ENGINEERING-PDH.com
ONLINE CONTINUING EDUCATION

HUMAN PERFORMANCE - VOL 2 OF 2 - REDUCING ERROR

Main Category:	Project Management
Sub Category:	-
Course #:	PRJ-123
Course Content:	96 pgs
PDH/CE Hours:	8

OFFICIAL COURSE/EXAM

(SEE INSTRUCTIONS ON NEXT PAGE)

WWW.ENGINEERING-PDH.COM
TOLL FREE (US & CA): 1-833-ENGR-PDH (1-833-364-7734)
SUPPORT@ENGINEERING-PDH.COM

PRJ-123 EXAM PREVIEW

- TAKE EXAM! -

Instructions:

- At your convenience and own pace, review the course material below. When ready, click "Take Exam!" above to complete the live graded exam. (Note it may take a few seconds for the link to pull up the exam.) You will be able to re-take the exam as many times as needed to pass.
- Upon a satisfactory completion of the course exam, which is a score of 70% or better, you will be provided with your course completion certificate. Be sure to download and print your certificates to keep for your records.

Exam Preview:

1. Four types of lines of controls—engineered, administrative, cultural, and oversight controls—work together to anticipate, prevent, or catch active errors from causing a significant event.
    a. True
    b. False
2. In general, physical controls tend to perform their intended functions despite human action or inaction. Using the Reliability of Controls figure, which of the following controls has the highest reliability?
    a. Procedure Use
    b. Interlocks
    c. PPE
    d. Caution Tags
3. According to the reference material, a Bureaucratic organization is one where information is a personal resource to be used in a political power struggle. It will be withheld, doled out, or used as a weapon to advance particular parties within the organization.
    a. True
    b. False
4. An attitude is a state of mind, or feeling, toward an object or subject. Which of the following attitudes do NOT promote safe work behaviors?
    a. Conservative approach
    b. Uneasiness toward human fallibility
    c. Pollyanna attitude
    d. Questioning attitude

5. According to the reference material, the Pareto principle, or __/__ rule, states that __ percent of the consequences stem from __ percent of the causes.
    a. 90/10
    b. 60/40
    c. 70/30
    d. 80/20
6. Organizational culture is best defined by the shared basic assumptions that have developed in an organization over time as it learns from and copes with problems. Culture is the sum total of the organization's learning.
    a. True
    b. False
7. APPENDIX A: Warning Flags—Factors that Defeat Controls, lists common weaknesses that serve as warning flags in a facility. Which of the following weaknesses matches the description: Important equipment problems linger, and repairs are postponed while the plant stays on line?
    a. Overconfidence
    b. Production Priorities
    c. Informal Operations and Weak Engineering
    d. Plant Event
8. According to the reference material, it is estimated that 60 percent of the causes of facility events have their origins in the processes and culture of the organization.
    a. True
    b. False
9. According to the Reinforced Expectations section in the reference material, _____ reduces the probability that undesired behavior recurs, since nothing happens when that behavior occurs.
    a. Positive reinforcement
    b. Negative reinforcement
    c. Extinction
    d. Punishment
10. According to the Learning Organizations section of the reference material, _____ is the discipline of a shift of mind to seeing interrelationships, rather than linear cause-effect chains, and seeing processes of change rather than a snapshot.
    a. Systems-Thinking
    b. Personal Mastery
    c. Team Learning
    d. Shared Vision

HUMAN PERFORMANCE
PART 2: ORGANIZATIONS
& LEADERSHHIP

CHAPTER 3 - MANAGING CONTROLS

Controls

In this chapter, the reader will become familiar with controls as they relate to DOE facilities. From that introduction, the reader will gain an appreciation of the importance of controls in preventing events. The various categories of controls used and their relative dependability will be addressed. Most importantly, the emphasis will be placed on how to identify and eliminate latent organizational conditions in the system that weaken controls by using a variety of available and familiar methods (tools) introduced herein.

For readers who have taken DOE sponsored Human Performance Improvement training or who are familiar with some of the key HPI literature such as the research of Dr. James Reason, the term "defenses" is often used. Depending on the linguistic traditions of various hazardous technological domains, the terms "defenses, barriers, controls", or similar terms may be used. In general, they all connote technological or organizational features specifically designed to protect against hazards. To emphasize the role of HPI in supporting the DOE's Integrated Safety Management systems, the term "controls" is used in this Handbook in preference to the word "defenses" or other similar terms.. The meaning of the terms is essentially the same. ISM uses the term "controls" so this is the term used throughout this Handbook to promote consistency of usage and consistency of understanding.

Controls are extremely important in DOE facilities; successful controls prevent or mitigate the severity of events. Proper understanding and use of controls are important to understanding and preventing accidents.

- An accident occurs only when one or more controls have failed; either they did not serve their purpose or they were missing.

- Once the origin of an accident has been determined and the causes identified, controls and barriers can be used as a means to prevent the same or a similar accident from taking place in the future.[1]

Controls comprise any human, technical, or organizational features that protect the facility and personnel against hazards.[2] In addition to human error, other hazards include radiation, industrial safety hazards, hazardous chemicals, and various forms of energy, such as electricity and rotating equipment. Controls can protect against a hazard, mitigate consequences, or warn. Controls take the form of containments; physical interlocks; redundant equipment, power sources, and annunciators; personal protective equipment; procedure use; caution tags; and self-checking, among others

Example of Failed Controls in Industry: Chernobyl

The Chernobyl Unit 4 nuclear reactor accident in the Ukraine on April 26, 1986, is a classic example of multiple failed or missing controls—some resulting from design flaws and some from the errors of operators. The schedule that day called for a safety demonstration test to

determine how long the turbines could provide electrical power from residual momentum alone in the event of a power loss.[3]

Operators failed in their role as the most important line of protection because they did the following.

(1) **Violated safe operating parameters** – Operators decided to continue the testing of the voltage generator, even though an initial operating error had caused the power level to fall to 7 percent of full power. The station operating procedures strictly prohibited any operations below 20 percent of full power. Operations at these low power levels created a positive void coefficient in the reactor's core, which can lead to runaway reactivity. The operators should have aborted the test completely and returned the reactor to normal power to prevent this, but they did not.

(2) **Disabled engineered safety systems** – Operators subsequently disabled the emergency cooling and shutdown systems in order to complete the experiment by controlling the reactor themselves. That operators could physically disable these safety systems was indeed a flaw in the design of the system.

(3) **Retracted control rods beyond regulations** – When power dropped too low, operators forcibly raised power by retracting the control rods to an extreme level—much greater than that allowed by regulations. Here again a design flaw allowed such a manipulation. During the test, steam flow to the turbines was reduced. Thus, heat was not being carried away from the core as normal. When temperature in the core increased rapidly, giving rise to more boiling and increasing reactivity, an operator attempted a manual scram. The operator likely did not understand the consequences of his actions. Rather than slow down reactivity, insertion of the graphite-tipped control rods caused quite the opposite effect. The power surge triggered multiple steam explosions. The reactor vessel head was blown off, and, in a second chemical explosion, the roof of the building was blown off.

(4) **Design flaw: No containment –** The RBMK reactor design did not include a steel-reinforced concrete containment structure present in all other reactor designs. The presence of a containment structure would have precluded the release of aerosolized fuel and fission products into the environment. Instead, there was a total meltdown of the fuel and fire in the reactor housing burned for 10 days, dispensing radionuclides into the atmosphere.

The Chernobyl accident took dozens of lives, completely destroyed the plant, and forced relocation of tens of thousands of people. Adverse impacts to the environment continue to this day.

Examples of Controls in Every-day Life

Controls are built into our everyday lives. We will consider two examples—fire protection and driving a car. Take the controls against a fire in your home. There are fire-resistant building materials (*exterior:* brick, stucco, or cement-based siding, metal or tile roofs, steel doors, and so on.; *interior:* metal studs, sheetrock walls and ceilings, ceramic tile flooring, and so on).

Ground-fault interrupter (GFI) circuit breakers automatically cut off electricity when they sense shorts in the circuit. The above controls guard against a fire starting or they slow its spread in the event of a fire. Smoke detectors and alarms warn of danger should a fire start. Fire extinguishers, fire hydrants and hoses, and the local firemen are controls that contain and put out a fire if it should break out.

There are many controls associated with driving an automobile. Traffic lights signal drivers to proceed or stop at an intersection. Speedometers help drivers control vehicle speed. Drivers' licenses provide proof that people are qualified to operate an automobile. Seatbelts and air bags mitigate the effects of collisions. Ripples built into the edges of asphalt highways alert drivers with a rumbling noise when the vehicle is riding on the edge of the road. Likewise, controls in the facility take the form of procedures; physical interlocks; redundant equipment, power sources, and annunciators; as well as those that rely on people, such as self-checking, peer-checking, three-way communication, reviews and approvals, and supervisory oversight.

Severity of Events

The significance, or severity, of a particular event lies in the *consequences* suffered by the physical plant or personnel, not the error that initiated the event.[4] The error that causes a serious accident and the error that is one of hundreds with no consequence can be the same error that has historically been overlooked or uncorrected. For a significant event to occur, multiple breakdowns in controls or barriers must first occur. Whereas human error typically triggers an event, it is the number of controls and the weaknesses of those controls that dictate the severity of the event.

The existence of many flawed controls is directly attributable to weaknesses in the organization or management control systems. Individual error-prevention practices are important and need to be implemented and maintained. However, to focus only on error reduction to prevent events is a bad strategy for this reason. Error reduction can only reduce the time between events. The greater successes in minimizing the occurrence of severe events are realized by focusing on defense-in-depth. Improving controls will minimize severity. Therefore, one of management's top priorities must be verifying the integrity of controls.

The Organization's Role in Controls

Human performance occurs within the context of the organization—its processes, physical structures and culture. It is the organization that acquires, organizes, and makes use of resources (people, money, and equipment) in support of facility operations. When facility operations fail to accomplish what is intended, events are the results. Significant events triggered by human error are rightfully characterized as *organizational failures.* Significant events, excessive DOE oversight, and extended facility shutdowns are reflective of severe organizational failures. At the other extreme, facilities that demonstrate sustained operational excellence are managed by strong organizations that execute processes effectively and whose workforce adheres to high standards.

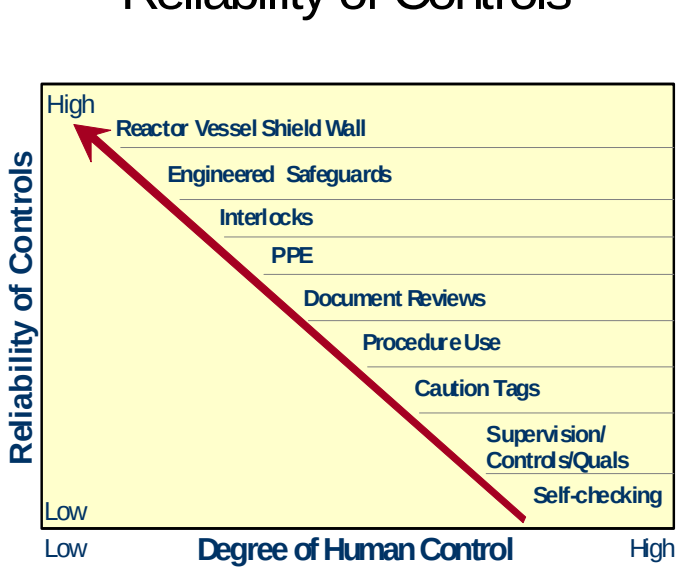
Defense Functions

Controls serve various functions, including the following.[5]

- **Create Awareness** – understanding the risks and hazards and recognizing the presence of hazards. Examples include pre-job briefings, post-job reviews, risk assessments, procedures, component labeling, color-coding, self-checking, computer screen layout, logs, meetings, communication practices, danger tags, and radiological postings.
- **Detect and Warn –** alerted to the presence of off-normal conditions or imminent dangers. Examples include alarms and annunciators, equipment operator rounds, concurrent verification, peer-checking, supervision, confined-space entry requirements, self-checking, and problem-solving methodology.
- **Protect** – guarding people, equipment, and the environment from error or harm. Examples include personal protective equipment, supervision, equipment lockout, interlocks, shielding, and ventilation.
- **Recover** – restoration from off-normal conditions and restoring the system to a safe state. Examples include independent verification, emergency procedures, eye wash stations, pre-established response procedures, continuity of operations plans, re-entry teams, and decontamination.
- **Contain** – restricting or limiting the accidental release of harmful energy or substances. Examples include double-shell storage tanks, glove boxes, remote manipulations, tank berms, piping and valves, and containment.
- **Enable Escape** – providing the means to flee from uncontrolled hazard. Examples include emergency plans, crash bars on doors, emergency lighting, and network installation management (NIM) routes.

Reliability of Controls

As might be expected, some controls are more reliable than others. Controls, barriers, or safeguards tend to be more reliable when they are not dependent on people to carry out their protective functions. In general, physical controls tend to perform their intended functions despite human action or inaction. Engineered controls, such as physical interlocks and equipment design, are more reliable than administrative controls, such as procedures, human performance tools, and training programs, as shown in the graphic above. When the effectiveness of a defense mechanism relies on the



performance of people—as do procedures, training, self-checking, and verifications—then it is less reliable. When plant safety and reliability are dependent on people during risk-important activities, the physical plant is more vulnerable to their errors. Reliability is related to the dependability of the defense or barrier to perform its intended function when needed. If it is imperative to prevent error, then physical, engineered controls are more appropriate.

DEFENSE-IN-DEPTH

Controls themselves are not necessarily perfect. Multiple, overlapping controls are needed to compensate for this reality. The Defense-in-depth concept is achieved by imbedding controls in an overlapping fashion into the organization, its culture, and the physical facility. Thus, if one controls fails or is ineffective, other systematically placed redundant controls will fulfill the same defensive function. Controls include various devices, methods, or practices that make an activity or process go safely and predictably to protect key assets from human error. Four types of lines of controls—engineered, administrative, cultural, and oversight controls—work together to anticipate, prevent, or catch active errors from causing a significant event. An explanation of each of these four types of control, as well as examples and common flaws associated with each follow.

Engineered Controls

Engineered design controls are all those hardware, software, and equipment items in the physical environment that affect people's behavior, choices, and attitudes, and are a result of engineering design. Engineered controls act either actively or passively. *Active controls include equipment such as pumps or valves that perform a specific safety-related function. Passive controls include pipes, vessels, and berms that provide containment and generally do not have moving parts.* The most reliable defense mechanisms are passive because they require no operational or maintenance support to remain effective, eliminating dependence on human involvement.

- **Elements of Effective Engineered Controls**

  The *human-machine* environment contains several opportunities to "control" human error. Human-centered designs consider human error and its potential consequences, eliminating or minimizing error traps with equipment.

  - The habitability and accessibility of the physical work environment.
  - The elimination of unnecessary human interactions with facility equipment or the automation of the equipment.
  - The use of interlocks and error-tolerant designs are used to mistake-proof human-machine interactions, especially those with risk-important systems and critical components.
  - Provision of interlocks and protection systems to prevent improper operator actions and to initiate automatic protective actions when necessary. Interlocks and protection systems will not prevent all possible operator errors, but they can substantially reduce the risks if they are properly maintained.

- Supervisors initiate modifications to eliminate or minimize errors associated with workarounds and human-machine interface deficiencies. These actions are especially important at critical steps.
- Reliance on configuration control, material condition, foreign material exclusion (FME), and housekeeping practices.
- Resolution of problems with environmental conditions, labeling, accessibility, lighting, and habitability, if possible, to minimize their impact on performance, especially on risk-important equipment. These are administrative controls in support of the engineered controls.

▪ **Common Flaws with Engineered Controls**

The following list highlights some of the more common equipment-related conditions that challenge worker performance and can contribute to facility events:

- out-of-service equipment, controls, alarms, and indicators;
- workarounds, temporary repairs, or long-term temporary modifications/alterations;
- nuisance alarms and disabled annunciators;
- excessive noise;
- missing labels or labels oriented such that they cannot be seen or read easily;
- poor lighting;
- high temperatures or high humidity (heat stress factors);
- unusual plant or equipment conditions; and
- poor accessibility, cramped conditions, or awkward layout of equipment.

Administrative Controls

Administrative controls, such as procedures, inform people about what to do, when to do it, where it is to be done, and how well to do it, and are usually documented in various written policies, programs, and plans. Administrative controls rely on human judgment, training, and personal initiative to follow the direction contained in documents. Consequently, administrative controls are not as reliable as engineered controls.

▪ **Example: Administrative Controls**

A wide range of management methods exists to ensure proper facility operations and to control various hazards. Administrative controls that significantly impact human performance include the following:

- strategic business planning (goals, budgeting, priorities, plans, resource acquisition, and so forth);
- formal organizational structure, lines of authority, roles, and responsibilities;
- policies, programs, and processes for the conduct of production work activities (preventive maintenance, procedure development, modifications, configuration control, operations, and so forth);
- communication methods (conversations, e-mail, logs, meetings, reports, newsletters, signs, postings, telephones, radios, alarms, and so on);
- technical and administrative procedures (clearances/tagging, foreign material exclusion, industrial safety, human performance, troubleshooting, records, parts and materials, self-assessment, corrective action, and so forth);
- training programs;
- qualification standards that establish the physical, psychological, educational, or proficiency requirements for the assigned duties of a position;
- work management processes (work initiation, prioritization, review and approval, planning, and scheduling);
- human resources policies and practices related to staffing levels, overtime, and discipline;
- human performance tools, expectations, and standards; and
- information technology and information handling.
- work authorization permits such as radiation work permits (RWPs) and confined space permits
- lock out - tag outs

- **Common Flaws with Administrative Controls**

The following administrative conditions, among others, can be causes or contributing factors in facility events:

- two or more actions embedded in one procedure step;
- vague expectations and standards;
- superficial document reviews or the lack of a “qualified reviewer” process for technical procedure development;
- critical steps not identified in procedures and work packages;
- excessive work package backlog that exceeds planner resources;

- work packages planned without inclusion of operating experience;
- unresponsive procedure revision process;
- excessive deferred preventive maintenance;
- insufficient staffing leading to excessive overtime, workload, and fatigue;
- routine authorization to exceed overtime limits (leading to chronic fatigue);
- inadequate time for direct supervision of work in the field;
- unclear qualification standards; and
- incomplete or missing electrical load lists to aid in ground isolation.

Cultural Controls – Values, Beliefs, Attitudes

An effective safety culture engenders the belief that when production and safety conflict, safety will prevail. Cultural controls include those leadership practices that teach (consciously or unconsciously) people how to perceive, think, feel, and behave toward challenges to safety.[6] Culture is defined by people's behavior, and safe behavior is value-driven.[7] What an organization says its values are may not be reflected in its behavior. The true values of an organization are reflected in the observed acts of its people, especially its managers.[8] For instance, when procedures are vague or incomplete, people tend to default to what they think is important for success as they define it.

Organizational culture comprises a set of *shared* assumptions, values, and beliefs that characterize the choices and behaviors of the members in an organization. Culture is to the group what character and personality are to the individual. Because of the special nature of hazards present at DOE facilities, organizations that work in these facilities need a *strong* safety culture. "Strong" implying the extent to which the organization's members adopt or internalize such values and behaviors. More will be said about culture in Chapter 5.

Values What managers place importance on and what is considered "high priority" becomes valued in the organization, whether this is publicly espoused or not. Key management values are usually visible at the site or at the facility in meeting rooms and conspicuous, high-traffic areas (both in the facility and outside the facility) where everyone sees them. When workforce behaviors become consistent with management's espoused values over the long term, then the organization has truly internalized those values.

Beliefs What people believe (or perceive) to be true tends to drive their attitudes and behavior. A belief is an acceptance of and conviction in the truth, existence, or validity of something, including assumptions about what will be successful. People erroneously believe they can always maintain control whenever and wherever. Typically, this is the case when people decide to take shortcuts or violate a safety policy. This belief changes as people understand the realities associated with human performance. The following beliefs have a significant positive impact on event-free performance.

- Absolutely safe environments do not exist.
- Human beings are fallible.
- People want to do a good job.
- Human error is normal.
- There is no such thing as a "routine" task or activity.
- Significant events are organizational failures.
- Error presents an opportunity to learn and improve organizational effectiveness.

Attitudes An attitude is a state of mind, or feeling, toward an object or subject. Importantly, attitudes affect people's choices and behaviors toward safety and error prevention. Positive feelings follow safe behaviors when people experience positive and consistent feedback from supervisors and peers and they understand why the feelings are important. If people experience negative feelings when they use safe behaviors (pain, fear, anxiety, frustration, humiliation, embarrassment, boredom, or discomfort) they will tend to avoid those behaviors and practices. The following attitudes promote safe work behaviors.

- **Uneasiness toward human fallibility** – individuals acknowledging their capacity to err, to make a mistake or slip at any time, and being wary of conditions conducive to error; tending to follow procedures carefully and applying human performance tools rigorously.

- **Questioning attitude** – maintaining vigilant situational awareness toward surrounding working conditions to detect error-likely situations, unsafe or hazardous working conditions, or otherwise unusual conditions; not proceeding in the face of uncertainty and basing decisions on facts

- **Conservative approach** – taking actions or making decisions that err in the direction of safety rather than production, especially when doubt exists; exhibited by placing systems, equipment, or the facility in a safe condition before stopping an activity

- **Avoiding "unsafe" attitudes** – being aware of and avoiding attitudes and practices detrimental to high levels of reliability, such as Pollyanna, summit fever, heroic, pride, fatalism, and invulnerability to error

Work Group Norms

A person's peer group is the largest, single determinant of an individual's behavior on the job. Norms tell people what they are supposed to do, wear, say, and believe; what is acceptable and what is unacceptable; what to look for; what to ignore; how to see things; and how to interpret what they see and hear. Norms are passed on by word of mouth and are enforced by how a person's peers respond when a norm is broken.[9] If work group members think one person is working too hard, they may make jokes and unkind remarks to the person until he/she adopts the group's norm for what is considered an appropriate level of effort. In extreme cases, the peer group may shun or attack the person until he or she complies with the group's "rules."

Leadership Practices

Management's style and response to various challenges or opportunities has a distinct impact on the work culture . Management, through the following leadership practices as described in Chapter 5, "Culture and Leadership," tends to shape the culture of the staff by the following:

- facilitating communication;
- promoting teamwork;
- coaching and reinforcing expectations;
- eliminating latent organizational weaknesses; and
- valuing the prevention of error.

Common Flaws with Cultural Controls

Sometimes it is easier to know when a culture is unhealthy by observing the practices, choices, interactions, and decisions of the organization's personnel. The following examples illustrate some flawed cultural controls:

- placing importance on personal judgment;
- being overly confident in one's own abilities to solve problems;
- being reluctant to challenge the decisions of others;
- relying only on one's own resources;
- applying human performance tools carelessly;
- lacking correction or coaching of at-risk practices, or using human performance tools improperly;
- having inconsistencies between what managers say they want and what they reward or pay attention to;
- making uncritical observation comments so as to not offend those observed;
- initiating disciplinary action for honest mistakes;
- providing bonuses based solely on productivity measures; and
- proceeding to the next action or step before signing off concurrent verification.

Oversight Controls

Vulnerabilities with controls can be found and corrected when management decides it is important enough to devote resources to the effort. The very nature of latent conditions is such that they will not self-reveal, they must be discovered. The fundamental aim of oversight is to

improve facility resilience to significant events triggered by active errors in the workplace—that is, to minimize the severity of events. Oversight controls provide opportunities to see what is actually going on in the facility, to identify specific vulnerabilities or performance gaps, to take action to address those vulnerabilities and performance gaps, and to verify that they have been resolved.

Senior Management Team Focus on Human Performance

Since human error is one of the greater sources of risk to the facility, the senior management team must give it careful and regular consideration. Instituting a standing working group structure to monitor human performance has proven successful. This structure promotes management awareness of current challenges to human performance and their effects on performance. This group establishes the vision, strategy, and processes for managing human performance toward a vision of event-free operations. The members of the senior management team, as an example, may serve on a *Human Performance Steering Committee.*

The steering committee or equivalent promotes accountability for human performance at the department-manager level using various measures of human performance, self-assessments, the corrective action program, and other sources of feedback. Managers closely monitor human performance events and trends, evaluate their causes and contributors, and communicate the results to personnel to increase their understanding and awareness. This system of accountability helps verify that human performance processes and changes are implemented as intended, consistent with the organization's purposes, resources, and goals; that expectations are performed to stated standards; and that performance gaps are identified and closed.

Performance Improvement Processes

Systematic performance improvement processes promote continuous improvement. However, weaknesses with oversight and performance improvement have contributed to long-term poor performance. The following flawed oversight controls tend to degrade this line of defense.

- Senior management oversight of the human performance is inadequate.
- Meetings of the Human Performance Steering Committee are held irregularly.
- Self-assessments are not focused on important attributes, or are not formally performed or tracked.
- The measurement and trending of risk-important processes are insufficient or are not performed.
- Root cause analyses are shallow and focus on individual errors without addressing organizational contributors to events.
- There is a lack of rigorous observations of work in the field.
- Managers are unaware of current human performance challenges in their organizations.

- Performance indicators of human performance are ineffective or are not in place.
- Expectations for change management are inadequate.

Human Performance Improvement Plans

Human performance improvement plans (HPIP) provide management with a systematic approach for correcting identified problems. Without plans, improvement is unlikely and rework is probable. An ongoing HPIP addresses the latest challenges to safety related to human performance. The HPIP, a living plan that is updated as new issues emerge, is reviewed during every Human Performance Steering Committee meeting to verify improvement is actually occurring.

PERFORMANCE MODEL

Human Performance – A system is a network of elements that function together to produce an outcome. A facility contains numerous systems, among them, the electrical system, the water circulation system, the work process system, the telephone system, the fire suppression system, and the heating, ventilation, and air conditioning (HVAC) system. There are also numerous intangible systems that function in the facility environment. For instance, the social system, the organizational system, incentives and disincentives systems, and belief systems are examples that typically function behind the scenes. *Human performance can also be considered a system.*

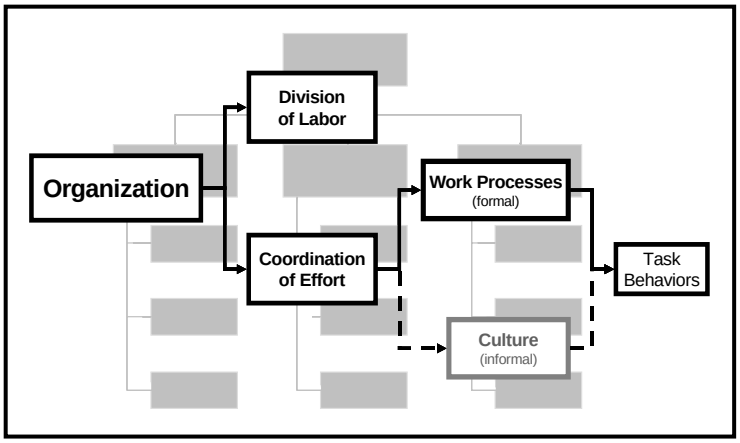
Understanding organizational systems and the impact of facility processes and values and leadership dynamics on performance is important to improving human performance. Systems-thinking involves pondering the multiple causes and effects, the variables that come to bear on the worker at the point of touching equipment in the facility.

An organization is defined as a group of individuals, including managers, supervisors, and workers, with a shared purpose or mission and means (processes) to efficiently apply resources toward the safe and reliable (values) design, construction, operation, and maintenance of the physical facility. Recall that the third principle of human performance states: *individual behavior is influenced by organizational processes and values.* Thus, human performance does not take place in a vacuum. Rather, performance occurs within the confines of the organization. No matter how well work is organized, how good procedures are, how well equipment is designed, or how well teamwork is achieved, people will never perform better than what the organization will support.[10]

Workers make decisions, perform tasks and carry out activities in the workforce according to prescribed protocols Procedures, policies, programs, training, and even culture influence worker behavior. The organization affects all of these. As illustrated in the *Anatomy of an Event* (Chapter 1), organization and the associated management control systems are the prevalent origins of events. Events are not so much the result of error-prone workers as they are the outcome of error-prone tasks and error-prone work environments, which are controlled by the organization.[11]

There is a direct cause-and-effect relationship between the organization and the individual performer. It is the organization that determines the division of labor and the coordination of effort—what people do, when they do it, under what conditions it is accomplished, and how well it is to be done.[12] Roles and responsibilities have to be clearly determined.

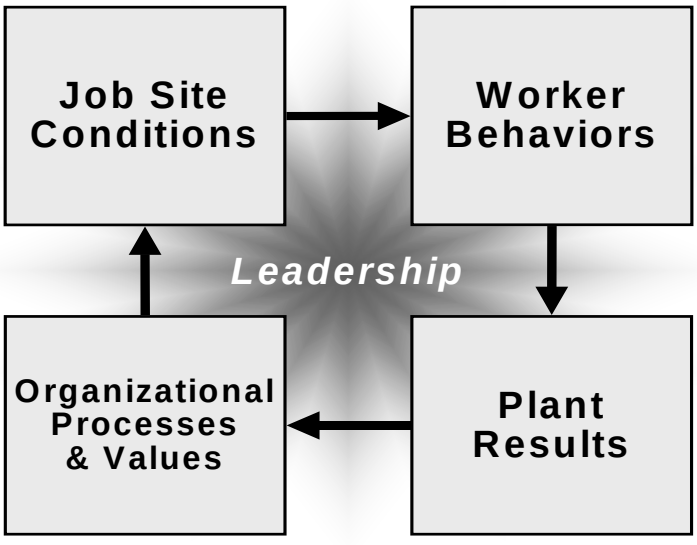
Organizational Effectiveness



Organizational effectiveness is demonstrated by the organization's ability to accomplish its goals. To achieve organizational effectiveness, the management team must organize it resources, especially its people. Organizing involves determining the *division of labor* and *coordinating the effort* as shown in the graphic on organization. Establishing functions, goals, roles and responsibilities, structure, and job assignments determines the division of labor. Managers pay attention to the tools of the organization—things typically written on paper (the administrative control system). They use formal policies, business plans, priorities, directives, goals and objectives, programs, processes, planning and scheduling, action plans, and expectations and standards to provide direction and controls to accomplish the facility's mission. The purpose of controls is to make processes (or tasks) go smoothly, properly, and according to high standards.[13]

Managers shoulder the *responsibility* for overall facility performance. To discharge their responsibilities, managers use work processes as the primary mechanism to coordinate work.[14] Functions carried out by managers to establish work processes include:

- deciding the administrative and functional structure needed to establish a standardized sequence of tasks to be accomplished;
- developing and approving procedures to direct workers' production and maintenance tasks;
- training people to do the work, specifying what, how, why, and when they are expected to accomplish their tasks;
- establishing processes that provide feedback and identify opportunities for improvement; and
- setting priorities of the organization.



The effectiveness of work processes is improved when managers communicate clear expectations to the workers, when they promote open communication, and when they strive for quality procedures and make use of an effective corrective action program.

The *Performance Model* shown in the boxes above is a simple, cause-and-effect model of these interdependencies that shows the organizational nature of human performance. The individual boxes in the model represent either conditions or action, and arrows indicate influence or causality.

Organizational Factors

Organizational factors have a strong influence on human performance. Organizational factors encompass all the ways management uses to direct and coordinate the work of the facility, which together shape the behavior of the people performing their jobs.[15] Collectively, they are the hub of all that goes on at the facility. Organizational factors reveal themselves in engineered controls, administrative controls, cultural controls, and oversight controls (corporate and independent). Some of the more important organizational factors known to impact performance are the following:[16]

- communication methods and practices
- management styles and degree of workforce participation
- tools and resources
- procedure development and review
- cleanliness of the work environment
- layout of facilities and structures
- staffing levels
- experience level of the workforce
- design and modification
- work processes
- management visibility
- human resources policies and practices
- training programs
- priorities (production and safety)
- expectations and standards
- emphasis on health and safety
- work planning and scheduling

For specific jobs or tasks, organizational factors create a unique array of job-site conditions (work environment)—good or bad—that set people up for either success or failure.

Job-Site Conditions

These factors define the unique set of conditions for a particular worker about to perform a specific task or action. The job site is that location or place where behavior occurs during task performance and can be characterized by either environmental or individual factors. Environmental factors (overarching both from the organization and the work environment) include conditions external to the individual and often beyond his or her direct control, such as

procedure quality, component labeling, human-machine interface, heat, and humidity. Individual factors include conditions that are a function of the person assigned the task, some of which are also beyond his or her direct control, such as knowledge, skills, experience, family problems, and color blindness.

> *Workplaces and organizations are easier to manage than the minds of individuals workers. You cannot change the human condition, but you can change the conditions under which people work.*
>
> *Dr. James Reason Human Error*

A special subset of job-site conditions that provoke human error are called error precursors (described in Chapter 2). When such conditions cause a significant mismatch between the task environment and the individual, an active error is likely to occur. The individual's capabilities and limitations (mental, physical, or emotional) may or may not match well with the environmental factors for the work as planned. In summary, job-site conditions shape worker behavior, for good or for bad. More detail is provided in the section on the Behavior Engineering Model.

Worker Behaviors

Worker behaviors include all the actions (or inactions) by an individual at the job site. Examples are component manipulations, use of human performance tools and other work practices, calculations, tool use, verbal exchanges, and procedure use. The effect of individual behavior is a change in the state of facility structures, systems, and/or components—plant results—for good or bad.

Plant Results

This element of the performance model represents the outcomes to the physical plant—good or bad. Examples of facility results include productivity, rejections, non-conformances, forced shutdowns, equipment reliability, safety-system availability, and outage effectiveness, as well as injuries, overexposures, spills, and damage. The quality of facility performance depends on the presence, integrity, and effectiveness of both processes and controls.

MANAGING CONTROLS – Performance Improvement Model

It is a commonly held belief that people are always able to distinguish right from wrong and that people lack proper motivation when they act carelessly or without clear judgment.[17] This is a faulty assumption. Error-prone tasks and work environments are usually created by latent organizational weaknesses. These are undetected deficiencies in organizational processes or values or equipment flaws that create workplace conditions that provoke error (error precursors) or degrade the integrity of controls (flawed controls). Undetected organizational deficiencies plague human performance.

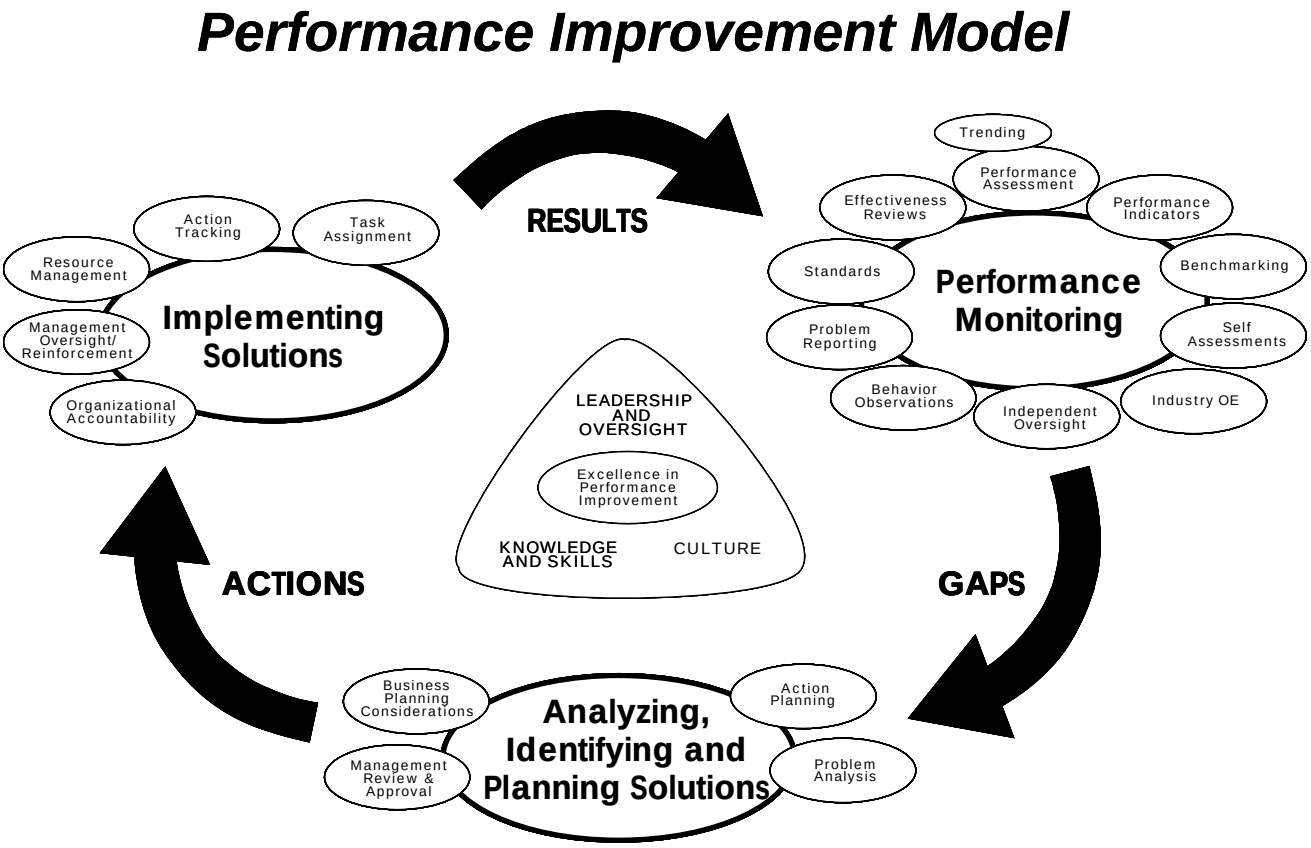
Latent errors or conditions are difficult to prevent. Once they are created they do not fade away, but rather they accumulate in the system. Because of their hidden characteristic, it is management's primary challenge to *limit the time these vulnerabilities exist.* Managers should aggressively identify and correct vulnerabilities with controls at the earliest opportunity. A more significant contribution to safety can be expected from efforts to decrease the duration of latent errors than from measures to decrease their basic frequency.[18]

"Managing" is the ongoing act of planning, directing, or controlling activities and resources toward accomplishing or achieving a purpose. Because significant events are few in number, less information is available about the presence of flawed controls and controls. This means that performance information has to be gathered from other sources. Luckily, these sources are pre-existing and are known to managers, supervisors, and staff. Typically, reliance is placed on field observations, self-assessments, benchmarking, apparent cause evaluations, and trending to provide management with information needed to improve performance and to eliminate vulnerabilities to facility events. See Appendix A for a list of factors known to defeat controls.

Performance improvement involves three primary activities.

- ***Performance monitoring*** *– activities that assess current performance, identifying gaps between current and desired levels of performance or results.*
- ***Analyzing, identifying, and planning solutions*** *– activities that determine actions needed to close the gaps.*
- ***Implementing solutions*** *– the collective activities that result in applying the chosen solutions and verifying their effectiveness to close the gaps.*

These three activities are depicted in the Performance Improvement Model below.



METHODS (Tools) FOR FINDING LATENT ORGANIZATIONAL CONDITIONS

- self-assessments
- trending
- operating experience
- behavior observations
- problem (causal) analysis
- surveys and questionnaires
- corrective action program
- performance indicators
- benchmarking
- independent oversight
- problem reporting
- management oversight, involvement, and reinforcement
- event investigation

Many of the methods for finding latent organizational conditions described below are addressed in more detail in HPI Handbook, Volume 2, section 3 "Management Tools." The information in this section and in section 3 of Volume 2 is targeted to managers and supervisors.

Self-Assessments

The organization can identify gaps in performance by comparing the present performance for a given work activity to the expected performance (based on standards). The difference between actual and expected performance is referred to as the "performance gap." An analysis of this gap in performance yields information about conditions and circumstances needed to determine corrective action. Improvements can then be targeted to reduce the performance gap. This same process can be used to compare actual processes and methods to expected, desired processes and methods. The self-assessment outcome may show shortfalls in worker knowledge, skill, attitudes and experience or in actions or behaviors caused by human fallibilities. It is more likely, however, to indicate deficiencies in job-site conditions related to task demands and the work environment or inadequate processes or weak organizational values that have influenced worker performance. The results of recurring self-assessments will yield patterns of weaknesses in controls.

Behavior Observations

Field monitoring of individual performance is an excellent technique for gathering information about how well the organization supports job-site performance. The purpose of an observation is not to criticize or to judge people, but to review the quality and effectiveness of work preparation, policies, and work practices, as well as their implementation.

An important purpose of observations is to identify opportunities to improve the organization of work, not just worker practices. The scope of behavior observations should include the whole job, not just worker behavior. Not only is it important to pay attention to worker practices but also to monitor the job-site context, potential hazards, and the controls relevant to the work activity. Results should be recorded for trending purposes to help identify strengths and weaknesses. Behavior observations can flush out organizational weaknesses that may not be obvious by other means, especially when this data is included with other information.

The quality of behavior observations is important to gathering accurate performance data. Managers and supervisors must be willing to be critical during an observation. Effective observations are planned, involve watching specific activities and critical steps, require feedback, and are recorded. Observers should be able to model expected behaviors. Their knowledge of human performance tools and at-risk practices must be sharp and exact. Behavioral checklists, such as scorecards or coaching cards, can be used to remind managers and supervisors what to watch for. For specific tasks, knowledge of critical steps, potential errors specific to the task, and targeted worker weaknesses are included within the scope of the observation.[19]

Error rates decrease when managers and supervisors are in the field with workers. Error rates tend to decrease when they monitor work in the field.[20] The following in-field supervisory practices contribute to fewer errors by the workforce:

- checking that workers accurately perceive the risks and priorities associated with the task;
- observing work practices at critical steps;
- reinforcing people appropriately when they exhibit proper and effective work practices;
- correcting people on the spot for at-risk and unsafe practices and coaching performance that otherwise does not meet expectations; and
- solving production problems and removing performance obstacles for the work team or individual.

Problem Reporting

Finding and eliminating latent weaknesses improve dramatically when worker feedback and communication are encouraged. Workers are in the best position to provide the feedback to help identify latent organizational weaknesses. Managers need to optimize related work processes that support work in the field to facilitate worker reporting issues. Workers are the beneficiaries of what the organization provides them, and they are keenly aware of its shortcomings.

Feedback via post-job reviews provides a credible and fresh source of information. The fundamental purpose of information gained from this review is to improve the organization of work as it supports worker performance at the job site—procedures, work packages, training, supervision, workarounds, and so forth. Such information will help improve productivity, identify opportunities to strengthen controls against error and events, and eliminate error precursors embedded in the task. To promote the use of post-job reviews on a routine basis, they should be easy and quick to do, and the worker must see appropriate changes in response to his or her feedback.

Benchmarking

Benchmarking is a powerful management tool that should be considered in strategic organizational improvement planning. Best practices are strategies and techniques employed by top performers. Since top performers are not generally “best in class” in every area, it is important to know exactly the areas being targeted in the top performing organization. Those areas should be matched to areas in the home organization where improvement has been shown to be necessary. From detailed gap analyses, organizations can implement action plans that include benchmarking to address performance shortfalls. Comparison of facility practices with the practices of other like operations that are considered “best in class” is an ongoing effort. The implementation of changes resulting from benchmarking should include an overall strategy to disseminate the need, urgency, methodology, and responsibilities for changing a facility process to match that of a benchmarked organization. Adopting a new process should be carried out with specific objectives in mind that are tied to eliminating identified weaknesses in the pre-existing process.

Performance Indicators and Trending

Performance indicators allow for the identification of undesirable trends. They are tools to help managers focus actions on pressing issues in order to drive continuous improvement. Managers must measure what is important not just what is easy to measure. The following are representative of indicators used at DOE facilities:

- event-free days (number of days between events);
- number of errors from all problem reports submitted during a period of time;
- changes in employee survey parameters from survey to survey;
- industrial safety accident rate;
- document revision requests;
- indices (weighted calculation of several other indicators related to human performance; for example, events, industrial safety, security, radiological);
- procedure compliance;
- observations (scoring of work performance and coaching feedback);
- re-work (amount of maintenance-related work that results in delays or additional costs over a given period);
- out-of-service errors (error rates associated with lockout/tagout activities);
- repeat events;
- workarounds; and
- backlogs.

The Pareto principle, or 80/20 rule, states that 80 percent of the consequences stem from 20 percent of the causes. This naturally occurring pattern helps identify the "big hitters," so that limited resources can be concentrated on resolving or improving the issues that comprise 80 percent (more or less) of all the problems. Once the big-hitter categories have been identified, analysts can plot each category over time, and they can then be addressed. Corrective actions can be implemented to address apparent causes of those issues. Analysts can plot data over time for these categories to see how each category trends over time.

Operating Experience

There is a natural tendency for people to think "It can't happen here" or "That won't happen to me." As was discussed in Chapter 2, humans underestimate risk and overestimate their ability to maintain control. This sense of invulnerability is an unsafe attitude. The use of operating experience (using feedback acquired from previously operating equipment or a system, both internal and external to the facility) has proven effective in improving performance and keeping facilities safer. Operating experience helps ground individuals to the risks and vulnerabilities

associated with specific activities. This must be a relentless pursuit of leadership. Operating experience is most effective when the right information is communicated to the right people in time to make a difference. Lessons learned can be reinforced during various training forums and through day-to-day activities such as pre-job briefings, coaching and reinforcement by supervisors, as well as through engineering design reviews.

Managers must make effective use of operating experience tools (Operating Experience Summaries and the DOE Lessons Learned Program[21]). Managers routinely provide relevant operating experience information to workers at the time they have a need for it. The pre-job briefing is an excellent venue in which to share the operating experience. The challenge is to get workers to internalize the lessons learned and to apply them where appropriate to their upcoming job. Supervisors should ask individuals with key responsibilities in the work activity to explain how they will avoid specific errors committed in the events described. Supervision then considers appropriate controls to avoid or mitigate errors and the consequences suffered in the described event. Supervisors should elicit work history experiences from individuals experienced with the task and assigned to the present job. They will usually have pertinent information, notably about latent weaknesses that hampered previous job performance and what will prove very useful to the other assigned workers.

Independent Oversight

It is common for people to forget to be afraid of the risks and threats and to become complacent about latent weaknesses or flawed controls, especially when they are anxiously engaged day in and day out with their project or activities. Is this condition symptomatic of a lack of "situational awareness"—the accuracy of a person's current knowledge and understanding of working conditions compared to actual conditions at a given time? Or, is it the absence of "mindfulness," the presence of a certain "mindset," or the existence of some unexplainable "blind spots"? How is it that an individual from another operation visiting in the facility can readily spot a process weakness, an unsafe practice, an error-likely situation, or a weakness in a defense that has gone unnoticed by resident workers and staff? It is because the outsider brings a fresh set of eyes, perceptions based on an ideal mental model of what should be and expectations that unencumbered by local culture, experience and constraints. It is exactly this disparity between insiders and independent observers in their ability to recognize degraded conditions that makes independent oversight such a powerful tool.

Reviews of facility activities by outside organizations provide an opportunity to reveal "blind spots" to facility management that otherwise would remain hidden or latent in the system. Quality Assurance departments, corporate oversight groups, DOE oversight and assistance groups, and independent assessment groups, such as the Defense Nuclear Facility Safety Board (DNFSB) oversight, provide opportunities to identify latent conditions. With an emphasis on nuclear safety, DOE evaluations and DNFSB reviews identify conditions, processes, and practices that fall short of expectations for safety and industry best practices that can possibly lead to degraded system performance if uncorrected.

Problem Analysis

Using tools or combinations of tools such as root or apparent cause analysis, and common cause analysis covers the underlying causes of problems or adverse trends, commensurate with their significance. It is not the intent of this handbook to describe these analysis tools in detail.

Analysts conducting root cause analysis of significant plant events should focus on what could have prevented the event rather than simply concentrating on who caused an event. It is also important to determine what controls worked to keep the event from being more severe. When causal analysis is fixated on individual culpability, finding effective corrective actions will be elusive at best, as it is unlikely the analyst will identify the real causes of the event.[22] An effective investigation focuses on discovering the latent weaknesses embedded in the organization, its culture, and the physical plant, rather than simply singling out one or two individuals for counseling or training.

"Inattention to detail" and "not following procedures" are not root causes even though these are still commonly cited as such in the DOE complex. A root cause is the cause that, if corrected, will prevent recurrence of the event. Human error cannot be eliminated completely—inattention will continue to occur despite our best efforts to eliminate it.

Investigations of events triggered by active error are usually distorted by hindsight—the analyst's knowledge of facts after the event that were not known, or knowable, by the principal individuals before the event. Hindsight predisposes the analyst to search for data that confirms the apparent shortcomings of the individual(s). Also, explaining what people could have or should have done explains nothing about why they did what they did. The challenge for the analyst is to determine why actions of the individuals made sense to them at the time. An analyst can build that context by identifying the following for each individual: [23]

- what they were trying to accomplish (goals);
- what they were paying attention to (focus); and
- what each person knew at critical points in the sequence of events (knowledge and situational awareness).

This information is obtainable from the individuals involved, through interviews and by a review of the job-site conditions for each individual (procedures, recorder traces, logs, computer printouts, review of the workplace, equipment, and so forth). The answers to the bulleted questions become the starting point for further investigation into the causes of the event.

The *Anatomy of an Event* model, introduced in Chapter 1, offers another structured approach to analyzing human performance issues. Working backward through the model from the event consequences to the organizational weaknesses that stimulated the event, helps explain the context of performance. Four major areas of fact need to be uncovered: (1) the specific consequences; (2) initiating actions (active errors) and error precursors that provoked the active errors; (3) flawed controls that either failed to prevent the active errors or failed to prevent or mitigate the event consequences; and (4) the organizational weaknesses that contributed to every

factor previously mentioned.[24] In the end, the analysis should clearly show the causal links (line of sight) from the organizational weaknesses to the event consequences.

Management Oversight

Fundamentally, management must have assurance that the risk of human error is minimized and controlled, especially during risk-important activities. A system of accountability helps verify that challenges to human performance are aggressively identified and addressed. Management verifies that expectations are performed to standards, that performance gaps are identified and closed, that corrective actions are completed effectively, and so on. See *Human Performance Steering Committee* earlier in this chapter to review one way the senior management team can perform its oversight responsibilities.

Surveys and Questionnaires

Monitoring changes in employee attitudes via periodic surveys identifies trends in values and beliefs. Workforce responses to surveys and standard questionnaires enable comparison of attitudes, values, and beliefs across an organization and detection of changes over time.[25] Survey results help managers determine where their time and effort can be applied most effectively to address misunderstandings and inappropriate values that impact the organizational culture. Questionnaire and survey questions must be carefully designed, tested and tied to specific organizational realities to be effective. Be careful not to ask for input and then fail to do anything constructive with it. There is a tendency in management to ask for input from workers and then not to act on it. When people are uninformed of the results and changes derived from the information gathered, they will become doubtful of management's sincerity in wanting improvement, and will be uncooperative with future surveys.

Corrective Action Program

DOE's Corrective Action Management Program (CAMP) is a comprehensive tool to help management identify, document, evaluate, and trend performance issues to facilitate the development and implementation of appropriate actions to correct problems.[26] CAMP provides management with a tool to systematically adjust controls and performance.

Briefly, the four steps of the program include:

- identifying and reporting problem findings from operational events, internal or external assessments or investigations, observations during daily work performance and worker safety concerns;
- evaluating each problem finding and developing appropriate corrective actions and corrective action plans;
- closing and implementing corrective actions to resolve findings delineated in the corrective action plan; completion and implementation status is tracked and reported to ensure timely and adequate resolution of each finding; and

- completion of all corrective actions for the findings listed in the corrective action plan and an independent follow-up assessment to verify closure.

Change Management

Change management is a methodical process that enables managers to establish the direction of change, align people and resources, and implement the selected modifications throughout the organization. Regardless of the scope of the change, it should be managed. Typically, change management has been reserved for large-scale organizational change and is not considered for day-to-day activities. However, most daily management activity involves some degree of change, such as changes in crew composition, outage schedule, policies, procedures, and equipment. More specifically, schedule changes are a common contributor to facility events.

Experience has shown that change fails most often when it implemented without developing a plan that includes:[27]

- defining the problem;
- determining the current condition;
- determining the desired final condition—a vision of what is expected;
- sufficiently considering the new values, attitudes, and beliefs needed to accommodate the change;
- identifying who is responsible to ensure the change is successful;
- describing the process to achieve the desired change, including consulting with all the people affected by the change;
- establishing a schedule for implementation;
- providing positive reinforcement of new behaviors by supervision and management; and
- specifying the actions planned to verify that the change has been successful.

Effective change management reduces the potential of error by managers when they change things. Without a structured approach to planning and implementing change, the error potential of managers and the support staff is higher. Organizations that have been successful with change have used a systematic process driven by quality leadership as well as excellent management.[28]

APPENDIX A: Warning Flags—Factors that Defeat Controls

The Institute for Nuclear Power Operations (INPO), with the help of several utility executives, conducted a study of utilities that experienced extended plant shutdowns. The results of the study identified several common weaknesses with organization and management. INPO concluded that these latent conditions are conducive to the degradation and accumulation of flawed controls and human-performance-related events. If not responded to aggressively, these weaknesses could lead to permanent facility shutdown and possible closure. INPO refers to these common weaknesses as "warning flags." [29]

- **Overconfidence** – The "numbers" are good, and the staff is living off past successes. Consequently, the staff does not recognize low-level problems and remains unaware of hazards.
- **Isolationism** – There are few interactions with other utilities, INPO, and industry groups. Benchmarking is seldom done or is limited to "industrial tourism," without the implementation of good practices learned. As a result, the plant lags the industry in many areas of performance and may be unaware of it.
- **Defensive and Adversarial Relationships** – The mind-set toward the NRC or INPO is defensiveness or "do the minimum." Internal to the organization, employees are not involved and are not listened to, and raising problems is not valued. Adversarial relationships hinder open communication.
- **Informal Operations and Weak Engineering** – Operations standards, formality, and discipline are lacking. Other issues, initiatives, or special projects overshadow plant operational focus. Engineering is weak, usually through a loss of talent, or lacks alignment with operational priorities. Design basis is not a priority, and design margins erode over time.
- **Production Priorities** – Important equipment problems linger, and repairs are postponed while the plant stays on line. Nuclear safety is assumed and is not explicitly emphasized in staff interactions and site communications.
- **Inadequate Change Management** – Organizational changes, staff reductions, retirement programs, and relocations are initiated before their impacts are fully considered. Recruiting or training is not used to compensate for the changes. Processes and procedures do not support strong performance following management changes.
- **Plant Events** – Event significance is unrecognized or underplayed, and reactions to events and unsafe conditions are not aggressive. Organizational causes of events are not explored in depth.
- **Ineffective Leaders** – Managers are defensive, lack team skills, or are weak communicators. Managers lack integrated plant knowledge or operational experience. Senior managers are not involved in operations and do not exercise accountability or do not follow up.
- **Lack of Self-Criticism** – Oversight organizations lack an unbiased outside view or deliver only good news. Self-assessment processes, such as management observation programs, do not find problems or do not address them; or the results are not acted on in time to make a difference.

This page is intentionally blank.

REFERENCES

[1] Hollnagel. Accidents and Barriers, Linkoping, Sweden. p.1; eriho@ikp.liu.se.

[2] Maurino, Reason, Johnston, Lee. *Beyond Aviation Human Factors*, 1995, p.10.

[3] Reason. *Managing the risks of Organizational Accidents*, 1998, pp. 76-77; http://en.wikipedia.org/wiki/chernobyl_accident.

[4] INPO. Significant Event Evaluation and Information Network (SEE-IN) Program Description (INPO 94-001), 1994, p.7.

[5] Maurino, Reason, Johnston, Lee. *Beyond Aviation Human Factors*, 1995, pp.11-13.

[6] Schein. *Organizational Culture and Leadership*, 3rd edition, 2004, p. 246.

[7] International Society for Performance Improvement. Handbook of Human Performance Technology: Improving Individual and Organizational Performance Worldwide, 1999, p.338.

[8] Porras. Stream Analysis, A Powerful Way to Diagnose and Manage Organizational Change, 1987, p.57.

[9] Porras. Stream Analysis, A Powerful Way to Diagnose and Manage Organizational Change, 1987, p.57.

[10] Maurino, Reason, Johnston, and Lee. *Beyond Aviation Human Factors*, 1995, p.xi.

[11] Reason. Managing the Risks of Organizational Accidents, 1998, pp.127-129.

[12] Schein. *Organizational Psychology*, 1994, pp. 12-15.

[13] Drucker. Management: Tasks, Responsibilities, Practices, 1974, p.218.

[14] Apostolakis. "A Structured Approach to the Assessment of The Quality Culture in Nuclear Installations." A paper presented at the American Nuclear society International Topical Meeting on Safety Culture in Nuclear Installations, Vienna, Austria, April, 1995, p.2.

[15] Porras. Stream Analysis, A Powerful Way to Diagnose and Manage Organizational Change, 1987, pp.35-40.

[16] United Kingdom Health and Safety Executive. Reducing Error and Influencing Behaviour, 1999, p.44.

[17] Wickens. Engineering Psychology and Human Performance, 1992.

[18] Reason. Human Error, 1990, pp. 179-80.

[19] Geller. The Psychology of Safety, 1998, pp. 194-212.

[20] After Entergy implemented its management observation program, which emphasized coaching time, it experienced a significant reduction in problem reports related to human error. 2000, as cited in INPO. Human Performance Reference Manual, 2006, endnote 21, p. 108. Entergy is a New Orleans based utility that provides electrical power to nearly three million customers in Arkansas, Louisiana, Mississippi and Texas.

[21] The DOE Corporate Operating Experience Program is at www.hss.energy.gov/csa/analysis/oesummary/index.html. The DOE Corporate Lessons Learned Program is at www.hss.energy.gov.csa.analysis/11/.

[22] Maurino, Reason, Johnston, Lee. Beyond Aviation Human Factors, 1995, p. 34.

[23] Dekker. The Field Guide to Human Error Investigations, 2002, pp. 77-99.

[24] Maurino, Reason, Johnston, Lee. Beyond Aviation Human Factors, 1995, p.66.

[25] Rothwell, Sullivan, & McLean. Practicing Organization Development, 1995, pp. 149-152.

[26] The Corrective Action Management Program meets requirements of DOE Order 414.1C. Quality Assurance (6/05). Corrective Action Program Guidance is provided in DOE G-414.1-5. The Corrective Action Tracking System (CATS) is on the web at www.hss.energy.gov.CSA/CSP/CAMP.

[27] Interaction Associates. Facilitative Leadership (course notebook), 1990.

[28] Kotter. Leading Change, 1996, p. 20.

[29] INPO. Human Performance Reference Manual, 2006, pp. 95-96.

CHAPTER 4 - CULTURE AND LEADERSHIP

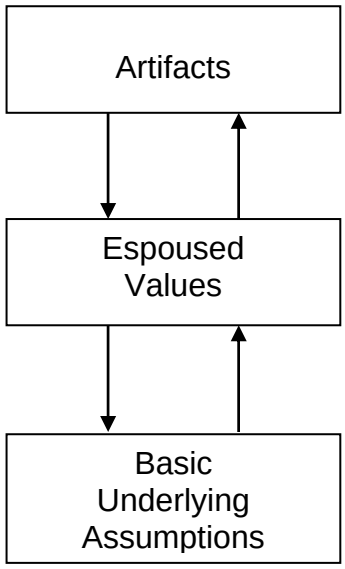
ORGANIZATIONAL CULTURE

Dr. Edgar Schein, professor emeritus at MIT's Sloan School of Management, has created a seminal body of work in the field of organizational development. Included among the 14 published books to his credit are those that deal heavily with organizational culture: *Organizational psychology, Organizational Culture and Leadership* and *The Corporate Culture Survival Guide."* Schein views culture as a pattern of shared basic assumptions that the group learned as it solved its problems of external adaptation and internal integration. Over time, this pattern of shared assumptions has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way you perceive, think, and feel in relation to those problems.

Schein suggests that the simplest way of thinking about organizational culture is to liken it to personality and character in the individual. As we grow up we learn certain ways of behaving, certain beliefs and certain values that enable us to adapt to the external realities that face us and give us some sense of identity and integration. As organizations grow and succeed, they undergo the same kind of learning process. What are initially the beliefs and values of the group's founders and leaders gradually become shared and taken for granted if the organization is successful in fulfilling its mission and managing itself internally. It is the past history of success that makes cultural beliefs and values so strong. As organizations grow and age they also develop sub-units, and the learning process described here occurs in these sub-units as well since they have different tasks and different issues of internal integration.[1]

Schein suggests that organizational culture can be considered in three layers as shown in the following graphic.

Levels of Culture



Visible organizational structures and processes
(hard to decipher)

Strategies, goals, philosophies
(espoused justifications)

Unconscious, taken for granted beliefs, perceptions, thoughts, and feelings
(ultimate source of values and action)

Schein's organizational model illuminates culture from the standpoint of the observer, described by the three levels as shown above. At the first and most cursory level are artifacts (*organizational attributes)* that can be seen, felt, and heard by the uninitiated observer. Included here are facilities, offices, furnishings, visible awards and recognition, the way its members dress, and how each person visibly interacts with each other and with organizational outsiders.

The next level deals with the espoused values (*professed culture)* of an organization's members. Here, company slogans, mission statements, and other operational creeds are often expressed, and local and personal values are widely expressed within the organization. Organizational behavior at this level usually can be studied by interviewing the organization's membership and using questionnaires to gather attitudes about organizational membership.

At the third and deepest level, the organization's *basic underlying assumptions* are found. These are the elements of culture that are unseen and not cognitively identified in every day interactions between organizational members. Additionally, these are the elements of culture which are often taboo to discuss inside the organization. Many of these "unspoken rules" exist without the conscious knowledge of the membership. Those with sufficient experience to understand this deepest level of organizational culture usually become acclimatized to its attributes over time, thus reinforcing the invisibility of their existence. Because cultures are learned by members of the organization, changing culture requires much discussion, communication, and learning and takes a long time to bring to fruition. Changing behaviors is also difficult because people have very strong "patterns" that they follow from habit.[2]

In summary, organizational culture is best defined by the shared basic assumptions that have developed in an organization over time as it learns from and copes with problems. Culture is the sum total of the organization's learning. The culture of a group is defined as: *a pattern of shared basic assumptions that was learned by the group as it solved its problems of external adaptation and internal integration that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems.*[3] In short, "it's the way we do things around here."

SAFETY CULTURE

It is vital that people's shared basic assumptions or beliefs are accurate and support safety. People can become very comfortable with the technology and the fact that "there hasn't been a major event here." Workers can come to believe (usually unconsciously) that their facility or system is robust—it has some safety margin. This mindset can be very dangerous. Assume for a moment that there is an operational hazard present in the system and there also exists this strong belief: the system is robust. This collective belief or assumption results in a lack of a sense of urgency about fixing defective equipment, so a physical barrier fails. Because the plant is robust, operators don't follow all the procedures, so the people barrier fails. Because the plant is robust, people fail to report minor problems or unusual observations, so the learning barrier fails. Finally, because the plant is robust, operators make non-conservative decisions in situations of uncertainty, and the "last chance" barrier fails—the outcome is an undesirable event.[4]

Because of the special characteristics and unique hazards associated with DOE research and defense operations, and the environmental restoration and D & D operations, associated organizations need to nurture a strong safety culture. It must be understood that safety is a

collective responsibility in which everyone in the organization shoulders an obligation to ensure that it comes first.

There are several definitions of safety culture that apply to the DOE and its operations. Dr. Jonathan Wert[5] defines *Safety Culture* as "a work environment where a safety ethic permeates the organization and people's behavior focuses on accident prevention through critical self-assessment, pro-active identification of management and technical problems, and appropriate, timely, and effective resolution of the problems before they become crises." The British Health and Safety Commission defines *Safety Culture* as "the product of the individual and group values, attitudes, competencies, and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization's health and safety programs."

Safety culture is about good safety management established by organizations with a holistic, whole of community, whole of life approach. Good safety culture implies a constant assessment of the safety significance of events and issues so that the appropriate level of attention can be given. A strong safety culture is dependent first and foremost on the organization's ability to properly manage safety in the facility over time. Dr. James Reason advocates that three ingredients are absolutely vital for driving the safety culture—and they are the province of top management. These driving forces are *commitment, competence, and cognizance*—the three C's.

Commitment consists of motivation and resources. High levels of commitment are comparatively rare and hard to sustain. This is why the organization's safety culture is so important. Will the organization seek to be the model for good safety practices or simply be content to stay just ahead of the regulators? A good safety culture has to endure changes in senior management. It must provide the necessary driving force regardless of who sits in the corner offices. The resources issue involves funding to achieve safety goals, but more pointedly it has to do with the caliber and status of the people assigned to direct the management of system safety.

Competence refers to the technical competence needed to achieve the safety goals. Paired comparison studies that examine pairs of companies matched in all respects except for safety performance have shown that the two characteristics most likely to distinguish safe organizations from less safe ones are (1) top-level commitment and (2) possession of an adequate safety information system. So, competence is closely related to the quality of the organization's safety information system. Does it collect the right information? Does it disseminate it? Does it act upon it?

Cognizance refers to the correct awareness of the dangers that threaten the facility's operations. Two features are common to organizations lacking the necessary level of cognizance. The first is where those at the top of the organization, possessing the largest degree of decisional autonomy, blame most of their safety problems on the personal shortcomings of those working at the sharp end. The second symptom is where managers treat safety measures like pieces of equipment. They put them in place, then tick them off as another job done. But safety measures have to be watched, worried about, tuned, and adjusted. Cognizant organizations understand the real nature of the "safety war." They see it for what it really is—a long guerilla struggle with no final conclusive victory.[6]

Reason's three C's needed to drive safety are supportive of the idea that a safety culture is a *leadership attitude that ensures a hazardous technology is managed ethically so individuals and the environment are not harmed.* Edgar Schein has said that ". . . one could argue that the only thing of real importance that leaders do is to create and manage culture. . . ." This section of the chapter addresses how leaders mold, influence, and sustain safety culture.

When people are tasked with a work assignment for which they lack specific guidance, they will defer to what they believe is the right thing to do. Often confronted with incorrect, incomplete, or inaccurate procedures or with equipment malfunctions, inadequate tools, and the like, workers regularly have to make tradeoffs between productivity and protection. It is a normal human behavior to want to "get the job done" rather than taking the time to do the job safely due to overconfidence, underestimating risks, and so on. This is especially true when supervisors expect and reward the results and are silent about behaviors needed to stay safe. The reality is that in many organizations safety tends to be assumed, and not much is said about it.

Core values are the underlying set of beliefs and assumptions an individual deems most important for him or herself, the work group, or the organization. Values are necessary to help people with day-to-day decision-making such as the dilemma noted above—an assignment with insufficient guidance. Values are embedded in the organizational culture. They are only helpful when they can be translated into concrete behaviors.[7] Managers must explicitly demonstrate to the workforce by their actions and behaviors that safety has to be preserved as a core value. Managing the culture requires conscious, careful consideration. Without the solidification and preservation of safety as a core value, managers will unconsciously reinforce getting the job done, with production becoming the default core value.[8]

Dr. Ron Westrum believes the flow of information is the most critical organizational safety issue associated with safety culture. Westrum's idea was to characterize general ways of coping with information, especially information that suggests anomaly. Failures in information flow figure prominently in many major accidents, but information flow is also a type marker for organizational culture. In some organizations, information flows well and elicits prompt and appropriate responses. In others, it is hoarded for political reasons or it languishes due to bureaucratic barriers.

Westrum identifies three typical patterns that define how information flows within an organization. The first is characterized by a preoccupation with personal power, needs, and glory. The second is a preoccupation with rules, positions, and departmental turf. The third is a concentration on the mission itself, as opposed to concentration on persons or positions. These patterns are called respectively pathological, bureaucratic, and generative. These preferences create recognizable climates that affect the processing of information and other cognitive activities. The climate not only shapes communication, but also cooperation, innovation, and problem-solving. The table below describes how organizations process information.

How Organizations Process Information

Pathological	Bureaucratic	Generative
Power-oriented Information is a personal resource to be used in a political power struggle. It will be withheld, doled out, or used as a weapon to advance particular parties within the organization. Messengers are shot, responsibilities are shirked. Cross-department bridging is discouraged. Faced with failure—scapegoating is standard.	Rule-oriented Information tends to be stuck in the control stage. This type generates only modest cooperation. Messengers are neglected, standard channels or procedures are used for getting information to the right recipient (often too late to be useful). New ideas often present problems. Cross-department bridging is only tolerated. Faced with failure—seek justice	Performance-oriented Encourage individuals to observe, to inquire, to make their conclusions known; and, where observations concern important aspects of the system, people are proactive in getting the information to the right people by any means necessary. Cross-department bridging is encouraged Faced with failure—inquiry into what is wrong

Patterns of information handling thus reflect the safety climate or culture. If leaders emphasize that information is to help accomplish the mission, then that use will predominate. If leaders emphasize that information must advance departmental goals, then that behavior will predominate. If leaders show through their behavior that information is only important as it advances or impedes their personal interests, then that use will predominate.[9]

Recognizing the varying definitions that have been proffered for safety culture, DOE in partnership with it's contractor community has adopted the following working definition:

An organization's values and behaviors modeled by its leaders and internalized by its members, which serve to make safe performance of work the overriding priority to protect the workers, public, and the environment.

The maturity and robustness of safety culture depends on the degree to which all employees internalize the attributes of safety. Even though the concept of safety culture is somewhat intangible, it is possible to reveal safety culture tendencies in our organizations by observing certain practices and behaviors.[10] The following attributes of a safety culture have been adopted from the DOE ISM Manual:

Leadership

Clear expectations and accountability

- Line managers provide ongoing reviews of performance of assigned roles and responsibilities to reinforce expectations and ensure that key safety responsibilities and expectations are being met.
- Personnel at all levels of the organization are held accountable for shortfalls in meeting standards and expectations related to fulfilling safety responsibilities. Accountability is demonstrated both by recognition of excellent safety performers as well as identification of less-than-adequate performers. In holding people accountable, in the context of a just culture, managers consider individual intentions and the organizational factors that may have contributed.
- Willful violations of requirements are rare, and personnel and organizations are held strictly accountable in the context of a just culture. Unintended failures to follow requirements are promptly reported, and personnel and organizations are given credit for self-identification and reporting of errors.

Management engagement and time in field

- Line managers are in close contact with the front-line; they pay attention to real-time operational information. Maintaining operational awareness is a priority. Line managers identify critical performance elements and monitor them closely.
- Line managers spend time on the floor. Line managers practice visible leadership in the field by placing “eyes on the problem,” coaching, mentoring, and reinforcing standards and positive behaviors. Deviations from expectations are corrected promptly and, when appropriate, analyzed to understand why the behaviors occurred.
- Managers set an example for safety through their personal commitment to continuous learning and by their direct involvement in high-quality training that consistently reinforces expected worker behaviors.

Conservative decision making

- Individuals are systematic and rigorous in making informed decisions that support safe, reliable operations. Workers are expected and authorized to take conservative actions when faced with unexpected or uncertain conditions. Line managers support and reinforce conservative decisions based on available information and risks.
- Individuals are intolerant of conditions or behaviors that have the potential to reduce operating or design margins. Anomalies are thoroughly investigated, promptly mitigated, and periodically analyzed in the aggregate. The bias is set on proving work activities are safe before proceeding, rather than proving them unsafe before halting. Personnel do not proceed and do not allow others to proceed when safety is uncertain.

Open communication/raising issues in an environment free from retribution

- Individuals promptly report errors and incidents. They feel safe from reprisal in reporting errors and incidents; they offer suggestions for improvements.
- A high level of trust is established in the organization. Reporting of individual errors is encouraged and valued. A variety of methods are available for personnel to raise safety issues, without fear of retribution.

Demonstrated safety leadership

- Line managers (from the Secretary to the DOE cognizant Secretarial Officer to the DOE Field Office Manager to the Contractor Senior Manager to the front-line worker) understand and accept their safety responsibilities inherent in mission accomplishment. Line managers do not depend on supporting organizations to build safety into line management work activities.
- Line managers have a clear understanding of their work activities and their performance objectives, and how they will conduct their work activities safely and accomplish their performance objectives.
- Line managers demonstrate their commitment to safety. Top-level line managers are the leading advocates of safety and demonstrate their commitment in both word and action. Line managers periodically take steps to reinforce safety, including personal visits and walkthroughs to verify that their expectations are being met.
- The organization demonstrates a strong sense of mission and operational goals, including a commitment to highly reliable operations, both in production and safety. Safety and productivity are both highly valued.
- Line managers are in close contact with the front-line; they pay attention to real-time operational information. Maintaining operational awareness is a priority. Line managers identify critical performance elements and monitor them closely.

Staff recruitment, selection, retention, & development

- The organization values and practices continuous learning, and requires employees to participate in recurrent and relevant training and encourages educational experiences to improve knowledge, skills, and abilities. Professional and technical growth is formally supported and tracked to build organizational capability.
- Training to broaden individual capabilities and to support organizational learning is available and encouraged – to appreciate the potential for unexpected conditions; to recognize and respond to a variety of problems and anomalies; to understand complex technologies and capabilities to respond to complex events; to develop flexibility at applying existing knowledge and skills in new situations; to improve communications; to learn from significant industry and DOE events.
- People and their professional capabilities, experiences, and values are regarded as the organization’s most valuable assets. Organizational leaders place a high personal priority and time commitment on recruiting, selecting, and retaining an excellent technical staff.

- The organization maintains a highly knowledgeable workforce to support a broad spectrum of operational and technical decisions. Technical and safety expertise is embedded in the organization. Outside expertise is employed when necessary.
- The organization is able to build and sustain a flexible, robust technical staff and staffing capacity. Pockets of resilience are established through redundant resources so that adequate resources exist to address emergent issues. The organization develops sufficient resources to rapidly cope and respond to unexpected changes.

Employee/Worker Engagement

Personal commitment to everyone's safety

- Responsibility and authority for safety are well defined and clearly understood as an integral part of performing work.
- The line of authority and responsibility for safety is defined from the Secretary to the individual contributor. Each of these positions has clearly defined roles, responsibilities, and authorities, designated in writing and understood by the incumbent.
- Individuals outside of the organization (including subcontractors, temporary employees, visiting researchers, vendor representatives, etc.) understand their safety responsibilities.
- Organizations know the expertise of their personnel. Line managers defer to qualified individuals with relevant expertise during operational upset conditions. Qualified and capable people closest to the operational upset are empowered to make important decisions, and are held accountable justly.

Teamwork and mutual respect

- Open communications and teamwork are the norm. People are comfortable raising and discussing questions or concerns. Good news and bad news are both valued and shared.

Participation in work planning and improvement

- Individuals understand and demonstrate responsibility for safety. Safety and its ownership are apparent in everyone's actions and deeds. Workers are actively involved in identification, planning, and improvement of work and work practices. Workers follow approved procedures. Workers at any level can stop unsafe work or work during unexpected conditions.

Mindful of hazards and controls

- Organizational safety responsibilities are sufficiently comprehensive to address the work activities and hazards involved.
- Work hazards are identified and controlled to prevent or mitigate accidents, with particular attention to high consequence events with unacceptable consequences. Workers understand hazards and controls before beginning work activities.
- Individuals are mindful of the potential impact of equipment and process failures; they are sensitive to the potential of faulty assumptions and errors, and demonstrate constructive skepticism. They appreciate that mindfulness requires effort.

Organizational Learning

Performance monitoring through multiple means

- Line managers maintain a strong focus on the safe conduct of work activities. Line managers maintain awareness of key performance indicators related to safe work accomplishment, watch carefully for adverse trends or indications, and take prompt action to understand adverse trends and anomalies.
- Performance assurance consists of robust, frequent, and independent oversight, conducted at all levels of the organization. Performance assurance includes independent evaluation of performance indicators and trend analysis.
- Line managers throughout the organization set an example for safety through their direct involvement in oversight activities and associated performance improvement.
- The organization actively and systematically monitors performance through multiple means, including leader walk-arounds, issue reporting, performance indicators, trend analysis, benchmarking, industry experience reviews, self-assessments, and performance assessments. Feedback from various sources is integrated to create a full understanding.
- Line managers are actively involved in all phases of performance monitoring, problem analysis, solution planning, and solution implementation to resolve safety issues.

Use of operational experience

- Operating experience is highly valued, and the capacity to learn from experience is well developed. The organization regularly examines and learns from operating experiences, both internal and in related industries.
- Organization members convene to swiftly uncover lessons and learn from mistakes.

Trust

- A high level of trust is established in the organization. Reporting of individual errors is encouraged and valued. A variety of methods are available for personnel to raise safety issues, without fear of retribution.
- Credibility and trust are present and continuously nurtured. Line managers reinforce perishable values of trust, credibility, and attentiveness. The organization is just – that is, the line managers demonstrate an understanding that humans are fallible and when mistakes are made, the organization seeks first to learn as opposed to blame. The system of rewards and sanctions is aligned with strong safety policies and reinforces the desired behaviors and outcomes.

Questioning attitude

- Line managers are skilled in responding to employee questions in an open, honest manner. They encourage and appreciate the reporting of safety issues and errors. They do not discipline employees for the reporting of errors. They encourage a vigorous questioning attitude toward safety, and constructive dialogues and discussions on safety matters.
- Individuals cultivate a constructive, questioning attitude and healthy skepticism when it comes to safety. Individuals question deviations, and avoid complacency or arrogance based on past successes. Team members support one another through both awareness of each other's actions and constructive feedback when necessary.

Reporting errors and problems

- A high level of trust is established in the organization. Reporting of individual errors is encouraged and valued. A variety of methods are available for personnel to raise safety issues, without fear of retribution.

Effective resolution of reported problems

- Organizational systems and processes are designed to provide layers of defenses, recognizing that people are fallible. Prevention and mitigation measures are used to preclude errors from occurring or propagating. Error-likely situations are sought out and corrected, and recurrent errors are carefully examined as indicators of latent organizational weaknesses. Managers aggressively correct latent organizational weaknesses and measure the effectiveness of actions taken to close the gaps.
- Results from performance assurance activities are effectively integrated into the performance improvement processes, such that they receive adequate and timely attention. Linkages with other performance monitoring inputs are examined, high-quality causal analyses are conducted, as needed, and corrective actions are tracked to closure with effectiveness verified to prevent future occurrences.
- Processes are established to identify and resolve latent organizational weaknesses that can aggravate relatively minor events if not corrected. Linkages among problems and organizational issues are examined and communicated.
- Frequent incident reviews are conducted promptly after an incident to ensure data quality to identify improvement opportunities.
- Vigorous corrective and improvement action programs are in place and effective. Rapid response to problems and closeout of issues ensures that small issues do not become large ones. Managers are actively involved to balance priorities to achieve timely resolutions.
- Expertise in causal analysis is applied effectively to examine events and improve safe work performance. High-quality causal analysis is the norm. Causal analysis is performed on a graded approach for major and minor incidents, and near-misses, to identify causes and follow-up actions. Even small failures are viewed as windows into the system that can spur learning.
- Performance improvement processes encourage workers to offer innovative ideas to improve performance and to solve problems.

LEADERSHIP

Fostering the principles for a strong safety culture is one of the most challenging tasks facing the facility management team. Leadership that is successful in achieving a strong safety culture will most likely move a facility to the *next level* of human performance.[11]

> A leader is *any individual* who takes personal responsibility for his or her performance as well as the facility's performance *and* attempts to influence the improvement of the organization that supports that performance.

Human error and its consequences can occur anywhere and at anytime. Fortunately, most errors are trivial, having no consequence on the facility. But errors may challenge safety, and create dire consequences to the facility, its people, and the environment. Therefore, management must clearly understand how the organization influences people's behavior through shared values and the safety culture to get things done

Workers, supervisors, and managers must believe they can prevent human error and its consequences. The assumptions, values, and beliefs people cling to strongly influence the choices they make when they encounter unanticipated situations or when procedure direction is vague or absent. Influencing and managing these factors to encourage people to internalize the above principles is the central theme of leadership in human performance improvement. *Focusing on the people's shared assumptions, values, beliefs, and practices—the culture—is, perhaps, the most effective way to maximize the organization's resistance to events.*[12] A strong culture promotes long-term success of the facility. But culture is hard and slow to change. Focusing on performance, reducing errors and improving work processes is achievable in the short-run.

Leader's Role

The organization is the engine that drives the performance system (see the Performance Model in Chapter 3). This is achieved by directing and influencing human performance and insulating the job site and the performers with layers of controls, barriers, controls, and safeguards. In the past, human performance consisted primarily of workers simply paying attention and doing the job right the first time. However, it is clear from years of accident research that a significant event presents unmistakable evidence of an organizational failure, not simple individual failure. Multiple controls typically fail, contributing to the event's severity. Because it takes teamwork to suffer a significant event, it follows that managers, staff, supervisors, and workers have to work together to be free of events.

Balancing the competition for resources between production and prevention/safety presents a constant challenge to management. Therefore, the leader's role is to *align* organizational processes and values to optimize both production and safety at the job site.

Production and Prevention: Competing Purposes

Production and prevention (error and event) practices always compete in the minds of workers. Leaders have to work hard to keep the facility, environment, and personnel safe. Well-informed leadership at all levels of the organization will ensure that the vision, values, and beliefs (prevention-centered attributes) do not conflict with the mission, goals, and processes (production-centered attributes). Consistency and alignment promote both production and prevention behaviors—together generating the desired long-term results as illustrated in the graphic below.

Production behaviors are those actions or activities aimed toward meeting specific schedules to achieve mission objectives by producing a product within deadlines and budget considerations. The outcomes of production are self-evident—completing jobs on schedule, operating and maintaining equipment, generating products, minimizing expenses, and satisfying the customer.

Error-prevention behaviors, such as self-checking, peer-checking, reviews and approvals, and procedure use, *avoid* errors and events. Prevention behaviors require that people think, be "mindful," while executing prevention tactics. Production activities have to slow down long enough to allow people to think, while executing prevention tactics to prevent errors. In contrast to the noisy evidences of production behavior outcomes, the outcomes of prevention activities are the quiet non-events. There is no shouting, clapping of hands, exchanging "high fives," or staff parties. Following a near miss in the facility, people will express concern and will take part in discussions of the circumstances. Otherwise, workers do not generally comment or show emotion following a given period of safe operations. For this reason, it is relatively easy for workers to come to regard prevention activities as optional when they conflict with the accomplishment of production objectives.

Production behaviors naturally take precedence over prevention behaviors unless there is a strong safety culture—nurtured by strong leadership. Both production and prevention behaviors are necessary for long-term success. But sometimes managers err when they *assume* people will be or are safe. Safety and prevention behaviors do not just happen. They are value-driven, and people may not choose the conservative approach because of the stronger production focus of their immediate supervision or work group. Therefore, *leadership is a defense.* A robust safety culture requires aggressive leadership that emphasizes the principles and attributes of a strong safety culture.[13] *Leadership is not optional.*

KEY LEADERSHIP PRACTICES

Five leader behaviors that promote excellence in human performance have been identified. Leaders act to influence both individual and organizational performance in order to achieve high levels of facility safety and performance through the following practices:[14]

- facilitate open communication;
- promote teamwork;
- reinforce desired behaviors;
- eliminate latent organizational weaknesses; and
- value error prevention.

Facilitate Open Communication

In many major accidents there was someone who knew something that if it had been communicated in time to the right people could have prevented the accident from taking place. It is this knowledge that reinforces the dictum that communication is the most effective defense against significant events.[15] Effective leaders work hard to root out any obstacles to communication. The organizational atmosphere must promote open, candid conversations about safety. Leaders, no matter what positions they hold, actively encourage others to identify error-likely situations and latent organizational weaknesses.

A safe atmosphere is cultivated when people treat each other with honesty, fairness, and respect—when they establish healthy relationships. An atmosphere of camaraderie, teamwork and collaboration motivates individuals to improve the effectiveness of the organization. Eventually, people become more willing to be held accountable and they seek assistance by admitting to and learning from errors.

If an individual believes his or her errors will be punished, then information related to those errors will likely remain obscure. In a *just* environment, the likelihood that a problem will be reported increases. High-performing organizations do not punish employees who make errors while trying to do the right thing.[16] Healthy organizations view error as an opportunity to learn.

Promote Teamwork

People have difficulty seeing their own errors, especially when they are working alone. Teamwork may improve the ability of individual team members to collectively prevent human performance problems. Because people are fallible, teamwork should make individual thinking and reasoning *visible* to the other members of the team. Dialogue between members of a team gives each one the opportunity to challenge assumptions and to detect team errors.

Accident research conducted in the aviation industry in the late 1970s showed repeatedly that failures in the cockpit to work as a team had devastating consequences. Sixty-six percent of air carrier, 79 percent of commuter, and 88 percent of general aviation accidents involved flight crew failures in interpersonal communications, decision-making, and leadership. In fact, more

accidents were caused by these failures than by lack of technical flying skills.[17] These findings led the airlines to create training programs to improve teamwork in the cockpit. Key goals of the "Crew Resource Management" (CRM) training included the following, among others:

- teaching team members how to pool their intellectual resources;
- acquiring collective situational awareness that admits challenges from junior team members;
- improving communication skills; and
- emphasizing the importance of teamwork.

The behavioral characteristics important to the success of pilot performance on the flight deck from the CRM training were adopted in the nuclear power industry in the early 1990s, with the development of the Control Room Teamwork Development Course. The following attributes for improving teamwork, proven essential to pilot performance and control room operator performance are applicable to teams working at DOE facilities.

- **Ask Questions –** asking a series of questions to understand what is happening with the facility.
- **Advocate –** expressing a concern, position, or solution and making certain others understand what the individual knows.
- **Take Initiative** – taking the initiative to influence the behavior of others, especially when it comes to the condition of the physical plant (facility).
- **Manage Conflict** – resolving differences of opinion and getting all information on the table to reach the best solution; maintaining open communication channels among team members.
- **Critique Performance** – learning from experience, identifying what works well, and pinpointing what areas need improvement.

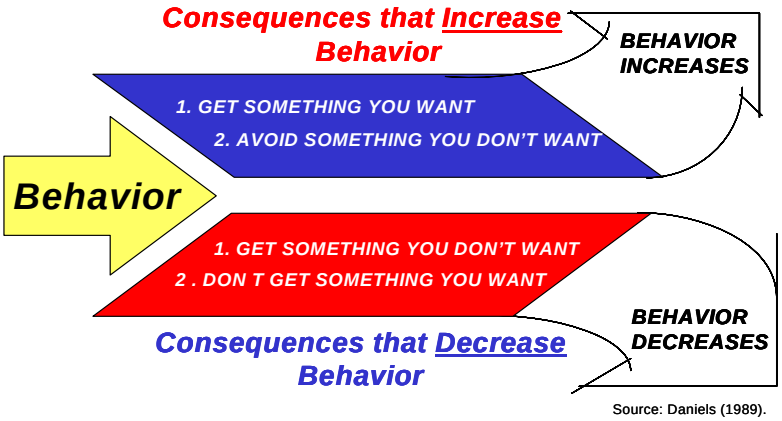
Reinforce Expectations

There is a direct cause-and-effect relationship between a manager's actions and an employee's behavior precisely because *behavior is motivated by its consequences***.**[18] Consequences, far more than training, directives, or threats, reinforce behavior. People tend to seek and do things they like and avoid things they do not like.[19] This is a fundamental principle of human behavior. If people are to make a habit of applying human performance tools, then positive consequences must be associated with their behaviors.

Managers and leaders need to positively reinforce individuals who obtain value-added results through safe behaviors. Individuals who cut corners to get jobs done on schedule and under budget at the expense of quality and safety should be corrected, coached, or, perhaps, counseled. Consequences either keep the behavior going or stop it in the long term. Leaders should take time to understand and learn how to use reinforcement to promote targeted behaviors.

All behavior that is occurring in the facility now is the result of consequences that are also occurring now. Similarly, the organization is perfectly attuned to get the performance it is

getting, right now. All behavior is reinforced. If at-risk behavior is common, it is because management has not made a difference with appropriate negative consequences. Behavior has four basic consequences.[20] The following model describes the effect consequences have on behavior.



The following consequences can be used to get the desired performance by targeting specific behaviors.

- **Positive Reinforcement – "**Get something you want" enhances the probability that the preferred behavior will recur and maximizes performance. This optimizes use of discretionary effort by the individual.
- **Negative Reinforcement –** "Avoid something you don't want" enhances the probability that the preferred behavior will recur, but only to meet the minimum standard.
- **Note**: Consequences that cause behavior to either increase or continue at a high standard are known as "reinforcers."
- **Punishment –** "Get something you don't want" reduces the probability that undesired behavior will recur if unwanted consequences are consistently coupled with the behavior. Punishment may also involve "losing something you don't want to lose"—a penalty. Sometimes this is necessary to get the new expectation started for an individual. However, it should not be used for the long term.
- **Extinction –** "Don't get something you want" reduces the probability that undesired behavior recurs, since nothing happens when that behavior occurs. Usually, the behavior eventually disappears after several repeated attempts.

Training, procedure direction, incentives, reminders from supervisors or peers, administrative policies, and expectations precede and set the stage for individual performance. These preexisting elements have more strength when they (a) specify the behavior, (b) specify whom, (c) occur at the right moment (just in time), and (d) imply the consequences.[21] The consequences in terms of reinforcers and incentives need to be determined for desired behavior. Expectations need positive reinforcers, while unacceptable behaviors need penalties—disincentives—or the elimination of positive reinforcers that motivate unsafe or at-risk practices. Any punishments or penalties existent in the system also need to be eliminated for expected practices. Positive reinforcers are more effective if they are *positive* for the individual, *immediate* with respect to

when the behavior occurs, and *certain*. Penalties are stronger if the consequence is negative, immediate, and certain for the individual concerned.[22]

Eliminate Latent Organizational Weaknesses

Organizational weaknesses show up as vulnerabilities, flaws, and defects in controls and controls (engineered, administrative, cultural, and oversight controls). Methodically searching for and eliminating latent organizational weaknesses eliminates factors that contribute to significant events. Chapter 3 describes several methods of finding latent organizational weaknesses, which are listed here below for reference:

- self assessments
- trending
- operating experience
- behavior observations
- problem (causal) analysis
- surveys and questionnaires
- corrective action program
- performance indicators
- benchmarking
- independent oversight
- problem reporting
- management oversight, involvement and reinforcement
- event investigation

The use of a systematic diagnostic approach for discovering recurring individual or work group performance problems provides another means of identifying organizational weaknesses. Managers and supervisors need a tool that helps them develop a clear understanding of a performance discrepancy and why it is happening. With the aid of the Behavior Engineering Model (BEM) discussed below, performance analysis helps define the performance gap by contrasting current performance with desired performance and systematically identifying the factors that contribute to the performance gap. Once valid reasons for the performance gap are understood, the manager or supervisor can develop more effective and efficient corrective actions. A sample *Performance Gap Analysis* form is provided in Appendix A to help in the analysis and solution to human performance problems. Starting with a known performance problem, the user(s) searches for answers to a series of questions that help in determining the performance discrepancy and selecting potential corrective actions.

- what is the performance problem?
- Is the problem worth solving?
- Is there clear direction to perform as desired?
- Are there appropriate consequences for performance (behavior)?
- Do the workers already know how? (Could they do it if their lives depended on it?)
- Are there other obstacles to desired performance?

Value the Prevention of Error

People's beliefs and attitudes toward hazards and error traps affect their adherence to high standards. If error-free performance (avoiding active errors) is **not** held up as an important value or is not expected for daily work; then people may adopt unsafe practices to get their work done; possibly placing themselves, others, or the facility at risk of an event. Consistently maintaining high standards communicates the value of error prevention. By clinging to high standards regardless of the perceived risk, adherence to expectations will become the norm.

Positive attitudes about error prevention depend greatly on what is rewarded and which behaviors are reinforced. It is easier to change behavior when positive attitudes exist. Positive values and attitudes follow behaviors that consistently result in success for the individual. It is not necessary for values and attitudes to precede behavior, but it is preferable.

The most effective way to communicate values is to act in accordance with them while reinforcing people when they apply them.[23] The following leader behaviors convey the values of the organization, in order of influence:[24]

- what managers pay attention to, measure, and control;
- reactions to an accident, event, or crisis;
- allocation of resources;
- deliberate attempts to coach or role model;
- criteria for allocation of rewards and punishment; and
- criteria for selection, advancement, and termination.

If those in positions of responsibility and influence react appropriately, with integrity, and consistent with stated values, people will adopt safe behaviors.

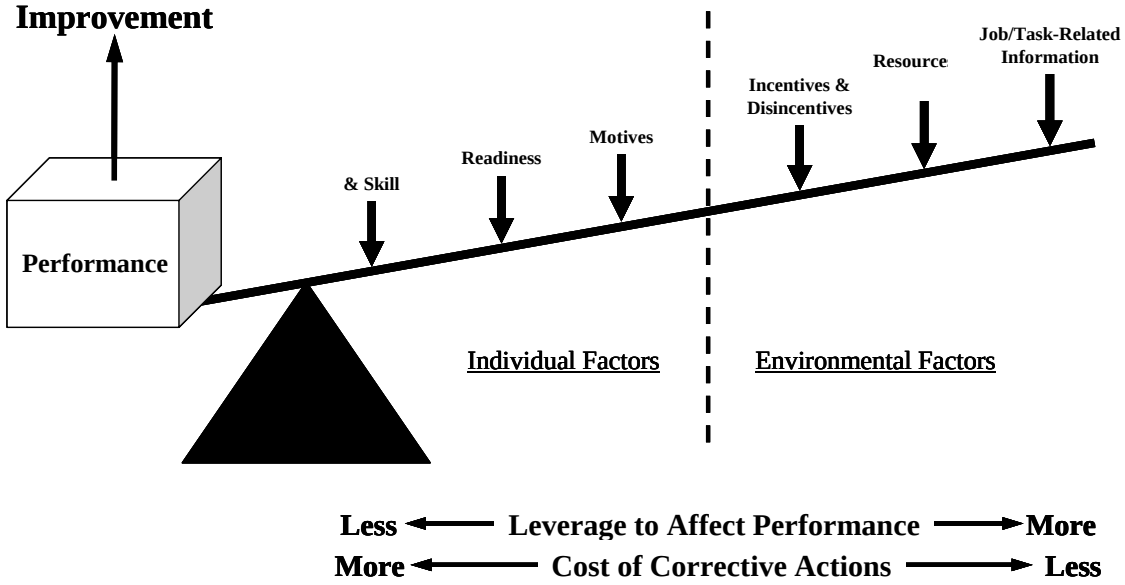
BEHAVIOR ENGINEERING MODEL (BEM)

The Behavior Engineering Model (BEM) is the original work of Tom Gilbert as described in his book *Human Competence, Engineering Worthy Performance* (1978). BEM is an organized structure for identifying potential factors that impact performance at the job site and for analyzing the organizational contributors to those factors. As previously stated, job-site conditions that affect behavior can be categorized into two types of variables: (1) the *environment* and (2) the *individual*. Environmental factors include conditions external to the individual; individual factors include internal conditions generally under the person's control. However, some aspects of human nature, such as stress, instinctive reflexes, and mental biases, are not always controllable.

The BEM specifies those factors relevant to the individual performer and the environment in which the person performs. The BEM illustrated in two tables on pages 4-15 through 4-18 is a derivation of Tom Gilbert's original work. In reference to headings on the BEM table, prior conditions that stimulate behavior—*direction to act*—include directives, knowledge, or cues that inform or prompt a person to act. Job-site conditions that set the occasion for behavior—

opportunity to act—include those factors that make action achievable or realizable. And conditions that tend to reinforce the act—*willingness to act*—are shaped by the match of the individual's motives with the incentives associated with the job or task. These categories attempt to describe the "stimulus-response" components of human behavior.[25]

Strategically, environmental factors provide the greatest leverage in terms of potential for improving human performance, shown below. Leverage and cost are important factors to consider when determining corrective actions. Think back to the *Anatomy of an Event*. It is estimated that 85 percent or more of the causes of facility events have their origins in the processes and culture of the organization. Changes in environmental factors offer greater impact at less expense on performance improvement than changes at the individual level.[26] For example, if the causes of a performance problem point to individual factors (motives, capacity/readiness, and knowledge and skills), implementation of corrective actions would have less immediate influence and the cost in generating the desired improvement will likely be greater.[27]



The BEM is illustrated in the following tables*[8]. The first describes those job-site conditions that are relevant to the performer's work environment, and the second describes conditions relevant to the individual. Deficiencies with the numbered items can create error-likely situations for the individual during the task at hand.

*[8] INPO has since further defined the BEM concept to more specifically apply to nuclear power plants. The new model is referred to as BEM-N for BEM-nuclear. INPO also credits the International Society for Performance Improvement (ISPI) for their contributions to that work. DOE also credits ISPI and makes note of the many historical and ongoing contributions of ISPI members to advancing the scholarship and practice in performance management.

	Direction to Act	Opportunity to Act	Willingness to Act
	Job or Task-Related Information (requirements / guidance on what one is supposed to do and how well)	**Resources and Environment** (external conditions affecting performance of the job or task)	**Incentives and Disincentives** (an environment of rewards and sanctions explicitly or implicitly associated with the job or task)
Environmental Factors	1. Job or task goals, desired results, roles and responsibilities, and criteria for success are clearly identified. 2. The risk importance of the job or task and critical steps, if any, have been denoted and communicated as such. 3. Clear expectations and standards for the conduct of work exist and have been communicated. 4. The usability, accuracy, and availability of procedures support error-free performance. 5. Relevant feedback on previous job or task performance, including opportunities for development, has been given to the individual (if applicable).	1. Tools, material, clothing, furniture, facilities, systems, and equipment accommodate human limitations and are available and accessible. 2. Other individuals or organizations are available for support, if needed. 3. Adequate time is allotted, and other work conditions that could hinder performance are eliminated or minimized. 4. The values, attitudes, and beliefs of the person's immediate work group about hazards in the workplace support safe practices.	1. Financial and non-financial rewards and disincentives are contingent on performance. 2. Competing incentives for poor performance are eliminated. 3. The job or task provides opportunities for success and career advancement, meets employee needs, and results in identifiable pieces of work traceable to the individual. 4. People are treated with honesty, fairness, and respect regardless of position in the organization. 5. Work group standards are consistent with the above.

	Direction to Act	Opportunity to Act	Willingness to Act
Environmental Factors	**Relevant Error Precursors**: • simultaneous, multiple tasks • repetitive actions; monotonous • irreversible actions • interpretation demands • unclear goals, roles, and responsibilities • lack of or unclear standards • confusing procedure or vague guidance • unclear strategic vision • meaningless rules • excessive communication requirements • delays or idle time • long-term monitoring	**Relevant Error Precursors**: • time pressure • distractions / interruptions • changes / departures from routine • confusing displays or controls • identical and adjacent displays or controls • workarounds • OOS$^{\phi}$ instrumentation or warning systems • hidden equipment response • unexpected equipment conditions • lack of alternative indication • complexity • unavailable tools, parts, etc. • high data flow • back shift / recent shift change • adverse physical climate / habitability • conflicting conventions; stereotypes • backshift; recent shift change • poor equipment layout / access • nuisance alarms • equipment sensitivity to vibration	**Relevant Error Precursors**: • high workload • fear of consequences of mistakes • production overemphasis • personality conflict • excessive time on task • repetitive actions / monotony • mistrust among coworkers / work groups • regular use of at-risk practices • excessive time on task • excessive group cohesiveness / peer pressure • no accounting of performance • acceptability of “cook-booking”

	Direction to Act	Opportunity to Act	Willingness to Act
	Knowledge and Skills (basic/specialized understanding of concepts, theories, system construction, fundamentals, and skills)	**Capacity and Readiness** (physical, mental, and emotional factors influencing individual's ability / capacity to perform a job or task)	**Personal Motives** (intrinsic & induced motivation related to an individual's needs for achievement, affiliation, security, and control)
Individual Factors	1. Individual is qualified for the job or task and possesses the knowledge, skills, experience, and proficiency necessary to perform the task successfully. 2. Individual understands the job or task objective(s), critical steps, and potential consequences if performed improperly. 3. Individual understands the roles and responsibilities of others.	1. Individual possesses the intelligence, sociability, aptitude, size, strength, and dexterity to perform the job or task successfully. 2. Individual is available for work, undistracted, and fit for duty.	1. Individual cares about performing the job or task well. 2. Individual possesses a healthy work ethic and is willing to do what is right regardless of what others would do. 3. Individual feels that the job or task is meaningful and attainable, progress is recognizable, and the task generates a personal sense of accomplishment.

	Direction to Act	Opportunity to Act	Willingness to Act
Individual Factors	**Relevant Error precursors**: • unfamiliarity with task • first time with task • new technique not used before • lack of proficiency • lack of experience • imprecise communication habits • indistinct problem-solving skills • unaware of critical parameters • tunnel vision (lack of big picture)	**Relevant Error precursors**: • stress • habit patterns • assumptions • complacency or overconfidence • mind set • Pollyanna risk perception • mental shortcuts (biases) • limited short-term memory; attention span • limited perspective (bounded rationality) • illness or fatigue • anxiety • poor teamwork skills • major life event • sugar cycle (after a meal) • poor manual dexterity • low self-esteem; moody • physical reflex or imprecise physical action • physical size too large or small for task • human variability • spatial disorientation	**Relevant Error precursors:** • production, "get-r-done" mindset • willingness to sidestep the rules for personal gain • "unsafe" attitude toward critical steps • questionable ethics • boredom • fear of failure / consequences • excessive professional courtesy • excessive group cohesiveness • social deference • no sense of control / learned helplessness • avoidance of mental strain

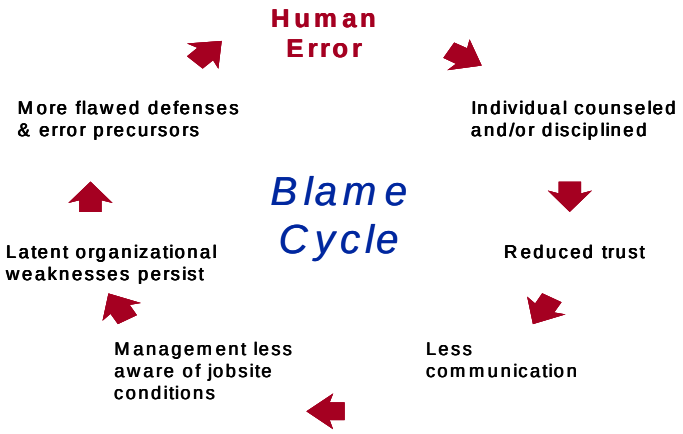
The BEM can serve as an analysis tool for evaluating human error and related performance problems, providing a framework for exposing the real root causes that originate within the organization.

The BEM contains many of the factors—good and bad—that influence human performance, including *error precursors*. The BEM is included here to show that error precursors, like other job-site conditions, are the result of organizational processes and values. In each case, one or more aspects of the organization that establish a job-site condition or error precursor can be identified. For instance, an individual's level of knowledge is likely an outcome of the organization's training program, or the human resources selection process may have overlooked required abilities necessary for the task at hand.[28]

CREATE A JUST CULTURE

The Blame Cycle

The "blame cycle" depicted below is urged on by the belief that human error occurs because people are not properly motivated.[29] In reality, no matter how motivated an individual is, active errors will continue to occur, occasionally. Events will continue as long as event investigations stop prematurely at the active human error. The true causes (typically organizational weaknesses) will not be discovered—will remain latent or hidden—and errors and events will persist.



Categories of Violations

It is important to recognize that there are at least two major categories of violations—*routine and thrill-seeking or optimizing*. Routine violations typically involve corner-cutting at the skill-based level of performance by taking the path of least effort between two task-related points. These shortcuts can become a habitual part of a person's behavior, particularly when the work environment is one that rarely sanctions violations or rewards compliance. Routine violations are also prompted by "clumsy" procedures that direct actions along what seems to be a longer-than-necessary pathway.[30] Routine violations are not necessarily reckless. Routine violations often look like latent weaknesses.

Thrill-seeking or optimizing violations are violations "for the thrill of it." Thrill-seeking violations reflect that human actions serve a variety of motivational goals and that some of these are quite unrelated to the functional aspects of the task. These violations are committed to appear macho, to avoid boredom, or simply for kicks. This category of violation is reckless.

In some organizations employees are named, blamed, shamed, and re-trained based on the consequence of their action, not the intent of the action. If either the violation or error they committed caused an accident or an event of some kind, they are disciplined, but the very same actions (both violations and errors) without a consequence, are ignored or allowed to slide. In some organizations people are allowed to commit violations right along until there is an event, then all hell breaks loose. What this means is that someone who inadvertently errs is held

accountable for their actions in the same fashion that someone who intentionally performs work he or she knows is contrary to known standards.

A just environment is all about getting the balance right between how willful violations and unintentional errors are addressed in the organization. All too often organizations do not make clear the distinctions between errors and violations. A just organization clears the smoke in the air between erring and violating. To do so, management sets a zero tolerance policy for reckless conduct—bad acts that we call violations. Zero tolerance for violations is balanced by the belief and the widespread confidence among the leadership that the vast majority of unintended unsafe acts will go unpunished as honest errors—unintended departures from expected behavior—on the part of the performer. There are proven methods to help organizations determine culpability for serious incidences in which unsafe acts are involved.

The Foresight Test

The question to ask is: "Did the individual knowingly engage in behavior that the average individual in the work group would recognize as being likely to increase the probability of making a safety-critical error?" If the individual's peers respond that they would have recognized the action as promoting an error, then it is likely the individual in question should also have recognized the same thing. If the peers failed to see the connection between the action taken and increased risk, then it is reasonable to assume that the individual also did not see the connection. In any one of the following situations, however, the answer to this question is likely "yes" and as such is indicative of culpability:

- performing work under the influence of a drug or substance known to impair performance;
- clowning around while driving a towing vehicle or forklift truck or while handling other potentially damaging equipment;
- taking unwarranted shortcuts like signing off on jobs before they are completed; and
- using tools, equipment, or parts known to be sub=standard or inappropriate.[31]

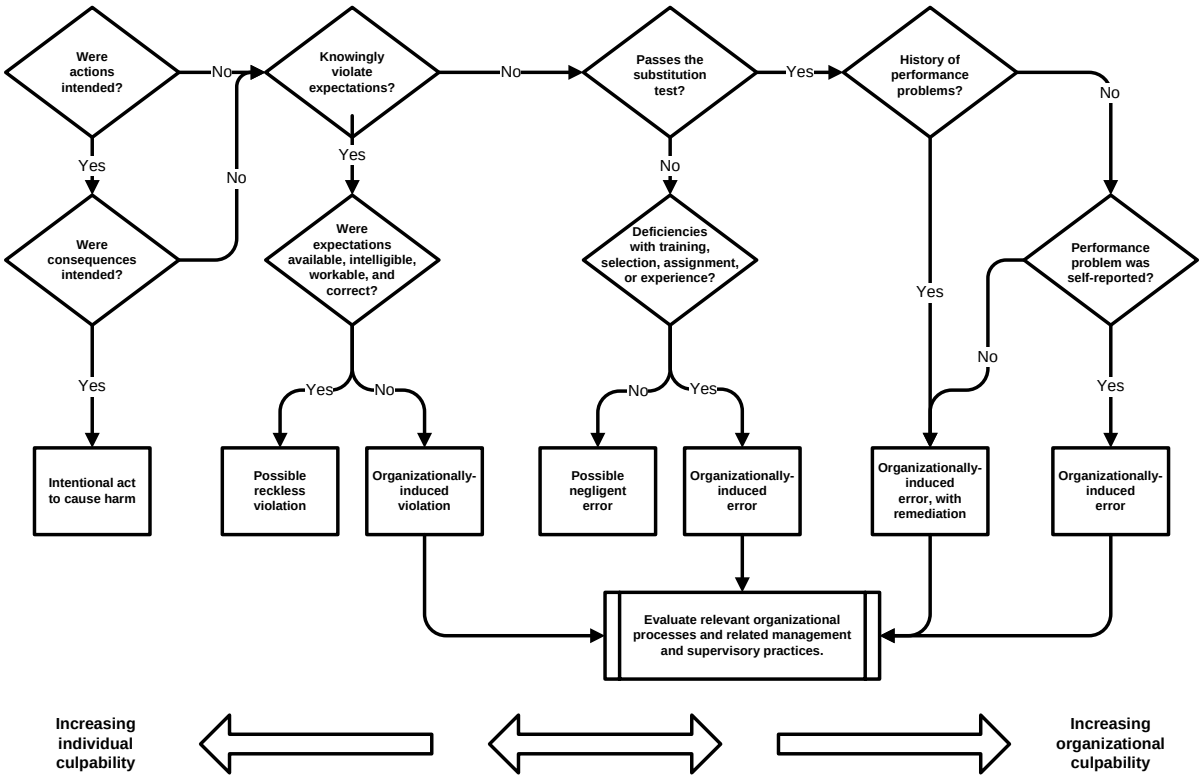
Keep in mind the Foresight Test is a "rule of thumb" measure. There will likely also be extenuating circumstances associated with any of these situations.

The Substitution Test

This test is in keeping with the principle that the best people can make the worst errors. This exercise involves substituting the individual concerned in the event with other individuals who do the same kind of work and who have comparable training and experience. Then the question is asked: "In light of how events unfolded and were perceived by those involved in real time, is it likely a different person with similar skills and training would have behaved any differently?" If the answer repeatedly comes back from the selected peers, "probably not," then apportioning blame has no place here and would likely obscure the underlying systemic deficiencies. Another way to use the substitution test is to ask the question in a different way of a small number of the erring individual's work mates: "Given the circumstances that prevailed at the time, could you be sure that you would not have committed the same or a similar type of unsafe act?" If the response is "probably not," then blame is very likely to be inappropriate. It is a "blameless" error."[32] The substitution test is often used in conjunction with the Culpability Decision Tree, which is discussed below.

The Culpability Decision Tree

The logic diagram below is a proven management tool intended to help determine the culpability level of an individual in response to events or near misses triggered by human error.[33] When used in conjunction with the organization's accountability policy, the tool supports the fair and consistent application of disciplinary outcomes across all departments and work groups. An explanation of how to make use of the Culpability Decision Tree is provided in Appendix B. The tool is an adaptation of Dr. James Reason's Culpability Decision Tree in his book, *Managing the Risks of Organizational Accidents*, which provides further in-depth description of the use of the diagram.



When an event is initiated by an *honest* error, as determined by one or more of the tools described above, the entire system that supports the performance in question should be evaluated (see "systems-thinking" in Chapter 3). Events triggered by human error are often symptomatic of a *system failure*. Instead of asking how the individual failed the organization, the question "how did the organization fail the individual?" would be more appropriate. In addition to the individual, what or who could have *prevented* the event? What flaws or oversights in work processes, policies, or procedures contributed, promoted, or allowed the error and event to occur? Because the majority of the causes of events originate in the system of controls, processes, and values established by the management team, management's first reaction to events should be to look within the organization.

A just culture is a prerequisite for a reporting culture. Useful tips for establishing a reporting culture appear in Appendix C.

ATTACHMENT A – PERFORMANCE GAP ANALYSIS♠

What is the performance problem?	a. What is currently happening?	
	b. What should be happening (desired performance)?	
Is the problem worth solving?	a. Does the problem affect plant performance or personnel safety?	Yes ☐ No ☐
	b. What is the potential cost or consequence of doing nothing?	Yes ☐ No ☐
1. Is there clear direction to perform as desired?	a. Are expectations, standards, priorities, roles, and responsibilities clear and understood by the performer(s)?	Yes ☐ No ☐
	b. Are resources, tools, equipment, and other assistance available and adequate?	Yes ☐ No ☐
	c. Are work documents accurate, do they contain sufficient detail, and are they usable for the performer(s)?	Yes ☐ No ☐
	d. Does the individual(s) get visible, objective feedback on the quality of work?	Yes ☐ No ☐
	e. Is the risk significance of the job/task clearly stated?	Yes ☐ No ☐
	f. Are there conflicts in direction and standards (between procedures, supervisors and managers, departments, and so forth)?	Yes ☐ No ☐
2. Are there appropriate consequences for performance (behavior)?	a. Is the desired performance punishing to the performer (more work, delays, anxiety, ridicule, fatigue, and so forth)?	Yes ☐ No ☐
	b. Is current performance rewarding to the performer?	Yes ☐ No ☐
	c. Does the performer experience positive consequences for good performance? (If yes, are they immediate and certain?)	Yes ☐ No ☐

3. Do they already know how? (Could they do it if their lives depended on it?)	a. Is the performer(s) qualified and has he/she done it properly before? (If yes, knowledge and skills are probably satisfactory.)	Yes ☐ No ☐
	b. Are the tasks performed often enough to maintain proficiency? (If yes, see 3.D. If no, then provide opportunities to practice.)	Yes ☐ No ☐
4. Are there other obstacles to desired performance?	a. Are there personal problems beyond the performer's control that hinder desired performance (such as FFD, medical, family issues, physical limitations)?	Yes ☐ No ☐
	b. Are ergonomic challenges present in the workplace for example, workarounds and problems with labeling, habitability, equipment accessibility, clothing, PPE, and human-machine interface)?	Yes ☐ No ☐
	d. Are there inappropriate distractions or interruptions in the workplace?	Yes ☐ No ☐
	e. Is the task or process too complex?	Yes ☐ No ☐
	f. Are there obstacles to communication between the performer(s) and supervision?	Yes ☐ No ☐
	g. Are job/task performance requirements beyond the performer's capabilities (such as fatigue, sleep decrement, strength, dexterity, and color blindness)?	Yes ☐ No ☐
	h. Does desired performance matter to the performer(s) (for example, unsafe attitudes, morale, work ethic, self-esteem, and peer pressure)?	Yes ☐ No ☐
5. Identify valid reasons for performance discrepancy.	Reasons:	
6. Select potential corrective actions.	Solutions:	

ATTACHMENT B – CULPABILITY DECISION TREE

Start with the assumption that the actions under scrutiny have contributed either to an accident or to a serious near-miss in which a bad outcome was only just averted. In an organizational accident, there are likely to be a number of different unsafe acts. The decision tree should be applied separately to each of them. The concern here is with individual unsafe acts committed by either a single person or by different people at various points in the accident sequence. Because of the subjectivity of the questions the Decision Tree should be used by a small team or committee vise a single manager or supervisor.

The questions of the inquiry relate primarily to intention. Unintended actions define slips and lapses, in general, the least blameworthy of errors. Unintended consequences cover mistakes and violations. The decision tree usually treats the various error types in the same way, except with regard to the violations question.

Start at the top left box on the logic diagram. The numbers below relate to the boxes left to right

Were the actions as intended? The key questions relate primarily to intention. If both the actions and the consequences were intended, then we are likely to be in the realm of criminal behavior, which is probably beyond the scope of the organization to deal with internally. Unintended actions define slips and lapses—in general, the least blameworthy of errors—while unintended consequences cover mistakes and violations.

1. **Knowingly violating expectations?** If the individual was knowingly engaged in violating expectations at that time, then the resulting error is more culpable since it should have been realized that violating increases both the likelihood of making an error and the chances of bad consequences resulting. Violations involve a conscious decision on the part of the perpetrator to break or bend the rules (except when noncompliance has become a largely automatic way of working). Although the actions may be deliberate, the possible bad consequences are not—in contrast to sabotage in which both the act and the consequences are intended. Most violations will be non-malevolent in terms of intent; therefore, the degree to which they are blameworthy will depend largely on the quality and availability of the relevant procedures.

   Procedures are not always appropriate for the particular situation. Where this is judged to be the case (perhaps by a "jury'" of the perpetrator's peers), the problem lies more with the system than with the individual. But, when good procedures are readily accessible but deliberately violated, the question then arises as to whether the behavior was reckless in the legal sense of the term. Such actions are clearly more culpable than "necessary" violations—the non-compliant actions necessary to get the job done when the relevant procedures are wrong or inappropriate or unworkable.[34]

2. **Passes the substitution test?** The "substitution test," or something similar, is used to help in judging the culpability of organizationally induced violations. Could some well-motivated, equally competent, and similarly qualified individual make the same kind of error under those or very similar circumstances? If the answer provided by a jury of peers is "yes," then the error is probably blameless. If the answer is "no," then we have to consider whether there were any system-induced deficiencies in the person's training,

selection, or experience. If such latent conditions are not identified, then the possibility of a negligent error has to be considered. If they are found, it is likely that the unsafe act was a largely blameless system-induced error.

3. **History of performance problems?** Keep in mind that people vary widely and consistently in their liability to everyday slips and lapses. Some individuals, for example, are considerably more absentminded than others. If the person in question has a previous history of unsafe acts, it does not necessarily bear upon the culpability of the error committed on this particular occasion, but it does indicate the necessity for corrective training or even career counseling along the lines of "Don't you think you would be doing everyone a favor if you considered taking on some other job within the company?" Although absentmindedness has nothing at all to do with ability or intelligence, it is not a desirable trait in a pilot, a control room operator, a physician, or the like.

The line between acceptable and unacceptable behavior is more clear when the logic diagram is used. An intentional act to cause harm (lower left) is wholly unacceptable and should receive very severe sanctions, possibly administered by the courts rather than the organization. Knowingly violating expectations that were workable likely suggests reckless violation, a condition that warrants sanctions. The remaining categories should be thought of as blameless—unless they involve aggravating factors not considered here. Experience suggests that the majority of unsafe acts—perhaps 90 percent or more—fall into the blameless category.[35]

ATTACHMENT C – Establishing a Reporting Culture

It cannot be assumed that once a just environment is in place workers will naturally begin to report problems, errors and near misses. There are a number of organizational, as well as psychological, barriers that must be hurdled before a reporting culture can be put in place. The first barrier to overcome is a natural disinclination to confess one's blunders—no one wants to be held up to ridicule. The second barrier is the suspicion that such reports might go on the record and count against them in the future. The third is skepticism. People reason that if they go to the trouble of writing an event report that reveals system weaknesses, how will they be sure that management will act to improve matters? Fourth, actually writing the report takes time and effort, and many people conclude, "why bother?".

Following are some features of successful reporting programs. Each feature is designed to overcome one or more of the barriers noted above.

- *De-identification.* How this is achieved depends on the culture of the organization. In some organizations there is complete anonymity. Elsewhere organizations are content with confidentiality, wherein the person reporting is known only to a very few people.

- *Protection.* A very senior manager issues a statement guaranteeing that anyone who reports will receive at least partial indemnity against disciplinary procedures. Because some acts are culpable, it is not feasible to offer complete immunity from sanctions. Experience from successful programs indicates that circumscribed guarantees are sufficient to elicit large number of reports of honest errors.

- *Separation of functions.* Successful programs organizationally separate the functions of collecting and analyzing the reports from the authority to initiate disciplinary proceedings.

- *Feedback.* Rapid, useful, accessible, and intelligible feedback to the reporting community is essential to overcome any perception that reports were going into a black hole. This may be achieved by publishing summary reports of the issues raised and the measures that have been implemented.

- *Ease of making the report.* Experience shows that people prefer responding to a reporting style that allows them to tell a story and express their own perceptions and judgments, as opposed to having to force-fit responses into a highly structured pre-programmed format. [36]

The greatest value of a safety information system lies in its ability to identify recurrent event patterns, error traps, and gaps or weaknesses in the controls. Reporting systems are usually coupled with corrective action programs wherein identified problems in the field are researched and plans are devised and actions carried out to eliminate the problem and prevent recurrence. A primary objective of acquiring this safety information is to help the organization (workers, leaders, and management) learn from past near misses, mistakes, and inconsequential errors.

This page is intentionally blank.

REFERENCES

[1] Schein. "Taking Culture Seriously in Organization Development: A New Role for OD?" MIT Sloan working paper # 4287-03. 2003; pp. 2-3.

[2] Schein. *Organizational Culture and Leadership*, 2004, pp. 7-16. The model is from www.onepine.info/pschein.htm. Title "People Whose Ideas Influence Organizational Work--Edgar Schein."

[3] Schein. Organizational Culture and Leadership, 2004, pp. 17.

[4] Packer. "Safety Culture." Presentation at the Canadian Aviation Safety Seminar, April 2006. The author used the Chernobyl accident as a classic case of operators acting and behaving from the assumption their plant was robust. If not so, they would not have bypassed all the interlocks and ignored alarms as the reactor was moving towards disaster.

[5] Dr.Wert is President of Management Diagnostics Inc., a consultant to the Nuclear Industry, and an author.

[6] Reason. Managing the Risks of Organizational Accident, 1997, pp. 113-114.

[7] Senge. The Fifth Discipline, 1990, pp 223-225.

[8] Adapted from a quote by Dr. Erik Hollnagel, Professor of Psychology at CSELAB, Department of Computer and Information Science, University of Linköping, Sweden, during his presentation, "Understanding Accidents," at the 2002 IEEE Seventh Conference on Human Factors and Power Plants in Scottsdale, Arizona.

[9] Westrum. "A Typology of Organizational Cultures," *Quality and Safety in Health Care*, 2004:13, pp 22-27.

[10] INPO. Principles for a Strong Nuclear Safety Culture. November 2004, pp. iii-iv.

[11] Ramsey and Modarres. Commercial Nuclear Power, Assuring Safety for the Future. 1998, pp.220-221.

[12] Helmreich and Merritt. *Culture at Work in Aviation and Medicine*. 1998; p.133-139.

[13] Kotter. *Leading Change*. 1996, pp.25-30.

[14] INPO. Excellence in Human Performance. 199, pp. 13-19.

[15] INPO. Excellence in Human Performance. 1997, p. 3.

[16] Pool. "When Failure is Not an Option," *Technology Review Magazine*, July 1997. p. 45.

[17] Helmreich, Merritt, and Wilhelm. "The Evolution of Crew Resource Management Training in Commercial Aviation," *International Journal of Aviation Psychology*, 1999:1, pp 19-32.

[18] Fournies. Why Employees Don't Do What They're Supposed to Do, and What to Do About It, 1999, p. xv.

[19] Daniels. Bringing Out the Best in People, 1994, p. 25.

[20] Daniels. *Performance Management*, 1989, p. 29.

[21] Geller. *The Psychology of Safety*, 1998, p. 133.

[22] Daniels. Bringing Out the Best in People, 1994, pp. 65-66.

[23] Larkin and Larkin. "Reaching and Changing Frontline Employees," *Harvard Business Review on Effective Communication*, 1999, p. 147.

[24] Schein. Organizational Culture and Leadership, 1992, p .231.

[25] Gilbert. *Human Competence, Engineering Worthy Performance*, 1996, pp. 82-85. Reprinted with permission of the International Society for Performance Improvement, www.ispi.org.

[26] Rummler and Brache. *Improving Performance*, 1995.

[27] INPO 06-003. Human Performance Reference Manual, 2006, p. 92.

[28] INPO 06-003. *Human Performance Reference Manual*, 2006, pp. 91-94.

[29] Reason. Managing the Risks of Organizational Accidents, 1998, pp. 127-129.

[30] Reason. Managing the Risks of Organizational Accidents, 1998, pp. 72-73.

[31] Reason and Hobbs. *Managing Maintenance Error*, 2003, p. 150.

[32] Substitution Test is the work of Neil Johnston, "Do Blame and Punishment have a Role in Organizational Risk Management?," *Flight Deck*, spring 1995, pp. 33-36, referenced in Reason, *Managing the Risks of Organizational Accidents*, 1998, p. 208, 222.

[33] Reason. Managing the Risks of Organizational Accidents, 1998, pp.208-212.

♠ Adapted with permission from *Analyzing Performance Problems*, by Dr. Robert F. Mager and Peter Pipe © 1997, p. 5. The Center for Effective Performance, Inc., 1100 Johnson Ferry Road, Suite 150, Atlanta, GA 30342. www.cepworldwide.com;800-558-4237.

[34] Reason. Managing the Risks of Organizational Accidents, 1998, p. 210

[35] Reason. Managing the Risks of Organizational Accidents, 1998, pp. 207-211.

[36] Reason. *Managing Maintenance Error*, 2003, pp. 151-152.

CHAPTER 5 - HUMAN PERFORMANCE EVOLUTION

INTRODUCTION

The contents of this chapter provides background information on the examples of key research and concepts that have influenced the HPI approach discussed in this handbook. As one would expect, it is within the organization that performance improvement has evolved over time. The reader is introduced here to several significant influences and forces that have helped shape organizations' thinking about human performance and how organizations adjusted their approach to doing business in order to improve the way people work. Improving performance has been a linchpin not only for increasing efficiency, augmenting quality and meeting productivity expectations, but also for reducing human error and eliminating unwanted events. The lessons learned from failures in safety at Bhopal, Chernobyl, Challenger, Exxon Valdez, Three-Mile Island and elsewhere have given rise to new ways of thinking about the organization and its role in creating and sustaining a safety climate. The objective of this chapter is to illustrate how the organizational forces that evolved over time contributed to the development of human performance improvement as described in this handbook and promoted within DOE through training interventions in recent years. HPI builds upon these historical approaches to improve performance. The DOE/INPO HPI approach is one example of how improvement may be achieved.

A Perspective on Organizations

Organizations are ubiquitous across the landscape today in America. There are international, national, regional, state, and local organizations. There are business and industry organizations; social, political, economic, and professional organizations; as well as religious, health, academic, athletic, and scientific organizations, among many others. People in all walks of life assess their personal sense of worth, and that of their friends and acquaintances, in part based on the organizations they belong to or have been a member of in the past. People are greatly influenced by their association within an organization over time. This influence extends far beyond the stereotypical mental models we have of professional military people, retired policemen, or college professors. People everywhere are shaped and molded by their experiences within organizations—especially by the organizations in which they work day in and day out.

Organizations are so pervasive in American society that the paradigm shift for the reader from independent human agent to organizational human agent happens at nearly light speed.[1] Yet, this transformation of society [into organizations] has occurred slowly over time as a ". . . *revolution for which no flags were raised. It transformed our lives during those very decades in which, unmindful of what was happening, Americans . . . debated instead such issues as socialism, populism, free silver, clericalism, and colonialism.*"[2] As large employing organizations began to dominate society in the early 20th century, additional organizations arose to minimize the "frictions" of huge organizations working and colliding with one another. Government bureaucracies developed to regulate industries and labor organizations and to rein in profit-focused capitalist bureaucracies, and communities organized to provide social services once provided by industrial organizations.

During the so-called Progressive era (1900-1920), labor activists tied worker safety to larger social issues of safe housing, child labor, and minimum living wages. Concerned that reform activities might radically impact their profits, corporations reacted by adopting safety campaigns that emphasized the responsibility of the workers themselves, rather than that of industry, to prevent accidents. This effort to blame workers for their accidents was based perhaps on societal reactions to the large number of immigrants in that era. While progressives blamed industrial organizations for the large number of injuries and deaths, industrial organizations shifted the blame to the workers themselves.

Those who manage organizations, who make the decisions and set the standards for safety, are often removed in time and distance from the consequences of their actions. The workers within the organization suffer the consequences of decisions made and may be blamed for causing events. In many organizations individuals are held responsible for the outcome of organizational decisions. Morton Thiokol engineers accurately predicted that the Challenger space shuttle's solid rocket boosters were not designed for cold weather launches and voiced their concerns to management. As one of the engineers explained in an article after the 1986 Challenger accident: "*It is no longer the individual that is the locus of power and responsibility, but public and private institution. Thus, it would seem, it is no longer the character and virtues of individuals that determine the standards of moral conduct, it is the policies and structures of the institutional settings within which they live and work*".[3]

FACTORS THAT IMPACT ORGANIZATIONS

Production

Organizations flourish or fail primarily for two reasons—quality and safety—that is, their ability or inability to compete in the marketplace or their ability or inability to avoid major events. U.S. corporations demonstrated excellent capacity to produce gargantuan quantities of tanks, artillery, planes, landing craft, surface ships, and submarines, as well as rifles, machine guns, clothing, and so on, in support of the nation's challenge to wage war both in Europe and in the Pacific during World War II. Wartime production schedules in defense facilities everywhere called for all out capacity to support the millions of men and women in uniform on the battlefields, in the air and on the seas, and in support capacities. Factories operated around the clock. Millions of women took jobs in the defense industry. Car manufacturers halted auto production and began building jeeps, trucks, tanks and landing craft, and even airplanes. Henry J. Kaiser, a road and dam builder, who had never built a ship, contracted with the government to build ships in California. The Kaiser shipyards constructed over 1,400 ships, one a day, during the war. America's ability to out-produce its enemies in war machinery, weaponry, and munitions is one of the lasting legacies of the global conflagration of the 1940s.

The war had brought the United States out of the depression. The victories in Europe and Japan brought millions of military people back home into civilian life. Marriages surged, igniting the post-war "baby boom." The enormous demand for housing and household appliances and convenience items spurred production. The automobile industry that had been non-existent during the war, soon became the manufacturing giant in the country. Consumers' infatuation with, and demand for, automobiles further stoked post-war industry. Demand for increased electrical power and for better highways led to massive hydro-electric projects and the building

of the interstate freeways. The seemingly endless capacity to produce characterized American corporations for the next two generations. Management's general view of itself and the workers during the production heyday was that they (managers) provided the head (thinking) and the workers provided the back, the hands, and the feet (brawn).

Quality Management

In the post-war world, Japan and Germany as well as other nations retooled for peacetime production with financial aid from the United States. In parallel, the world population expanded and the demand for goods and services exploded. Within a generation, the United States found itself competing with overseas rivals who could produce automobiles, machinery, radios and televisions, and hundreds of household convenience items cheaper, faster, and of equal or better quality. The Japanese had learned and applied quality control methods from American industrial engineers and statisticians, Joseph Juran, and William Edwards Deming.[4]

Defect Prevention The quality control techniques, actually formulated before the war by Juran and Deming, targeted manufacturing organizations. Central to their work was improving the control of production processes in order to reduce the number of defective parts, improve productivity and lower costs. This change in emphasis, from inspection to prevention, was quite revolutionary. It was achieved by using sampling methods to monitor processes and keep them under control. From this beginning, techniques and methodologies for process control were developed, including the philosophy that quality should be the responsibility of everyone in the organization. The process improvement ideas applied first to manufacturing were expanded to administrative functions and service industries so that the quality concept affected the whole organization. Japanese industry succeeded in taking over many markets. Corporations were able to drive down their costs while at the same time improve the quality of their products.

Quality is Everyone's Business The quality improvement movement in the private sector in this country in the late 1970s and 1980s emerged as a self-preservation initiative to reduce waste, cut costs, and improve product quality in order to compete.[5] Organizations had caught on to the idea that quality had to be built into the product, and not inspected, to be successful. Management's view of the workers as doers changed during this time. It became increasingly obvious that workers had to be included in plans to improve production processes. Numerous corporations adopted *Quality Circles* or similar programs rooted in employee participation. Small employee groups identified weaknesses in work processes, measured impacts, formulated root causes for the problems and weaknesses, and recommended to management ways and means of strengthening existing processes. Increased employee involvement in process improvement initiatives softened the earlier rancor and discord between management and workers. As the changes in processes resulted in improved products and a stronger competitive edge in the market, management's appreciation for the contribution of workers improved. Workers' seemed more willing to put more of themselves into the organization.

Customer Focus Quality is characterized as meeting or exceeding the needs and expectations of the customer. Thus, the goal of a business should be to find out what the customer wants and then fine-tune the process to ensure that they get it. The term "customer" is used to include internal customers as well as external customers. Thus, every work group has a customer—the person who receives their output.

Continuous Process Improvement Most people tend to think of their own work in terms of a task carried out in relative isolation from other work in the organization. The first step in quality improvement is for people to reorder their thinking about the work they do, to look at their work in terms of being part of a continuous process. A process is simply a sequence of tasks, which together produce a product or service. When all the steps in the process are flow-charted, it is easier to visualize one's own work in terms of being a step in a process. Every work group has a supplier and a customer. People take the output from another work group, do work that adds value, and then pass it on to another work group. The capability to achieve quality work is only as good as the weakest link in the process.

Continuous improvement processes are driven from the top, but implemented from the bottom. The selection of improvement projects needs a sharp focus. The problem areas must be prioritized; critical processes must be selected for improvement; and improvement goals must be set for the project team. This is a top-down process. The problem-solving and implementation is done by teams that include staff at the working level. This is a bottom-up process that requires the involvement and commitment of the staff. The slogan that "quality is everyone's business" drives home the idea that all employees—everyone from the mail room to the board room—play a role in improving quality. Employees are encouraged to report conditions adverse to quality, and they are encouraged to take part in quality improvement teams.

The blend of quality management techniques and philosophies noted above is generally referred to as Total Quality Management. Total Quality Management transformed into today's Six Sigma programs. Implementing quality improvement programs in the United States revitalized the automobile industry, telecommunications, and numerous other industrial and commercial enterprises. The quality improvement movement caught on in government agencies and among their primary contractors, including managing and operating contractors within DOE.[6] Quality management has had a notable and lasting imprint on organizations. Improving processes reduces waste and rework time; it raises product quality while reducing costs and stimulating productivity. The bottom line is that organizations become more cost effective. Workers' participation in problem solving and decision-making, while working in quality improvement teams, strongly influences how people think of themselves in the organization and how management views them. Workers have learned that the organization needs their brainpower as well as their brawn. Management learned that the people closest to the process know best how to improve the process when given a chance to participate in how work is accomplished. This teaming together of management and workers to improve organizational processes spilled over into the safety arena as we shall see.

Human Factors and Ergonomics

Human factors is the name of an engineering profession that focuses on how people interact with tasks, machines or computers, and the environment, with the consideration that humans have limitations and capabilities. Often, human factors will study the human within the system to ensure that we understand the limitations of the human within the current structure, product, or process. Human factors engineers will evaluate human-to-human, human-to-group, or human-to-organization interactions to better understand the phenomena associated with these interactions and to develop a framework for evaluation. Simply put, human factors involves working to make the environment function in a way that seems natural to people and attempts to

optimize tasks, the machine design, and the environment. Under the banner of safety, the purpose of human factors research and practice is to maximize the safety and "healthiness" of work environments and work practices and to ensure the usability of tools, devices, and artifacts in general. A priority in human factors is consideration of users' physical, behavioral, and information-processing characteristics and requirements. Experience has shown that failure to deal with such characteristics can lead to wasted functionality, user frustration, inefficient practices, discomfort, and error-prone activity.

In the end, human factors are concerned with providing a good "fit" between people and their work or leisure environments. "Fit" might be the literal word, as with the design of ejector seats for aircraft (ejector seats designed for average size), or might be more metaphorical (designing to complement task activities, such as a specifically designed kitchen). Notably, the fit can be made in either direction. We can fit the environment to the person (by providing adjustable ejector seats to accommodate a range of heights, weights) or we can fit the person to the environment (providing extensive training or using people of a certain build)

Although the terms "human factors" and "ergonomics"—the science of making design account for human characteristics—have only been widely known in recent times, the fields' origins are in the design and use of aircraft during World War II to improve aviation safety. The war marked the development of new and complex machines and weaponry, and these made new demands on operators' cognition. The decision-making, attention, situational awareness, and hand-eye coordination of the machine's operator became key in the success or failure of a task. It was observed that fully functional aircraft, flown by the best-trained pilots, still crashed. In 1943, Alphonse Chapanis, a lieutenant in the U.S. Army, showed that this so-called "pilot error" could be greatly reduced when more logical and differentiable controls replaced confusing designs in airplane cockpits. Chapanis, a founding father of ergonomics, also pioneered the design of the standard telephone touchpad, teleconferencing, safety labels, night vision, digitized speech, and human-computer interaction.

Paul Fitts was an American Air Force Colonel who also examined the man-machine interface in aviation. He studied pilot accident records, digging through 460 cases of what were labeled as "pilot errors" in 1947. He found that a large part of the cases consisted of pilots confusing the flap and gear handles. Typically, a pilot would land and then raise the gear instead of the flaps, causing the airplane to collapse onto the ground and leaving it with considerable damage. Fitts' examined the hardware in the average cockpit to find that the controls for gear and flaps were often placed next to one another. They looked the same, felt the same, and, which one was on which side was not standardized across cockpits. This was an error trap waiting to happen. In other words, confusing the two handles was not incomprehensible or random, it was systematic; connected clearly to features of the cockpit layout.[7]

Areas of interest for human factors practitioners may include: training, learnability, staffing evaluation, communication, task analyses, functional requirements analyses and allocation, procedures and procedure use, organizational culture, human-machine interaction, workload on the human, fatigue, stress, shift work, safety, user interface, attention, vigilance, decision-making, human performance, human reliability, human differences, human-computer interaction, control and display design, visualization of data, and work in extreme environments, among others.

In the decades since the war, ergonomics has continued to flourish and diversify. The Space Age created new human factors issues such as weightlessness and extreme g-forces. How far could environments in space be tolerated, and what effects would they have on the mind and the body? The Information Age has resulted in the new ergonomics field of human-computer interaction. Further, the growing demand for and competition among consumer goods and electronics has resulted in more companies including human factors in product design

The contributions made by human factors and ergonomic engineers are numerous and have benefited organizations in many ways. The listing here is a small representative sample.

- Improving the design of control panel boards, instrument boards etc. by clearly and uniquely distinguishing buttons, switches, warning alarms, instrument indicators and so on, by the use of color, shape, size, position, labeling, and proximity to reduce the probability of operator error.
- Improving the design of equipment and components taking into consideration the tasks that will be required to maintain the equipment. This includes easy access to components, grouping together components that are functionally related, clear labeling, minimal use of special tools, reduction (if not elimination) of delicate adjustments in the field, and equipment design that facilitates fault isolation
- Providing research on human behavior and performance in which workers are exposed to prolonged overtime that causes excessive fatigue; adverse working conditions, such as interruptions, distractions caused by abnormal noise, adverse environmental conditions and numerous other circumstances that negatively impact worker attention; and the ability to focus, concentrate, and perform error-free work. Thoughtful organizations have used the results of these research findings to revise hiring and training practices in order to reduce excessive overtime, to better organize work, and to better control the work environment.
- Ergonomics research related to positioning of office equipment and computers, the design of furniture, seating, the design of industrial power tools, conveyer systems transport vehicles, and a myriad of other items that have emerged in the workplace in recent decades that better complement people's physical limitations and capabilities.

Organizational Development

A new, older definition of organizational development (OD) emerged at a time (1969) when an organization was considered to be much like a stable machine consisting of interlocking parts. It stated: *Organizational Development is an effort planned organization-wide, and managed from the top, to increase organizational effectiveness and health through planned interventions in the organization's processes using behavioral-science knowledge.*[8]

Definitions of organizational development penned in more recent times when organizations recognized the need to adapt to changing economic and social dynamics include the following:

- *Organizational development is a system-wide application of behavioral science knowledge to the planned development and reinforcement of organizational strategies, structures, and processes for improving an organization's effectiveness.*[9]

- *Organizational development is a body of knowledge and practice that enhances organizational performance and individual development, viewing the organization as a complex system of systems that exist within a larger system, each of which has its own attributes and degrees of alignment. OD interventions in these systems are inclusive methodologies and approaches to strategic planning, organization design, leadership development, change management, performance management, coaching, diversity and work/life balance.*[10]

Kurt Lewin is widely recognized as the founding father of OD, although he died in 1947 before the concept became current in the mid-1950s. From Lewin came the ideas of group dynamics and action research that underpin the basic OD process as well as provide its collaborative consultant/client ethos. Lewin founded the Research Center for Group Dynamics at MIT. Other leaders in the field include Richard Beckhard, who defined OD as cited above, taught at the Sloan School of Management at MIT, and started the Organizational Development Network. Chris Argyris is Professor Emeritus at Harvard Business School. He is known for his work in organizational learning, theories of action, and double-loop learning. Frederick Edmund Emery was an important figure in the field of OD, particularly in the development of theory around participative work design structures such as self-managing teams. Peter Senge's work on organizational learning and Edgar Schein's work on organizational culture will be discussed in some detail in this chapter. Numerous other researchers, writers, and teachers are prominent in the OD field.

Books on organizational development and its subsets (management development, leadership development, development of teams, etc.) abound. Seminars and workshops designed to help organizations improve their effectiveness are ubiquitous. Nowadays the *Journal of Applied Behavioral Sciences* is viewed as the leading OD journal. There are hundreds, if not thousands, of OD consulting firms providing services to America's corporations facing one or more of the following organizational development issues.

Leadership Development	Managing Change	Team Building
• Management development	• Diversity management	• Workforce planning
• Organizational communication	• Knowledge management	• Collaboration
• Organizational diagnostics	• Performance Improvement	• Organizational culture
• Organizational performance	• Strategic planning	• Organizational learning
• Succession planning	• Systems-thinking	• Process improvement
• Organizational engineering	• Coaching and facilitation	• Employee research

The practical applications of OD research appear as the case studies and lessons learned in numerous books, professional journal articles, and seminar and workshop publications. Over the years, a wide variety of organizational plans, schemes, and methodologies have been adopted and described. The following are just a sprinkling of the larger mix.

- *Flattening organizational structures by reducing levels of management and supervision*. This is often done to reduce overhead costs—to save money—but it has also been shown to be effective in improving vertical communication within larger organizations, which leads to improved overall proficiency and effectiveness.
- *Reorganizing work so it can be performed by self-directed work teams*. For some operations, self-directed work teams perform outstandingly. Because the workers are given more responsibility, greater decision-making power, and trust, a greater synergism develops, and individual team members demonstrate an increased personal ownership for their work.
- *Succession-planning*. In highly technical operations, especially, replacement of workers who retire or resign has become a major management consideration to ensuring that the organization can continue to function safely and efficiently. Recruiting, qualifying, hiring, and training large numbers of people with the proper skill mixes within the required time frames demands special human resource skills.
- *Developing the leadership qualities needed to support the desired safety culture is an essential ingredient in improving an organization's reliability to withstand potential safety threats*. Training, mentoring, and coaching leaders and future leaders has become commonplace in American industry.
- *Strategic planning is essential to the organization's ability to compete in the market, to keep up with changing technology, to anticipate changing customer and marketplace demands and to weather economic shortfalls*. Organizations that fail to do strategic planning loose their competitive edge, fall behind the competition, face operational obsolescence, and organizational irrelevance.

Learning Organizations

The concept of "learning organizations" is the groundbreaking work of Dr. Peter Senge. His research, described in the book, *The Fifth Discipline* (1990), is a seminal work that described successful organizations from a whole new perspective. Dr. Senge's premise was that business had become so complex, so dynamic, and so globally competitive that organizations had to change in order to survive. Excelling in a dynamic business environment, he advocated, requires more understanding, knowledge, preparation, and agreement than one person's expertise and experience can provide. Continuous improvement requires a commitment to learning. The learning organization is one in which people continually expand their capacity to create the results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free, and where people are continually learning how to learn together. The five disciplines needed to build learning organizations are as follows:

- systems-thinking (the integrating discipline that ties and holds the other disciplines);
- personal mastery;

- mental models;
- shared vision; and
- team learning.

The first three disciplines have particular application for individuals; the last two disciplines are applicable to groups. Those in the organization who excel in these areas will be the natural leaders of the learning organizations. Senge's book provided numerous case studies to show how the five disciplines worked in particular organizations.

Systems-Thinking is the discipline of a shift of mind to seeing interrelationships, rather than linear cause-effect chains, and seeing processes of change rather than a snapshot. Systems-thinking starts with understanding "feedback" that shows how actions can reinforce or counteract (balance) each other. It builds to learning to recognize types of "structures" that recur again and again. Systems-thinking forms a language for describing interrelationships and patterns of change. It simplifies life by helping us to see the deeper patterns lying behind the events and the details.

Personal Mastery is the discipline of continually clarifying and deepening our personal vision, of focusing our energies, of developing patience, and of seeing reality objectively. If we have a personal vision, and we also see current reality objectively, then the difference between the two causes "creative tension." That tension can be used to draw us from where we are—in current reality—to the vision. Creative tension is a motivator to help people create the results in life that they truly seek.

Mental Models are deeply ingrained assumptions, generalizations, or even pictures or images that influence how we understand the world and how we take action. The discipline of working with mental models starts with turning the mirror inward; learning to unearth our internal pictures of the world, to bring them to the surface and hold them to rigorous scrutiny. Mental models also include the ability to carry on "learningful" conversations that balance inquiry and advocacy, where people expose their own thinking effectively and make that thinking open to the influence of others.

Shared Vision is a practice that involves unearthing shared "pictures of the future," which help foster genuine commitment and enrollment rather than compliance.

Team Learning is the discipline that involves mastering the practices of *dialogue* and *discussion,* the two distinct ways that teams converse. With dialogue, there is the free and creative exploration of complex and subtle issues, a deep "listening" to one another and suspending of one's own views. By contrast, in discussion, different views are presented and defended, and there is a search for the best view to support decisions that must be made at the present time. Dialogue and discussion are potentially complementary, but most teams lack ability to distinguish between the two and to move consciously between them.

The ideas and concepts associated with a "learning organization" resonated heavily with knowledge workers and with their employers. Traditional operating behaviors within organizations began to change. Unit Leaders and individual contributors became interested in and wanted to learn more about what other groups did and how they performed. Managers and

supervisors aggressively started to use work teams to solve problems and make decisions. Organizations started benchmarking their programs against the programs of so called “first in class” organizations to learn how they did things and how they managed a process or function. The sale of books on corporations that thrived in business and industry skyrocketed. The corporate leaders of companies like General Electric, Fed-Ex, Motorola, and others became superstars of the speaking circuit. Books on organizational development that aligned with the disciplines of the learning organization sold like hotcakes. Workers in both the public and the private sectors went back to college by the hundreds of thousands, if not to complete their degrees or “do a masters,” to improve skills and strengthen their capabilities overall. Existing MBA programs overfilled with students, new ones sprang up almost overnight. (about 90,000 individuals in the United States receive MBA diplomas each year) Corporations and government agencies alike gave workers time off or allowed flex-time work so they could attend classes and reimbursed employees tuition costs. Everyone it seemed was spending more time “learning” and was in the pursuit of meaningful inquiry.

Human Performance Technology

The International Society for Performance Improvement (ISPI) is dedicated to improving productivity and performance in the workplace. Founded in 1962 as the National Society for Programmed Instruction, ISPI now represents more than 10,000 international and chapter members through the United States, Canada, and 40 other countries. ISPI develops and promotes Human Performance Technology (HPT)—the systematic approach to improving productivity and competence that ISPI believes is the key to global competitiveness. Whereas training and education are critical to increasing competitiveness, meeting the educational challenge is only part of the answer. ISPI advocates further that an effective human resource system needs an outstanding learning system that focuses on performance. To improve human performance, it follows that organizations must manage the performance improvement system. That system must be the core of an organization’s human resource efforts if it is to maintain its competitiveness in the long run.

ISPI has two missions; one is to advocate the use of HPT. HPT uses a set of methods and procedures and a strategy for solving problems for realizing opportunities related to the performance of people. HPT specifically is a process of selection, analysis, design, development, implementation, and evaluation of programs to cost-effectively influence human behavior and accomplishment. HPT is a systematic combination of three fundamental processes—performance analysis, cause analysis, and intervention selection—that can be applied to individuals, small groups, and large organizations.

ISPI’s second mission is to develop and recognize the proficiency of its members. The society’s vision is that members have the proficiency and insight to customize HPT to meet the needs and goals of their organizations and clients, such that its members are recognized as valued assets. In its efforts to meet this vision, the society sponsors a large annual conference, conducts workshops, facilitates the HPT institutes, publishes two periodicals, maintains a bookstore, administers a certification program for performance technologists, and maintains a placement service.

Error Management

The growth of large, complex, technology systems in recent decades, such as nuclear power plants, commercial aviation, the petrochemical industry, chemical process plants, marine and rail transport, and the like have spawned rare, but often catastrophic, events referred to as organizational or system accidents. The Three Mile Island nuclear accident, the Exxon Valdez oil spill, the Bhopal India gas leak, the Challenger disaster, and numerous airline accidents, among others, caused growing public concern over the terrible costs, loss of life, risk to the public, and threat to the environment. In most instances, human error was cited as the cause of these incidences.

Dr. James Reason, studied human error for years (as did several others) and published his first book by that title in 1990. A central thesis of his work is that the relatively limited number of error types, ways in which errors actually manifest themselves, are conceptually tied to underlying (non-error producing) normal cognitive processes. He advocates that errors result from normal cognitive processes, the same origin as comes success.[11] Another thesis is that disasters are rarely the product of a single monumental error. Usually, they involve the collaboration of several, often quite minor, errors committed either by one person or, more often, by a number of people.

In 1997, Reason published *Managing the Risks of Organizational Accidents.* Reason maintained that to understand how organizational accidents occur requires that we look deeper into the system. Unsafe acts by individuals may trigger an event. However, latent conditions within the organization, aligned with local workplace and task factors, contribute to accidents in the form of process errors or as error-likely situations. Thus it is the combination of these latent conditions in conjunction with an active error that more correctly accounts for events. From this perspective, errors are the consequences, not the causes, of disturbances in the organization. Accidents are the result of failed controls and barriers. People are fallible, even the best make mistakes. It is human nature to err. However, events can be eliminated or controlled by *changing the conditions in which people work*. Managing the risks of organizational accidents requires that managers, supervisors, and staff work to eliminate latent organizational weaknesses. Reason proposes three compelling reasons why latent conditions have to be eliminated.

- They combine with local factors to breach controls. In many cases, they are weakened or absent controls.
- They are like “resident pathogens” within the workplace that can be identified and removed before the event.
- Local triggers and unsafe acts are hard to anticipate, and some proximal factors are almost impossible to defend against (for example, forgetfulness, inattention, and the like). [12]

The challenge is great for organizations trying to change the condition in which people work, to improve the operating system and lower the risk of accidents. However, the risks associated with not accepting the challenge are enormous. Accidents cost lives and they are also economically disastrous. Very few organizations can sustain levels of financial loss associated with product and materials damage, plant damage, building damage, tool and equipment damage, legal costs, and similar losses plus the loss of business, recruitment difficulties, and loss of morale.[13] Dr. Reason’s work is the foundation for the human performance improvement model

adopted by DOE and detailed in this standard. Chapter 2 of this document outlines worker tools used to reduce errors. Chapter 4 discusses tools for locating and eliminating latent organizational weaknesses and strengthening controls. The HPI Handbook, Volume 2 describes each of the tools, when they should be used, recommended practices when using a specific tool, and at-risk practices to avoid.

Mindfulness and Performance

Understanding "mindfulness" and its application to performance is informed by the work of Dr. Ellen Langer.[14] Mindfulness can be best understood as the process of drawing novel distinctions. It does not matter whether what is noticed is important or trivial, as long as it is new to the viewer. Langer suggests that actively drawing these distinctions keeps people situated in the present, the here and now. It also makes people more aware of the context and perspective of their actions than if they rely upon distinctions and categories drawn in the past. Under this latter situation, rules and routines are more likely to govern behavior, irrespective of the current circumstances, and this can be construed as "mindless" behavior. The process of drawing novel distinctions can lead to a number of diverse consequences important to performance, including:

- greater sensitivity to one's environment;
- more openness to new information;
- creation of new categories for structuring perception; and
- enhanced awareness of multiple perspectives in problem-solving.

The subjective "feel" of mindfulness is that of a heightened state of involvement and wakefulness of being in the present. Langer shares this example to make her point: When many of us learned to drive, we were told to pump the brakes slowly while trying to stop on a slippery surface. With the advent of antilock brakes, however, the more appropriate response is to firmly press the brakes down and hold them there. Thus, accidents that could be prevented in the past by our learned behavior can now be caused by the same behavior. This is an example of mindlessness that can easily occur in everyday life, as well as the workplace.

Langer contends that mindlessness can show up as the direct cause of human error in complex situations. Boredom and malaise, particularly, can be thought of as conditions brought on by mindlessness. Without noticing differences brought on by the passage of time within ourselves and the outside world, each day looks like every other. Employees in many occupations mechanically carry out the tasks that have been designed for them. The day when surgeons and airline pilots may check out psychologically because of standardization and routinization of their work is perhaps not very far off, with potentially disastrous consequences.[15]

High Reliability Organizations

In the early 1980s, Yale sociologist, Charles Perrow, investigated and wrote *Normal Accidents: Living with High Risk Technologies* (1984). Perrow concluded that while all organizations would eventually have accidents, because of their complexity and interdependence, some organizations were remarkably adapt at avoiding them. The question that high reliability

organization (HRO) pioneering researchers sought to answer in their research is, "Why do some organizations not have as many failures as others?"

From this question grew the definition and characteristics of HROs. The research has identified some key characteristics of HROs. These include organizational factors (i.e., rewards and systems that recognize costs of failures and benefits of reliability), managerial factors (i.e., communicate the big picture), and adaptive factors (i.e. become a learning organization). More specifically, HROs actively seek to know what they don't know, design systems to make available all knowledge that relates to a problem to everyone in the organization, learn in a quick and efficient manner, aggressively avoid organizational hubris, train organizational staff to recognize and respond to system abnormalities, empower staff to act, and design redundant systems to catch problems early. In other words, an HRO expects its organization and its sub-systems will fail and works very hard to avoid failure while preparing for the inevitable so that they can minimize the impact of failure.[16]

In the mid 1980s, a research group at the University of California at Berkeley (Dr. Karlene Roberts, Todd La Porte, and Gene Rochlin) began to study organizations in which errors can have catastrophic consequences. They focused on organizations that seemed to behave very reliably, which they called high reliability organizations (HROs).[17] Another group at the University of Michigan (Dr. Karl Weick and associates) began addressing similar issues. These researchers represented different disciplines (psychology, political science, and physics); they came together with an organizational perspective. They were initially concerned with understanding success in organizations in which error can result in serious consequences.

The Berkeley group's initial work was done in the Federal Aviation Administration's Air Traffic Control Center, in a commercial nuclear power plant, and aboard the U.S. Navy's aircraft carriers. This group produced a number of findings that distinguish HROs.[18]

- Organizations that must be successful all of the time *continually reinvent themselves.* For example, when community emergency incident command systems realize what they thought was a garage fire is actually a hazardous material incident, they completely restructure the response organization. An aircraft carrier uses its functional units slightly differently depending on whether they are on a humanitarian mission, a search and rescue mission, or are engaged in night flight operations training.
- In HROs, decision-making migrates down to the lowest level consistent with decision implementation. The lowest level people aboard U.S. Navy ships make decisions and contribute to decisions.
- Systems of organizations operate together to produce risk-enhancing or risk-mitigating outcomes.[19] For a U.S. Naval battle group to behave reliably requires that all system members act in concert, openly sharing communication, reducing status differentials at sea, and letting people with the salient information and training make decisions. The carrier and its aircraft squadrons have to operate in concert with the battle group's submarine frigate, destroyer, and cruiser complement.
- The organizations are committed to learning from everything they do.
- They do not punish people for making honest mistakes.

Langer's concept of *mindfulness* was adopted and adapted by Dr. Karl Weick et. al to help describe attributes of HROs. Weick's innovation was to transfer the *mindfulness* concept described by Langer in the individual model to the group level and thus to the organizational context.[20] These researchers argue that what characterizes organizations as HROs is their collective mindfulness of danger. Dealing with the unexpected is likely the greatest challenge any organization faces. The unexpected usually does not take the form of a major crisis; instead, it is generally triggered by a deceptively simple sequence in organizational life. Problems become more pressing when the expected strategy and performance outcomes fail to materialize or when unexpected impediments to strategy and performance emerge. People often take too long to recognize that their expectations are being violated and that a problem is growing more severe. Once they finally do recognize that the unexpected is unfolding, their efforts at containment are often misplaced or are too little too late. People can either manage unexpected events poorly, in which case the events spiral, get worse, and disrupt ongoing activity, or they can manage them well, in which case the events shrink and ongoing activity continues.[21]

Karl Weick and associates concluded that managing the unexpected event well means *mindful* management of the unexpected. The term "mindful management" comes from careful study of HRO organizations that operate under very trying conditions all the time and yet manage to have very few accidents. Indeed, the better of these organizations rarely fails, even though they encounter numerous unexpected events. These organizations face an "excess" of unexpected events because their technologies are complex and the people who run these systems have an incomplete understanding of their own systems and what they face.

HROs success in managing the unexpected is attributed to their determined efforts to act mindfully. This means they organize themselves in such a way that they are better able to notice the unexpected in the making and halt its development. If they have difficulty halting the development of the unexpected, they focus on containing it. And, if some of the unexpected breaks through the containment, they focus on resilience and swift restoration of system functioning.

Various people in an HRO correctly perceive events before them and can artfully tie them together to produce a "big picture" that includes processes through which error is avoided. The mindful approach by HROs is a striving to maintain an underlying style of mental functioning that is distinguished by continuous updating and deepening of increasingly plausible interpretations of what the context is, what problems define it, and what remedies it contains. The key difference between HROs and other organizations in managing the unexpected often occurs in the earliest stages, when the unexpected may give off only weak signals of trouble. The overwhelming human tendency is to respond to weak signals with a weak response. Mindfulness preserves the capability to see the significant meaning of weak signals and to give strong responses to those weak signals. This counterintuitive act holds the key to managing the unexpected. Weick and associates identified five characteristics of HROs that together make up what they term "mindfulness". (Note the similarities with the Berkeley group findings.)

Preoccupation with Failure – HROs assess all anomalies, large and small; they treat any lapse as a symptom that something is wrong with the system, something that could have severe consequences if separate small errors happened to coincide at one unfortunate minute. HROs encourage reporting of errors and near misses, they elaborate experiences of a near miss for what can be learned. They are wary of the potential liabilities of success, including complacency and

the temptation to reduce the margins of safety and drift into automatic processing. HROs are committed to learning.

Reluctance to Simplify – HROs take deliberate steps to create more complete and nuanced pictures. They simplify less and see more. They accept the world they face as complex, unstable, unknowable, and unpredictable. They encourage boundary spanners who have diverse experience, skepticism toward receiving wisdom, and negotiating tactics that reconcile differences of opinion without destroying the nuances that diverse people detect.

Sensitivity to Operations – This points to the HROs' concern with the unexpected. Unexpected events usually originate in "latent failures"—loopholes in the system's controls, barriers, and safeguards—whose potential existed for some time prior to the onset of the accident sequence, although usually without any obvious bad effect. These loopholes are imperfections in supervision, reporting of defects, engineered safety procedures, safety training, hazard identification, and the like. Normal operations may reveal deficiencies that are "free lessons" that signal the development of unexpected events. HROs do frequent assessments of the safety health of the organization.

Commitment to Resilience – HROs work to reduce errors and keep them small. The hallmark of an HRO is not that it is error-free, but that errors don't disable it. They improvise workarounds that keep the system functioning. HROs put a premium on experts, people with deep experience, special skills and training. They use flexible, informal ad hoc groups that come together quickly to solve problems and then disband (general uncommitted resources are crucial to resiliency), and HROs mentally simulate worst-case conditions and practice their own equivalent of fire drills.

Deference to Expertise – During normal operations, decisions come from the top. During high tempo, abnormal situations, decisions are pushed down and around. So decisions are made on the front line, and authority migrates to the people with the most expertise, regardless of their rank. The pattern of decisions "migrating" to expertise is found in flight operations on aircraft carriers, where uniqueness coupled with the need for accurate decisions leads to decisions that "search" for the expert and migrate around the organization. During times of danger, the predefined emergency structure makes decisions. The key is that members of the organization recognize clear signals for when to switch from one management mode to the other.[22]

The HROs maintain reliable performance despite constant exposure to the unexpected, in part by developing and maintaining their capability for mindfulness. A well-developed capability for mindfulness catches the unexpected earlier, when it is smaller; comprehends its potential importance despite the small size of the disruption; and removes, contains, or rebounds from the effects of the unexpected. HROs accumulate unnoticed events that are at odds with what they expected, but they tend to notice these accumulated events sooner, when they are smaller in size. They also concentrate more fully on the discrepancy, its meaning, and its most decisive resolution.

Organizations can learn to manage the unexpected better by acting more like a high-reliability organization. All organizations accumulate unnoticed events that are at odds with accepted beliefs about hazards and norms for avoiding these hazards. It is these similarities that encourage the transfer of the lessons of HROs to other organizations.

Researchers cite the following organizations as those that habitually exhibit the attributes of an HRO:

- power grid dispatching centers;
- naval aircraft carriers;
- hospital emergency departments;
- air traffic control systems;
- nuclear submarines;
- airline cockpit crews;
- offshore platforms;
- hostage negotiators[23]; and
- commercial nuclear power plants.

Resilience Engineering

Assessments of case studies and strategic analyses have identified the need to monitor and manage risk continuously throughout the life cycle of a system; and, in particular, to find ways of maintaining a balance between safety and the high pressure to meet production and efficiency goals. Resilience engineering is the work of Eric Hollnagel, David Woods, and associates (*Resilience Engineering,: Concepts and Precepts*, 2006). Resilience engineering is a field of study that uses the insights from research on failures in complex systems, organizational contributors to risk, and human performance to develop engineering practices. These engineering practices include measures of sources of resilience, decision support for balancing production and safety tradeoffs, and feedback loops that enhance the organization's ability to monitor and revise risk models and to target safety investments. Resilience engineering has emerged as a natural evolution from the principles of organizational reliability and a new understanding of the factors behind human error and performance.

Researchers who studied failures in different industries found that when failures occurred against a background of usual success there were multiple contributors referred to as latent conditions. These conditions arise in part because of the following.

- **Finite Resources –** there is never time or resources for all "adequate" reviews; there are never enough "well-qualified" systems engineers; and so on.
- **Uncertainty –** uncertainties in system performance, uncertainties in the environment, and uncertainties in the design process.
- **Change is Omnipresent –** as leaders exploit new capabilities, the result is change.

Recognizing these factors, researchers have identified the process that "a drift toward failure" precedes major events as planned controls erode in the face of production pressures and change. This failure arises from systematic and predictable organizational factors at work, not simply

erratic behaviors by individuals. As described above, HRO's create safety by anticipating and planning for unexpected events and future surprises. HROs do not take past success as a reason for confidence. Instead, they continue to invest in anticipating the changing potential for failure because of the deeply held understanding that their knowledge base is fragile in the face of the hazards inherent in their work and in the changes always present in their environment. SAFETY then becomes a value that requires continuing reinforcement and investment.[24]

Resilience engineering looks for ways to enhance the ability of organizations to create processes that are robust, yet flexible, to monitor and revise risk models and to use resources proactively in the face of disruptions or ongoing production and economic pressures. The initial steps in developing resilience engineering have focused on three critical components:

1. ways to measure the resilience of organizations;

2. tools for organizations to signal how to make tradeoffs in the face of pressure to achieve through-put and efficiency goals; and

3. techniques to visualize and anticipate the side effects of change and decisions on risk.[25]

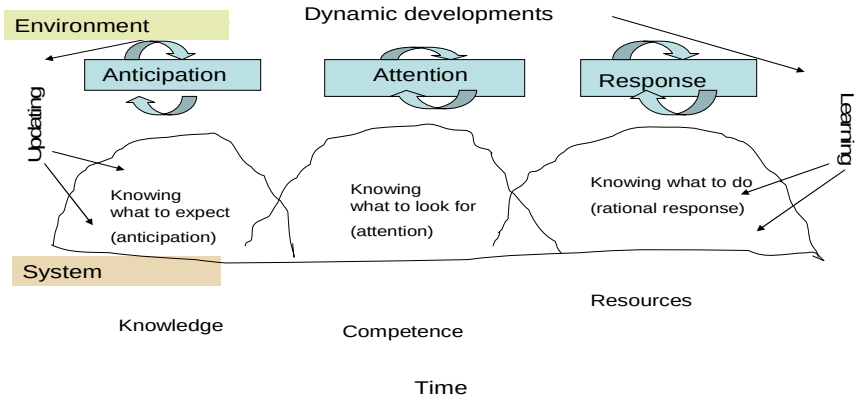
Organizational Resilience

Organizational resilience refers to how well an organization can handle disruptions and variations that fall outside of a system's design or safety envelope. Resilience is concerned with the ability to recognize and adapt to and handle unanticipated disorders and disturbances that call into question the model of competence and demand a shift of processes, strategies, and coordination. Resilience is the successful adaptation to change necessary to cope with the real-world complexity. Success has been ascribed to the ability of groups, individuals, and organizations to anticipate the changing shape of risk before failures and harm take place; failure, on the other hand, is simply the temporary or permanent absence of that ability. From this viewpoint, failures do not stand for a breakdown or malfunctioning of normal system functions, but rather represent the inability to make necessary adaptations to cope with the complexities.[26]

Safety is often expressed in terms of reliability, measured as the probability that a given function or component would fail under specific circumstances. It is not enough, however, that systems are reliable and that the probability of failure that could cause harm is below a certain value. They must also be resilient and have the ability to recover from irregular variations, disruptions and degradations of expected work conditions. Resilience requires a continuous monitoring of system performance. The fundamental characteristic of a resilient organization is that it does not lose control of what it does, but is able to continue and rebound. In order to be in control, organizations must know what has happened (the past), what happens (the present) and what may happen (the future), as well as knowing what to do and having the required resources to do it. Common conditions that characterize how well organizations perform and when and how they lose control are lack of time, lack of knowledge, lack of competence, and lack of resources.[27]

There are three qualities that a system must have to be able to remain in control in the face of an anomaly; and, therefore, to be resilient—**anticipation, attention, and response.** The whole

point about resilience is that these qualities have to be exercised continuously. The organization must constantly be watchful and prepared to respond. Also, it must constantly update its knowledge, competence, and resources by learning from successes and failures—both its own and those of others. A model of a resilient organization is shown below.[28]



Required qualities of a resilient organization

In addition to the qualities of anticipation, attention, and response, organizations must have the time to respond to disturbances and variations in its systems. Without time to respond before the incident, the response must come after the fact, and then is a reaction only to what happened.

Resilience requires a constant sense of unease that prevents complacency. It requires a realistic sense of abilities, or "where we are." It requires knowledge of what has happened, what happens, and what will happen, as well as of what to do. A resilient organization must be proactive; flexible, adaptive; and prepared. It must be aware of the impact of actions, as well as the failure to take action.[29]

Performance Improvement In the Work Place

Numerous industries in this country have embraced performance improvement. In the late 1970s following numerous airplane accidents involving human failures, the airlines developed crew resource management (CRM) training. CRM is designed to improve flight crew communication, team work, and delegation of responsibilities during abnormal conditions, among other things. The medical industry, the airline industry, and nuclear power industry adopted the use of full-scope simulators that authentically replicated operational situations. Simulators provided safe environments in which doctors, pilots, and control room operators alike could practice problem solving, decision-making, and 'performance of skills where they received feedback. For decades, simulator training has been a prerequisite for pilot and control room operator qualification and re-qualification. The U.S. Navy and the U.S. Coast Guard have also adopted HPI principles and practices.

In the mid-90's, the Institute for Nuclear Power Operations (INPO), representing about 100 nuclear power plants in this country, first introduced *Human Performance Fundamentals* training to educate nuclear power plant personnel. The training was an outgrowth of significant prior study conducted by the Institute to learn about human error, organizational accidents, and human performance. Striving for excellence in human performance at nuclear power stations is an

ongoing industry effort to significantly reduce plant events caused by human error. Human error is caused by a variety of conditions related to individual behaviors, management and leadership practices, and organizational processes and values. Behaviors at all levels need alignment to improve individual performance, reduce errors, and prevent events. Alignment involves facilitating organizational processes and values to support desired behavior. The *Excellence in Human Performance* document describes a set of behaviors that fosters this alignment. [30]

Earlier attempts by the nuclear power industry to improve human performance focused on results and the individual behavior at the worker level, a characteristic response to human error that prevailed in many organizations. However, organization and management influences on human behavior are equally important but are often overlooked or underestimated. Experience had revealed that most causes of human performance problems exist in the work environment, indicating weaknesses in organization and management. This does not relieve individuals of their responsibility to work safety and reliably. The human performance strategy in general encompasses the following:

- reducing the frequency of events by anticipating, preventing, and catching active errors at the job site;
- minimizing the severity of events by identifying and eliminating latent weaknesses that hinder the effectiveness of controls against active errors and their consequences; and
- cultivating an environment where honest errors can be openly reported and learned from.

This page is intentionally blank.

REFERENCES

[1] Perrow C. "A Society of Organizations," *Theory and Society*, 12/1991, pp. 725-762.

[2] Scott, W.R. Organizations: Rational, Natural, and Open System,. 2003, p. 95.

[3] Boisjoly, Curtis, and Mellican. In Ermann and Lundman, Corporate and Governmental Deviance: Problems of Organizational Behavior in Contemporary Society (5th ed), (1986), pp. 207-231.

[4] A good overview of quality management is available on the web at www.eagle.ca/~mikehick/quality.html.

[5] Both William Edwards Deming and Joseph Juran were enormously influential in helping American businesses improve their product quality and improve the way organizations managed their people. Deming's major works are *Quality, Productivity and Competitive Position*, 1982 (reprinted as *Out of Crisis)* and *The New Economics for Industry, Government and Education*,1993. Juran wrote *Management of Inspection and Quality Control*, 1945; *Quality Control Handbook*, 1951; and *Managerial Breakthrough*, 1964.

[6] INEL contractor personnel attended extensive training on total quality management in 1990-91 using Philip Crosby quality principles and concepts from his book *Quality is Free, 1980.*

[7] Dekker, S. The Field Guide to Human Error Investigations, 2002, p. 61.

[8] Beckhard, R. Organization Development: Strategies and Models, 1969, p.9.

[9] Cummings, Worley. Organizational Development and Change, 1997, p.2.

[10] Minahan, M. MM & Associates, Silver Spring, Maryland.

[11] Reason. *Human Error,* 1990, Chapter 3.

[12] Reason. Managing the Risks of Organizational Accidents. 1997; pp. 236-237.

[13] Reason. Managing the Risks of Organizational Accidents, 1997, pp. 238.

[14] Ellen J. Langer is the author of several books and numerous articles on the subject of mindfulness including *Mindfulness*, 1989, and *The Power of Mindful Learning*, 1997.

[15] Langer and Moldoveanu. "The Construct of Mindfulness," *Journal of Social Issues*, Spring 2000.

[16] http://www.highreliability.org/

[17] Rochlin, La Porte, and Roberts. "The Self-Designing High-Reliability Organization: Aircraft Carrier Flight Operations at Sea," *Naval War College Review*, Autumn 1987.

[18] Schuman. "The Analysis of High Reliability Organizations," in Robert K. H., ed. *New Challenges to Understanding Organizations*, 1993; pp.33-54. Bigley and Roberts. "Structuring Temporary Systems for High Reliability," *Academy of Management Journal*, *2001*; 44: 1281-1300.

[19] Grabowski and Roberts. " Risk Mitigation in Virtual Organizations," *Organizational Science*, 1999;10: 704-721.

[20] Weick, Sutcliff, and Obstfeld. "Organizing for High Reliability: Processes of Collective Mindfulness," *Research in Organizational Behavior*, 21, p. 90

[21] Weick and Sutcliff. Managing the Unexpected: Assuring High Performance in an Age of Complexity, 2001, Chapter 1.

[22] Weick and Sutcliff. Managing the Unexpected: Assuring High Performance in an Age of Complexity, 2001, Chapter 1.

[23] Wetherbee J. D. "NASA Safety: Cultural Improvements," PowerPoint presentation

[24] Woods D.D and Wreathall J. Managing Risk Proactively: The Emergence of Resilience Engineering, 2003; pp. 1-2.

[25] Woods D.D. and Wreathall J. Managing Risk Proactively: The Emergence of Resilience Engineering, 2003, pp. 3.

[26] Hollnagel, Woods, and Leveson. *Resilience Engineering: Concepts and Precepts*, 2006. pp. 21-23.

[27] Hollnagel and Woods. Joint Cognitive Systems: Foundations of Cognitive Systems Engineering, 2005, pp. 75-78.

[28] Hollnagel, Woods, and Leveson. *Resilence Engineering: Concepts and Precepts*, 2006, p. 350.

[29] Hollnagel, Woods, and Leveson. *Resilience Engineering: Concepts and Precepts*, 2006, p. 356.

[30] INPO. Excellence in Human Performance (Handbook), pp. 1-5.

GLOSSARY

Descriptions of Common Human Performance Terms and Phrases

Term or Phrase	Description
Accident	An unfortunate mishap especially one causing damage or injury.
Accountability	The expectation that an individual or an organization is answerable for results; to explain its actions, or be subject to the consequences judged appropriate by others; the degree to which individuals accept responsibility for the consequences of their actions, including the rewards or sanctions.
Action	Externally observable, physical behavior (bodily movements or speech). (See also *behavior.*)
Active Error	Action (behavior) that changes equipment, system, or plant state triggering immediate undesired consequences.
Administrative Control	Direction that informs people about what to do, when to do it, where to do it, and how well to do it, and which is usually documented in various written policies, programs, and plans.
Alignment	The extent to which the values, processes, management, and existing factors within an organization influence human performance in a complementary and non-contradictory way; facilitating organizational processes and values to support desired safe behavior.
Anatomy of an Event	A cause-and-effect illustration of the active and latent origins (linkages) of plant events initiated by human action.
Assumption	A condition taken for granted or accepted as true without verification of the facts. (See also *belief*, *mental model* and *unsafe attitudes.*)
At-Risk Practice	A behavior or habit that increases the chance for error during an action, usually adopted for expedience, comfort, or convenience.
Attitude	An unobservable state of mind, or feeling, toward an object or subject.
Barrier	Anything that keeps operations or processes within safe limits or protects a system or person from a hazard. (See also *controls* and *defense.*)
Behavior	The mental and physical efforts to perform a task; observable (movement, speech) and non-observable (thought, decisions, emotional response, and so forth) activity by an individual. Generally, we treat observable behavior as measurable and controllable.
Behavior Engineering Model	An organized structure for identifying potential environmental and individual factors that impact performance at the job site, and for analyzing the organizational contributors to those factors.
Belief	Acceptance of and conviction in the truth, existence, or validity of something, including assumptions about what will be successful.

Term or Phrase	Description
Benchmarking	A process of comparing products, processes, and practices against the best in class, the toughest competitors or those companies recognized as industry leaders; discovering innovative thinking or approaches.
Change Management	A methodical planning process to establish the direction of change, align people and resources, and implement the selected modifications throughout an organization, large or small.
Coaching	The process of facilitating changes in behavior of another person through direct interaction, feedback, collaboration, and positive relationships. (See also *feedback.*)
Cognitive (cognition)	Descriptive of mental activity related to sensing and thinking phases of information processing; perception, awareness, problem-solving, decision-making, and judgment.
Complacency	Self-satisfaction accompanied by unawareness of actual dangers, hazards, or deficiencies; being unconcerned in a hazardous environment.
Conservative Decision-Making	Reaching conclusions by placing greater value on safety than the production goals of the organization—decisions demonstrate recognition and avoidance of activities that unnecessarily reduce safety margins.
Controls	Administrative and engineering mechanisms that can affect the chemical, physical, metallurgical or nuclear process of a nuclear facility in such a manner as to effect the protection of the health and safety of the public and workers, or the protection of the environment. Also, error-prevention techniques adopted to prevent error and to recover from or mitigate the effects of error; to make an activity or process go smoothly, properly, and according to high standards. Multiple layers of controls provide defense in depth.
Critical Step	A procedure step, series of steps, or action that, if performed improperly, will cause irreversible harm to equipment, people, or the environment.
Culture	An organization's system of commonly held values and beliefs that influence the attitudes, choices and behaviors of the individuals of the organization. (See also *safety culture.*)
Cultural Control	Leadership practices that teach (consciously and unconsciously) their organizations how to perceive, think, feel, and behave.
Defense	Means or measures taken to prevent or catch human error, to protect people, plant, or property against the results of human error, and to mitigate the consequences of an error. Defense os a term used in much of the human performance literature. However in DOE the term "controls) is preferred as it is synomonous with the term "defenses" and "controls" is the term defined and used with the DOE ISMS. (See also *barrier* and *controls.*).

Term or Phrase	Description
Defense-in-Depth	The set of redundant and diverse controls, barriers, controls, and safeguards to protect personnel and equipment from human error, such that a failure with one defense would be compensated for by another defensive mechanism to prevent or mitigate undesirable consequences.
Dependency	The increased likelihood of human error due to the person's unsafe reliance on or relationship with other seemingly independent defense mechanisms. (See also *team error.*)
Engineered Controls	Those physical items (hardware, software, and equipment) in the working environment designed to modify behavior and choices, or limit the consequences of undesired actions or situations. These controls may be active (requires action/change of state) or passive (defense requires no action).
Error	An action that unintentionally departs from an expected behavior.
Error of Commission	An error that involves performance of an action other than the expected action.
Error of Omission	Failure to take an expected action.
Error Precursors	Unfavorable factors that increase the chances of error during the performance of a specific task by a particular individual. (See also *human nature*, *individual capabilities*, *task demands*, and *work environment.*)
Error-likely Situation	A work situation in which there is greater opportunity for error when performing a specific action or task due to error precursors (also known as "error trap").
Event	An undesirable change in the state of structures, systems, or components or human/organizational conditions (health, behavior, controls) that exceed established significance criteria.
Expectations	Established, explicit descriptions of acceptable organizational outcomes, business goals, process performance, safety performance, or individual behavior (specific, objective, and doable).
Facility	A building or structure in which operations are, or have been, conducted by or on behalf of, the . Included here are processing, laboratory (R&D), Decommissioned and Decontaminated buildings, storage buildings and the like, both nuclear and non-nuclear.
Factor	An existing condition that positively or adversely influences behavior. (See also *organizational factors.*)
Failure	The condition or fact of not achieving the desired end(s).
Fallibility	A fundamental, internal characteristic of human nature to be imprecise or inconsistent.

Term or Phrase	Description
Feedback	Information about past or present behavior, and results that is intended to improve individual and organization performance.
Flawed Controls	Defects with engineered, administrative, cultural, or oversight controls that, under the right circumstances, fail to: • Protect plant equipment or people against hazards; • Prevent the occurrence of active errors; and • Mitigate the consequences of error. (See also *anatomy of an event* and *defense-in-depth.*)
Function Allocation	The distribution of actions (functions) among human or machine elements of a system to achieve a particular outcome.
Gap Analysis	The process of comparison of actual results or behavior with desired results or behavior, followed by an exploration of why the gap exists.
Human Error	A phrase that generally means the slips, lapses, and mistakes of humankind.
Human Factors	The study of how human beings function within various work environments as they interact with equipment in the performance of various roles and tasks (at the human-machine interface): ergonomics, human engineering , training, and human resources.
Human-Machine Interface	The point of contact or interaction between the human and the machine.
Human Nature	The innate characteristics of being human; generic human limitations or capabilities that may incline individuals to err or succeed under certain conditions as they interact with their physical and social environments.
Human Performance	A series of behaviors executed to accomplish specific results (HP = B + R).
Human Reliability	The probability of successful performance of human activities, whether for a specific act or in general.
Individual	An employee in any position in the organization; that is, worker, supervisor, staff, manager, and executive.
Individual Capabilities	Unique mental, physical, and emotional abilities of a particular person that fail to match the demands of the specific task.
Infrequently Performed Task	Activity rarely performed although covered by existing normal or abnormal procedures.
Initiating Action	A human action, either correct, in error, or a violation; that results in an event. (See also *Anatomy of an Event.*)
Job	A combination of tasks and duties that define a particular position within the organization usually related to the functions required to achieve the organization's mission, such as Facility Manager or Maintenance Technician.
Job Site	The physical location where people touch and alter the facility.

Term or Phrase	Description
Job-Site Conditions	The unique factors associated with a specific task and a particular individual; factors embedded in the immediate work environment that influences the behavior of the individual during work. (See also *error precursors* and *organizational factors.*)
Knowledge & Skill	The understanding, recall of facts, and abilities a person possesses with respect to a particular job position or for a specific task.
Knowledge-based Performance	Behavior in response to a totally unfamiliar situation (no skill, rule or pattern recognizable to the individual); a classic problem-solving situation that relies on personal understanding and knowledge of the system, the system's present state, and the scientific principles and fundamental theory related to the system.
Knowledge Worker	An individual who primarily develops and uses knowledge or information (e.g. scientist, engineer, manager, procedure writer).
Lapse	An error due to a failure of memory or recall. (See also *slip* and *mistake.*)
Latent Condition	An undetected situation or circumstance created by past latent errors that are embedded in the organization or production system lying dormant for periods of time doing no apparent harm. (See also *latent organizational condition.*)
Latent Error	An error, act, or decision disguised to the individual that results in a latent condition until revealed later, either in an event, active error, testing, or self-assessment. (See also *latent condition*)
Latent Organizational Condition or Weakness	Undetected deficiencies in organizational processes, equipment, or values that create job-site conditions that either provoke error or degrade the integrity of controls.
Leader	An individual who takes personal responsibility for his or her performance and the facility's performance, and attempts to influence the organization's processes and/or the values of others.
Leadership	The behavior (actions) of individuals to influence the behaviors, values, and beliefs of others.
Leadership Practices	Techniques, methods, or behaviors used by leaders to guide, align, motivate, and inspire individuals relative to the organization's vision.
Management (manager)	That group of people given the positional responsibility and accountability for the performance of the organization.
Management Practices	Techniques, methods, or behaviors used by managers to set goals, plan, organize, monitor, assess, and control relative to the organization's mission. (See also *practices.*)

Term or Phrase	Description
Mental Model	Structured organization of knowledge a person has about how something works (usually in terms of generalizations, assumptions, pictures, or key words); a mental picture of the underlying way in which a system functions, helping to describe causes, effects, and interdependencies of key inputs, factors, activities, and outcomes.
Mistake	Errors committed because the intent of the act was incorrect for the work situation, typically defined by the condition of the physical plant; incorrect decision or interpretation. (See also *error* and compare with *slip.*)
Motives	The personal (internal) goals, needs, interests, or purposes that tend to stimulate an individual to action.
Near Miss	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.
Norm	A behavior or trait observed as typical for a group of people.
Organization	A group of individuals with a shared mission, set of processes, and values to apply resources and to direct people's behavior toward safe and reliable operation.
Organizational Factors	1) Task-specific sense: an existing job-site condition that influences behavior and is the result of an organizational process, culture, and other environmental factors. 2) General sense: the aggregate of all management and leadership practices, processes, values, culture, corporate structures, technology, resources, and controls that affect behavior of individuals at the *job site.*
Oversight Control	Methods to monitor, identify, and close gaps in performance.
Performance	Any activity that has some effect on the environment; the accomplishment of work. (See also *human performance.*)
Performance Gap	The difference between desired performance and actual performance, whether in terms of results or behavior.
Performance Improvement	A systematic process of identifying and analyzing gaps in human performance, followed by developing and implementing interventions or corrective actions to close the gaps.
Performance Indicators	Parameters measured to reflect the critical success factors of an organization. A lagging Indicator is a measure of results or outcomes. A leading indicator is a measure of system conditions or behaviors which provide a forecast of future performance (also known as “metrics”).
Performance Mode	One of three modes a person uses to process information related to one's level of familiarity and attention given to a specific activity. People will likely use multiple modes to complete a task. (See also *Skill-based*, *Rule-based*, and K*nowledge-based performance.*)

Term or Phrase	Description
Performance Model	A systems perspective of the context of individual human performance, showing how plant results and individual behavior are interrelated with organizational processes and values through job-site conditions.
Performance Monitoring	Review and comparison of performance against expectations and standards using problem reporting, feedback, reinforcement, coaching, observation data, event data, trend data, and so on. (See also *performance indicator*, *performance gap*, and *gap analysis.*)
Performance Problem	A discrepancy in performance with respect to expectations or operating experience, or an opportunity to improve performance created by changes in technology, procedures, or expectations. (See also *performance gap.*)
Physical Plant	Systems, structures, and components of the facility.
Plant Results	The outcomes of the organization in terms of production, events, personnel safety, external assessments, configuration, and so on.
Population Stereotype	The way members of a group of people expect things to behave; for example, in the U.S., up, right (direction), or red implies on or energized.
Positive Control	Active measure(s) to ensure that what is intended to happen is what happens, and that is all that happens.
Practices	Behaviors usually associated with a role that can be applied to a variety of goals in a variety of settings. (See also *work practices.*)
Prevention Behaviors	Behaviors or practices oriented toward the prevention of errors or events. (See also *production behaviors.*)
Principles	A set of underlying truths that can be used to guide both individual performance and the management of human performance
Proactive	Preemptive measures to prevent events or avoid error by identifying and eliminating organizational and job-site contributors to performance problems before they occur; preventing the next event.
Process	A series of actions organized to produce a product or service; tangible structures established to direct the behavior of individuals in a predictable, repeatable fashion as they perform various tasks.
Production Behaviors	Behaviors oriented toward creating the organization's product from the resources provided (corollary to *prevention behaviors*).
Reactive	Taking corrective action in response to an *event* or *error*.
Readiness	An individual's mental, physical, and emotional preparedness to perform a job as planned.
Reinforcement	The positive consequences one receives when a specific behavior occurs that increases the probability the behavior will occur again.

Term or Phrase	Description
Rigor	Completeness and accuracy in a behavior or process; cautiously accurate, meticulous, exhibiting strict precision during the performance of an action.
Root Cause	A cause that, if corrected, will prevent recurrence of an event.
Rule-Based Performance	Behavior based on selection of a defined path forward derived from one's recognition of the situation; follows an IF (symptom X), THEN (action Y) logic.
Safety Culture	An organization's values and behaviors—modeled by its leaders and internalized by its members—that serve to make safety the overriding priority. (See also *values* and *culture.*)
Self-Assessment	Formal or informal processes of identifying one's own opportunities for improvement by comparing present practices and results with desired goals, policies, expectations, and standards. (See also *benchmarking* and *performance monitoring.*)
Shortcut	An action, perceived as more efficient by an individual, that is intended to accomplish the intent of actions rather than the specific actions directed by procedure, policy, expectation, or training. (See also *violation.*)
Situation Awareness	The accuracy of a person's current knowledge and understanding of actual conditions compared to expected conditions at a given time.
Skill-Based Performance	Behavior associated with highly practiced actions in a familiar situation executed from memory without significant conscious thought.
Skill of the Craft	The knowledge, skills, and abilities possessed by individuals as a result of training or experience. Activities related to certain aspects of a task or job that an individual knows without needing written instructions.
Slip	A physical action different than intended. (See also *error*, *lapse*, and compare with *mistake.*)
Standdown	A period of time devoted by an organization toward the education, training, and sensitization of personnel on issues associated with performance improvement.
Supervisor	That member of first-line management who directs and monitors the performance of individual contributors (front-line workers) in the conduct of assigned work activities.
System	A network of elements that function together to produce repeatable outcomes; the managed transformation of inputs (resources) into outputs (results) supported with monitoring and feedback.
Systems Thinking	Consideration of the multiple, diverse, and interrelated variables and their patterns that come to bear on a worker at the job site; knowledge of the interdependencies of processes and leadership dynamics on performance—the organizational nature of human performance. (See also *Performance Model.*)

Term or Phrase	Description
Task	An activity with a distinct start and stop made up of a series of actions of one or more people; sometimes a discrete action.
Task Demands	Specific mental, physical, and team requirements that may either exceed the capabilities or challenge the limitations of human nature of the individual assigned to perform the task. (See also *error precursor.*)
Team Error	A breakdown of one or more members of a work group that allows other members of the same group to err due to either a mistaken perception of another's abilities or a lack of accountability within the individual's group.
Uneasiness	An attitude of apprehension and wariness regarding the capacity to err when performing specific human actions on plant components.
Unsafe Attitudes	Unhealthy beliefs and assumptions about workplace hazards that blind people to the precursors to human error, personal injury, or physical damage to equipment.
Values	The central principles held in high esteem by the members of the organization around which decisions are made and actions occur, such as reactor safety. (See also *culture* and *safety culture.*)
Violation	A deliberate, intentional act to evade a known policy or procedure requirement and that deviates from sanctioned organizational practices. (See also *Shortcut.*)
Vision	A picture of the key aspects of an organization's future that is both desirable and feasible—to be the kind of organization people would aspire to—that guide employees' choices without explicit direction, but understandable enough to encourage initiative.
Vulnerability	Susceptibility to external conditions that either aggravate or exceed the limitations of human nature, enhancing the potential to err; also the weakness, incapacity, or difficulty to avoid or resist error in the presence of error precursors. (See also *error precursor.*)
Work Environment	General influences of the work place, organizational, and cultural conditions that affect individual behavior at the job site. (See also *error precursors.*)
Work Execution	Those activities related to the preparation for, performance of, and feedback on planned work activities.
Worker	An individual who performs physical work on equipment, having direct contact (touching) with equipment, and is capable of altering its condition. (Compare with *knowledge worker.*)
Work Practices	Methods an individual uses to perform a task correctly, safely, and efficiently including equipment/material use, procedure use, and error detection and prevention. (See also *practices.*)