes, cautions and warnings to ensure that they are understood.

If a series of steps must be repeated, then establish a place-keeping method for the repeated steps, such as placing a sequential number next to the steps being reperformed, then repeat place-keeping.

The risk of not following a procedure, process or work instruction can be as high as 50/50 with potential to harm people, property and the place (environment).

Self & Peer Checks

Self-checking is a safety performance technique for individuals to focus attention on the task. The individual focuses attention on the appropriate component, to think about the intended action and its expected outcome before performance, and to verify component condition after performance.

The most common self-checking technique is the STAR technique: stop, think, act and review. This technique is used when checking protective equipment, reading signs, identifying equipment to be worked on, operating plant equipment or performing other functions.

A peer-check is a series of actions by two individuals working together at the same time and place, before and during a specific action, to prevent an error by the performer. Although together in the same area, independence of thoughts must be maintained. The intent is to prevent an error before the performer takes the action. People can request peer-checks at any time for any work situation.

Effective Communication

Effective communication is clear, concise and free of ambiguity. It is provided in a way that minimizes the chance of being misunderstood.

Three-part communication entails transmission of a message by the sender, a repeat back or a paraphrasing of the message by the receiver, and an acknowledgment of the accuracy of the repeat-back by the sender (Figure 6, p. 51).

It is used for all communications that involve giving or taking direction associated with process activities, especially for critical steps or actions. Examples include communicating system, plant or component status or parameters, or directing actions affecting personnel safety or system, plant or component configuration.

The fast-food industry found that the significance of human errors can be high in this high-volume and low-profit-margin industry. The industry highly relies on satisfied repeat customers. Fast-food restaurants use self-checks, peer checks and repeat-back communications and computer screens to reduce the potential for errors. For example, when placing an order at the drive-up window at a typical fast-food restaurant, the screen displays the order and the server repeats back the order for an accuracy check.

An example of another restaurant that has implemented actions to reduce errors and improve performance is a waffle restaurant with 2,100 restaurants in 25 states. A visit to several locations in the Atlanta, GA, area identified interactions between the customer, servers and cook consistently use error-reduction techniques:

•self-checking and peer-checking techniques;

•two- and three-way communications when preparing cus-

FIGURE 7
SAFETY PERFORMANCE MEASURES

Move from reactive lagging measures:

•compliance driving the safety program;

•low employee involvement in safety;

•training heavily focused on technical aspects of job;

•focus on a single cause;

•correct the individual failure;

•narrowly apply solutions;

•OSHA-recordable injuries;

•lost-time incidents;

•workers' compensation costs;

•regulatory violations.

To predictive leading measures:

•leaders inspiring and motivating employees to own safety and go beyond minimum standards;

•employees more involved in developing and implementing safety and training programs;

•training incudes both technical and soft skills;

•focus on organizational cause;

•correct system/process failure;

•improvement opportunities;

•reporting lessons learned, near-hits, good catches or suggestions;

•recognition of safety performance tools use;

•observation and coaching participation;

•quality of safety meetings;

•self and independent assessments;

•safety perception surveys;

•average time to correct deficiencies.

FIGURE 8
PREJOB BRIEF CHECKLIST EXAMPLE

PRE-JOB BRIEF CHECKLIST

Check Items That Apply / Add Additional Information to Notes

Description of Work ______________________________

____

Work Order # ____________ Operation Step Number # ____________

Risk Score (FGBP-SAF-0034): ☐ 1 ☐ 2 ☐ 3 ☐ 4

☐ Roles & Responsibilities Define and Assign:
- ☐ Assign Safety Advocate to lead 2-Minute Drill: ____________
- ☐ Interfaces: Operation, Tech Services, Environ, Safety, Security, etc.: ____________

☐ Clearance – Energy Source Controls (Electrical/Pressure/Stored Energy):
- ☐ Multiple Clearances Y / N ☐ Verify System prints ☐ Energy Check
- ☐ Verify Tagged Boundaries ☐ Clearance signed on / verified still on

☐ Human Performance Tools / Techniques
- ☐ Task performed in the last six months? YES ☐ NO ☐
- ☐ Procedures / Work Instructions: ____________
- ☐ Stop Work Criteria: ____________
- ☐ ____________

☐ Job Hazards and Special Precautions – see page 2

☐ Personal Protective Equipment – see page 2
☐ Environmental Controls – see page 2
☐ Foreign Material Exclusion (FME) Controls- (FOPR-OPS-0006)

☐ SAFER Dialogue:
- ☐ Summarize the critical steps, error-likely situations, and job hazards
- ☐ Anticipate potential errors
- ☐ Foresee probable and the worst-case consequences should an error occur
- ☐ Evaluate Defenses to prevent and catch errors
- ☐ Review recent and relevant operating experience related to the job

☐ Housekeeping

STOP if Conditions are not as Briefed! STOP

ATTENDEES:

____

____

____

tomer orders (grill operators use repeat-back to verify the customer's order called out by servers);

•reminders of specific parts of the order are placed on a clean plate; some industries refer to this practice as flagging or robust barriers (small pieces of hash browns, cheese, a jelly packet, a mayonnaise packet, pickles, etc., help grill operators know what the order is and on which plate to place specific items).

Stop When Unsure

A powerful tool that can create teamwork and prevent people from making mistakes is to stop when unsure. How is it used and is it recognized as a desirable behavior in the workplace?

Generally, the people who make fewer mistakes (errors) have an in-depth understanding of safety error traps, followed by use of appropriate safety performance tools for the desired behavior that produces safe positive results. Following are key safety error traps for consideration:

•Time pressure: Time pressure or being hurried can lead to taking shortcuts. Shortcuts can quickly lead to injuries, damage to equipment or harm to the environment.

•Distractions: Distractions are a concern as people multitask or use social media. Interruptions lasting 2.8 seconds on average were found to double the error rate in a sequencing activity (Altmann, Trafton & Hambrick, 2013).

•Inaccurate risk perception: Having performed the job previously without errors leads to complacency and overconfidence that can result in having an inaccurate risk perception. Just because a worker has done the job several times before does not mean there is less risk. Low risk does not equal no risk.

•Assumptions: When we make assumptions and choose to not use or refer to programs, processes or procedures, the risk of error can be as high as one in two.

When uncertainty exists, individuals are always expected to challenge assumptions and unexpected conditions or to confirm a detail. This is particularly true when saying or thinking the following words and phrases: *Probably*, *I assume*, *I think*, *maybe*, *should be*, *not sure*, *might*, *we've always*, *I'm 90% certain*. Stopping when unsure and contacting leadership are the only acceptable actions to prevent errors and events. This alerts people to imminent hazards, warning signs and uncertainties in the work environment or with the work instruction.

When questions are asked, we need to follow through and ensure that the question is properly answered before proceeding. Proceeding in the face of uncertainty can significantly increase the risk of error. The entire organization must support a stop-when-unsure environment to promote trust and teamwork.

Safe Results

The phrase, "What gets measured gets done" means that regular measurement and reporting keeps us focused, because we use that information to make decisions to improve results. The most critical measurements are called key performance indicators. These are agreed-upon measurements that reflect the organization's critical goals for success: a numerical snapshot that is measurable, objective and actionable (Wolf, 2010).

But unlike behaviors associated with production and cost, behaviors associated with good safety performance have no natural feedback mechanism unless an event occurs (e.g., injury, equipment damage).

In safety, there are two basic types of performance measures: predictive "leading" and reactive "lagging." Historically, safety has primarily focused on reactive lagging measures, which are real, easily counted and deal with the consequences of behaviors that are visible, tangible and measurable. Unfortunately, lagging measures are always past tense. For years, most organizations have used only lagging measures (e.g., OSHA data such as recordable incidents).

Lagging measures do not provide adequate instructive guidance, nor do they provide motivation to improve performance behaviors. In other words, they do not tell us enough about why we are succeeding or failing. In some cases, they encourage people not to report injuries or errors by providing financial incentives for reducing the rate or numbers of injuries.

To achieve the next level of safety performance, we need to focus on the behaviors of the organization by moving from reactive measures to predictive measures (Figure 7). Predictive leading measures allow organizations to take a more proactive approach to improving safety performance with workforce ownership, empowerment and involvement. They measure key behaviors that can have a predictable relationship to the desired safe performance.

A system-thinking-oriented organization asks, "How did they achieve it?" instead of, "What did they achieve?" What steps do we take to keep people safe every day? It takes an extra effort to use proactive measures such as safety meetings, suggestions, job briefs and participation.

Proactive leading measures keep the focus on the behaviors that resulted in successfully safe performance, the desired results.

In the 1990s, a nuclear power plant initiated a human performance program to resolve performance issues that did not meet the plant's expectations. The plant started with an independent assessment of performance. The independent assessment team made two basic recommendations:

1) Obtain workforce involvement.

2) Focus on one safety performance tool.

As a result, human performance leadership teams were created with workforce involvement. The team created zero-incident performance (ZIP). ZIP successfully integrated safety performance tools with the existing peer-to-peer safety observation program. The team primarily focused on the prejob brief and developed its own checklist.

The team focused on job preparations, specifically the pre-job brief. It developed a prejob brief checklist (Figure 8). The checklist was developed to meet minimum OSHA requirements (1910.269) along with specific behaviors that needed to be performed for safe and successful job completion.

The first few items on the checklist identify the risk score of the task. According to the risk management program, low-level repetitive tasks (risk score 1) required that a worker, designated as the safety advocate, lead the prejob brief. For higher-level risk tasks, the level of oversight increased: supervisor (level 2), manager (level 3) and plant manager/vice president (level 4).

Over time, briefing checklists were created by every department (operation, maintenance, chemistry, security, radiation protection, engineering, training). Each department owned its brief checklists, monitored use and revised them as necessary. Personnel who performed excellent job briefs were recognized.

The accumulation of these everyday interactions leads to building relationships and trust within the organization. As an example of everyday recognition, a worker is recognized for using a 2-minute drill prior to material handling (Figure 9, p. 54).

When participation in processes improves, people are encouraged and develop a sense of personal responsibility for continued contributions and continuous improvement.

FIGURE 9

EVERYDAY RECOGNITION EXAMPLE

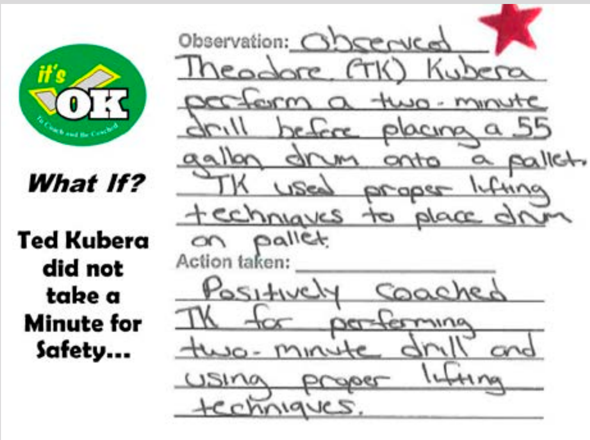
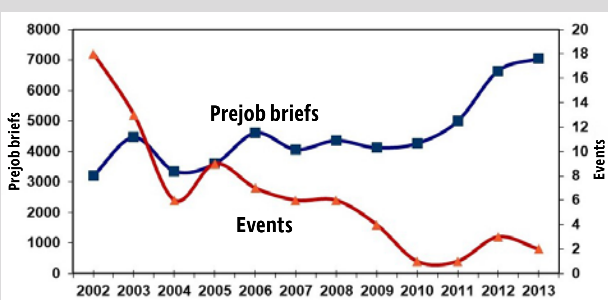


FIGURE 10

HUMAN PERFORMANCE INITIATIVE: PREJOB BRIEFS VS. EVENTS



Over time, the number of prejob briefs and peer-to-peer coaching increased dramatically and events decreased (Figure 10). Later, ZIP became keep improving performance (KIP) as the program went to other power stations.

At this station, it became unacceptable to not perform a prejob brief for employees and contracted workers who were later referred to as supplemental personnel. It can take several years of consistent focus on new behaviors to change a safety-focused culture.

This organization also experienced several examples of coaching that were recognized on a daily basis. As participation increased, safety performance improved.

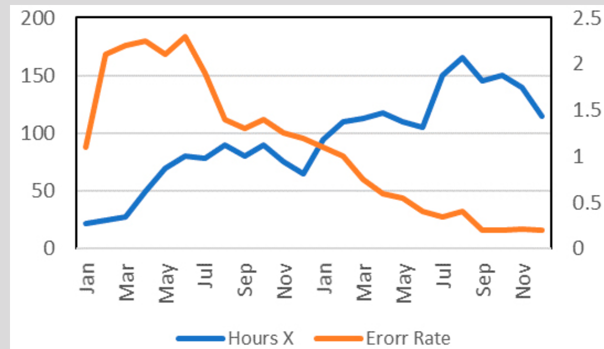
The U.S. nuclear power generation has greatly reduced the number of lost-time or restricted-duty OSHA-recordable injuries over the past several years. The industrial safety incident rate (lost-time and restricted work injuries per 200,000 hours) declined from 2.0 in 1990 to 0.02 in 2018. During the same period, the capacity factor (ratio of actual electrical energy output to maximum) increased from 70% to 93.4% (INPO, 2018).

Many factors led to and continue to sustain the nuclear power generation safety culture. A key contributor was the human and organizational performance initiative in 1999.

A safety performance principle is that behaviors are influenced by what is encouraged and reinforced. Interactions

FIGURE 11

CONTACT TIME VS. ERROR RATE, 2-YEAR PERIOD



(direct or indirect) between management, supervision and the workforce encourage or reinforce values. Given work demands, it is not uncommon for management to spend little or no time in the field having conversations with workers. Every conversation, body language or memo sends a message about you and what you value. One company found a direct correlation between contact time and error rate. It found that as contact time increased, the error rate decreased (Figure 11).

As a result, observations and coaching interactions by management and supervision were scheduled. The results of these interactions (both positive or improvement opportunities) were openly discussed at the next day's meeting. "Coach-the-coach" training followed, and coaches were recognized for high-quality observations and coaching. An it's-not-an-observation-until-there-is-a-conversation approach followed. The organization's active participation by sharing safety performance experiences with others is a powerful motivational tool to recognize and reinforce safe behavior.

The human error rate can be dramatically reduced using safety performance tools. However, getting to the next level of safety requires strong defenses (hazard and risk mitigation controls) to prevent events including injuries. Safety performance is just as important as quality, cost and production. In the nuclear power industry, the focus on human and organizational performance had a direct effect on production and the environment. Proactive measures allow organizations to take a more instructive approach to improving safety performance with workforce ownership, empowerment and involvement.

Leaders in a system thinking organization enable and reinforce discussions of the processes to prevent injuries. Such conversations increase awareness of doing the right thing, at the right time, all the time. When an outcome such as 1 million hours incident free is reached, a consequence of successful behaviors, we must recognize the series of small safety wins that led to this achievement, indicating that the process is working.

Safe results key message: Focus on proper safe behaviors to achieve desired results, not just results, creating an environment in which people are encouraged to take safe personal responsibility for themselves and others.

Conclusion

The benefits of safe and reliable job performance are evident in the productivity and job satisfaction of the workers. Safe and reliable behaviors at all levels are substantially influenced by the culture that exists within the organization. Successful organizations that have established productive work environments value the importance of safety. These organizations encourage and support a strong focus on the understanding and prevention of errors.

A systematic approach is needed to achieve and maintain the focus on safety and consists of the following key elements:

1) Organizational behaviors:

•Safety performance initiatives begin at the highest levels of the organization.

Humans make errors and organizational focus either reduces or increases errors.

2) Programs, processes, procedures and training:

•The quality of programs, processes and procedures with consistent adherence reduces the risk of error.

•All levels of the organization are trained to recognition of at-risk conditions and behaviors as well as how to correct, coach and reinforce desired behaviors.

3) Hazard risk analysis:

•Every job performed involves some level of hazards and risk.

•Safety performance tools reduce the likelihood of human error.

4) Team behavior:

•Crucial conversations occur at all levels of the organization, resulting in consistent alignment of the culture.

5) Individual behavior:

•Individual behaviors are influenced by organizational culture, and what is encouraged and reinforced.

•Safety performance tools used daily promote situational awareness.

6) Safe results:

•Focus on proper safe behaviors to achieve desired results, not just results, creating an environment in which people are encouraged to take safe personal responsibility for themselves and others.

A safety initiative that focuses on a systematic approach to improve and sustain safety performance derives its power from awareness and active participation of everyone in the organization. Active participation with the process at all organizational levels creates a culture in which safety is a valued component of overall operations.

Finally, safety performance is management sponsored and leadership driven. A key to success is the passion for excellence in safety performance that every leader of the organization displays. **PSJ**

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John F. Kowalski, CSP, ASP, CUSA, is owner and president of Safety Performance LLC. He is a safety and human performance professional with more than 40 years of diverse experience in safety and human performance. Since 1977, he has held various positions including senior consultant, staff advisor, industrial safety engineer, staff nuclear advisor, project engineer and engineer. He has extensive knowledge of power plant design, operation, industrial safety and human performance, and is recognized as an industry safety and human performance expert providing training, presentations, workshops and articles. Kowalski holds a B.S. in Nuclear Engineering from Pennsylvania State University. He is a professional member of ASSP's Western Pennsylvania Chapter.

John C. Summers is an expert in human performance, safety culture and process improvement with more than 44 years' experience. He has been a senior manager/director at several utilities as well as Institute of Nuclear Power Operations leader for the human performance initiative to improve the nuclear industry. In addition, he has provided general and focused training to more than 30,000 utility employees. Summers has presented papers at conferences around the world. He was a key U.S. contributor to International Atomic Energy Agency's *Managing Human Performance to Improve Nuclear Facility Operation*. Summers holds a master's degree in Organizational Technology from Kennesaw State University.