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Human Performance: Fossil Operations

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REPORT SUMMARY

Background

All humans make errors. Industrial human errors can result in a loss of life and can significantly impact the productivity and cost effectiveness of any facility or company. Several industries in which human error has had a significant impact (for example, airline, medical, military, nuclear power, aviation, and chemical) have implemented human performance programs with excellent results. Human errors by fossil plant operators can easily challenge plant safety and production. In the fossil operations arena, limited human performance techniques have been applied with excellent results. This report provides a basis for implementing a human performance program for fossil operations personnel.

Objective

- To provide material for the implementation of a human performance program within the Operations Department of a fossil plant to improve personnel safety and unit availability as well as reduce operating costs

Approach

This report provides a three-phase approach. First, basic human performance fundamentals necessary to understand why events happen, how errors are categorized, and how errors can be reduced or minimized are presented. Second, key considerations that must be addressed during the development and implementation of a human performance program are described. Third, examples of human performance tools—for both operators and their supervisors—that can be implemented at a facility to assist in reducing human errors are provided. The use of these tools has reduced errors in the nuclear, medical, and aviation industries and in the military. The tools are provided in a format such that they can be implemented a few at a time over several years to meet the needs and resource constraints of a particular facility. In addition, examples of various products that support the human performance program are provided.

Results

The implementation of a human performance program has been proven to reduce errors. U.S. Nuclear Regulatory Commission (NRC) data from 1985 to 1999 show that the number of significant events per nuclear unit per year dropped from 2.38 to 0.03 during this 15-year period. The National Safety Council reports that from 1995 to 2000, the number of occurrences in the DOE resulting from human error was reduced by half (>5000 to ~2500). Naval air mishaps resulting from human error have dropped almost in half (14 to 8) from 1977 to 1992. This

information is important for two reasons. First, all of these industries have started human performance programs and reduced the number of errors within their organizations. Second, the implementation of a human performance program is designed for long-term success.

EPRI Perspective

Although many examples of the human performance techniques presented in this report are directed specifically at the Operations Department, the human performance fundamentals, human performance tools, and considerations for program implementation are directly applicable to any organization within the plant. Implementation of the guidance contained in this report—in its entirety or in part, based on the needs of a facility—can improve unit availability and reduce fossil plant operating costs.

Keywords

Human performance
Operations performance
Error prevention

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INTRODUCTION

1.1 Purpose and Scope

Human performance is a series of behaviors executed in order to accomplish specific task objectives (that is, results). Human performance improvement is an approach to reducing errors and managing defenses. This report provides fossil plant Operations and management with the basic information necessary to implement an effective human performance program at their facility. The report describes fundamental knowledge of human performance, implementation considerations, tools and techniques, and examples of various human performance program products. The fundamentals and error prevention techniques are consistent with those that have been used successfully in the nuclear, medical, and aviation industries as well as the military. The report can be used in its entirety but is designed so that appropriate human performance tools can be selected and implemented based on the needs of the organization.

1.2 Background

Recent studies and surveys by the fossil-power-producing industry have indicated the need for improvement in the area of human performance. Improvements in unit reliability can be achieved through the effective implementation of the human performance fundamentals and tools described in this report. A substantial portion of the cost of human error can be avoided. One utility, described next, estimated that its fossil units experienced more than US $36 million in lost generation in a given year because of human performance errors. The following information shows the improvements that can be achieved.

A human performance program was started in 2001 at the facility, which is a three-unit, 330-MW per unit coal-fired plant. In the 1996–2000 timeframe, the site's forced outage rate was 7.94%. In 2005, the forced outage rate was 1.17%. During this period, the number of forced trips resulting from human errors decreased from 10 in the first year to 2 in the fifth year. During this five-year period, there were 24 forced trips resulting from human performance. Of these trips, 7 were caused by the individual's error, and the remaining 17 were latent organizational weaknesses. Of course, one consequential event can skew the data in a given year; but in the long run, overall plant reliability can be improved and operational costs reduced through an effective human performance program.

1.3 Report Structure and Overview

Figure 1-1 provides a graphical overview of this report.

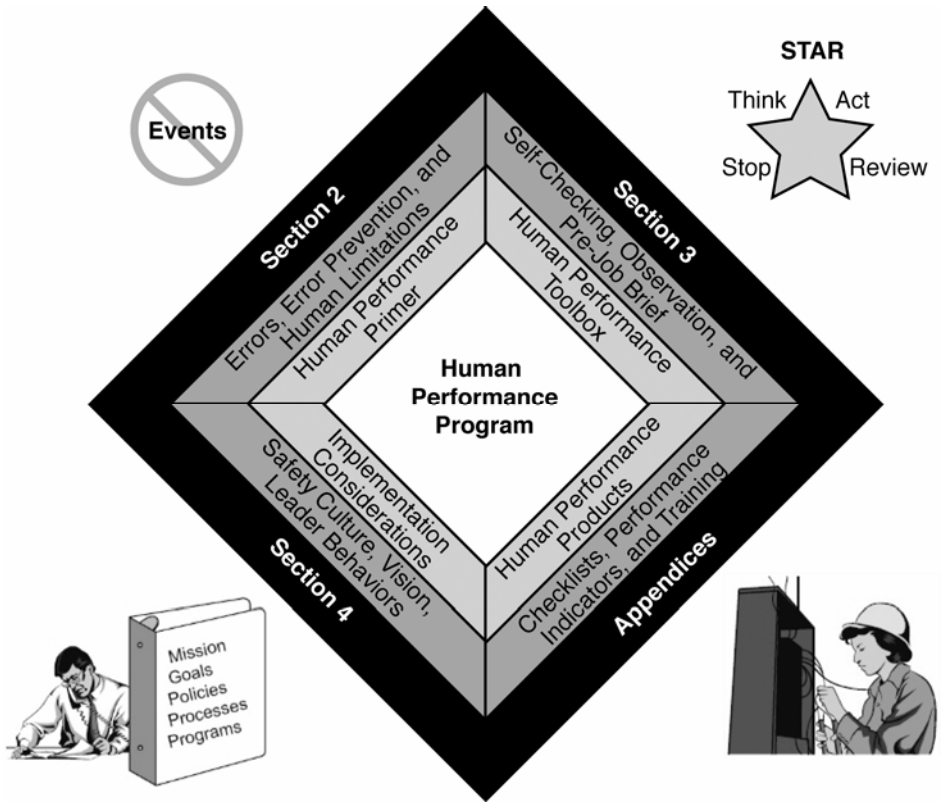

Figure 1-1
Human Performance Program Overview

Section 2 presents a human performance primer that provides an understanding of human performance fundamentals, including errors, types and causes, error modeling (such as the Generic Error Modeling System [GEMS] and the Swiss cheese model), error prevention, human limitations, and team errors. Section 3 describes key considerations that should be taken into account during program development and implementation, including safety culture, leadership behaviors, training, and communication. Section 4 provides the human performance "toolboxes" for Operations and Operations supervision; in particular, the tools and their use are described. In addition, observable behaviors and monitoring techniques are provided for each tool. The appendices provide examples of several deliverables that assist in the development of facility-specific products that are created during the various phases of human performance program development and implementation. These include a communication plan, event analysis techniques, checklists, performance indicators, and training tools.

1.4 Glossary of Terms and Acronyms

1.4.1 Industry Definitions and Nomenclature

Active error: Human action (behavior) that changes the equipment, system, or plant state, triggering immediate undesired consequences. Active errors occur at the point of contact between a human and some aspect of a larger system (for example, a human-machine interface). These errors are generally readily apparent (for example, pushing an incorrect button or ignoring a warning light) and almost always involve someone at the front line.

Behavior: 1) Observable (such as movement or speech) and non-observable (such as perception, thought, decisions to not act or inaction, or emotional response) activity by an individual; 2) the mental and physical efforts required to perform a task.

Champion: Employee who is responsible for leading human performance initiatives within the organization.

Communication: The process of exchanging information from one party to another.

Concurrent verification: A series of actions by two individuals working together at the same time and place to separately confirm the condition of a component before, during, and after an action, when the consequences of an incorrect action would lead to immediate and irreversible harm to the plant or personnel.

Consequences: Outcomes of an event.

Critical step: An irrevocable act whereby improper implementation could result in a plant transient or trip, damage to or improper or unintended function of significant plant equipment, or significant rework or injury to self or others.

Culture: An organization's system of commonly held values and beliefs that influences the attitudes, choices, and behaviors of the individuals of the organization.

Error: An action that unintentionally departs from an expected behavior; an act of commission or omission that leads to an undesirable outcome or significant potential for such an outcome.

Error of commission: An error that occurs as a result of an action taken.

Error of omission: An error that occurs as a result of an action not taken. Errors of omission may or may not lead to adverse outcomes.

Error-likely situation: A work situation in which there is a greater opportunity for error when performing a specific action or task error precursors.

Event: An unwanted or undesirable change in state of a system, structure, or component. It can also manifest itself as an unwanted or undesirable change in a worker or an organization (such as industrial safety, environmental health, behavior, or administrative control).

Flagging: A distinct form of marking that is used to identify components to be worked on or manipulated to ensure that workers do not work on or manipulate incorrect components that are similar in location or appearance.

Generic Error Modeling System (GEMS): Based on skill-, rule-, and knowledge-based errors. The fundamentals are based on the premise that people switch among different levels of cognitive control when faced with different situations. Depending on the situation, an individual chooses an information-processing mode (performance mode) that appears sufficient in order to control the situation.

Human error: A phrase that generally means the slips and mistakes of humankind. See also **active error** and **latent error**.

Human factors: Refers to the study of human abilities and characteristics as they affect the design and smooth operation of equipment, systems, and jobs.

Human performance: 1) Individual sense: a series of behaviors executed to accomplish specific task objectives (results); 2) organizational sense: the sum of what people (individuals, leaders, and managers) are doing and what people have done, that is, the aggregate system of processes, influences, behaviors, and their ultimate results that eventually manifests in the physical plant.

Human performance improvement: An approach that is fundamentally about reducing errors and managing defenses. Striving for excellence in human performance is an ongoing effort to significantly reduce events caused by human error. Human error is caused by a variety of conditions related to individual behavior, 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 behaviors.

Independent verification: A series of actions by two individuals working independently to confirm the condition of a component after the original act that placed it in that condition.

Initiating action: An action that is performed, either intended or not, so that the action itself or the results of that action are not as intended.

Knowledge-based performance: Associated with a situation model that is unfamiliar. As with rule-based performance-mode errors, knowledge-based performance errors are referred to as “mistakes.” However, the mechanism for error is different. Knowledge-based mistakes result from a cognitive limitation.

Latent error: An error, act, or decision that results from organization-related weaknesses or equipment flaws that lie dormant until revealed by human error, testing, or self-assessment.

Latent organizational weakness: Loopholes in the system's defenses, barriers, and safeguards whose potential existed for some time prior to the onset of the event sequence, although usually without any obvious negative effect. These loopholes consist of imperfections in features, such as leadership/supervision, training and qualification, report of defects, engineered features, safety procedures, and hazard identification and evaluation. Most accidents originate from or are propagated by latent weaknesses.

Mental model: Structured organization of knowledge a person has about how something works (usually in terms of generalizations, assumptions**,** pictures, or keywords). Mental models are psychological representations of real, hypothetical, or imaginary situations.

Mistakes: Reflect failures during intentional behaviors or incorrect choices; an error of reasoning, such as making a bad choice or failing to think through the full implications of an action.

Peer checking: Human performance tool; a series of actions by two individuals working together at the same time and place, before and during a specific action, to prevent an error by the performer. Peer checking is sometimes viewed as self-checking in parallel. Unlike concurrent verification, peer checking may involve audio or visual cues or both. When required by the supervisor or controlling document, a peer check may be documented. Peer checking is not required when using concurrent verification or independent verification.

Performance-shaping factor: Factors such as temperature, ergonomics, individual motivation, and experience that can have a positive or negative influence on human behavior.

Pre-job brief: Human performance tool; an interactive dialogue among those involved in the work to ensure that everyone understands the scope of work to be accomplished, procedural steps, roles and responsibilities, and hazards and controls that provides a heightened level of awareness of significant aspects of the task.

Post-job brief (review): Human performance tool; a valuable source of information conducted to determine whether the planning, briefing, and execution of the task or activity were effective. Post-job reviews aid in identifying opportunities to strengthen defenses against errors and events and eliminating error precursors embedded in the task or procedures.

Qualify, validate, and verify (QV&V): Human performance tool; a systematic mental process used to confirm raw information as fact. The use of QV&V promotes the development of critical thinking skills, allowing an individual or team to perceive information correctly and thereby ensure that actions taken are based on fact and are the best for the given situation.

Questioning attitude: Human performance tool; an attitude that encourages a person's foresight to precede his or her action so that planning, judgment, and decision making are appropriate for the situation.

Risk: The combination of 1) the frequency or probability of occurrence and 2) the consequence of a specified event. The concept of risk always has two elements: the frequency of event occurrence and the consequences of the event.

Root cause: A cause that is at the root of an effect. An effect can have more than one root; thus, a given effect can have, and usually does have, more than one root cause. A root cause is the most basic reason for a defect or problem in a product or process. Elimination of the root cause leads to the elimination of the defect or problem.

Rule-based performance: Associated with more unusual situations or problems. In these situations, an individual looks to familiar patterns or solutions stored in his or her memory to resolve a problem. The cognitive thought process typically follows an "if-then" logic.

Safety culture: The product of individual and group values, attitudes, competencies, and patterns of behavior that determines the commitment to and the style and proficiency of an organization's health and safety programs. Organizations with a positive safety culture are characterized by communication founded on mutual trust, by shared perceptions of the importance of safety, and by confidence in the efficacy of preventive measures. The term "safety culture" entered public awareness through the vocabulary of nuclear safety after the Chernobyl nuclear power plant explosion.

Self-checking: Human performance tool; an attention-management technique that an individual uses to focus attention on the appropriate component, think about the intended action and its expected outcome before performance, and verify the component condition after performance.

Situational awareness: The degree to which one's perception of a situation matches reality; the mental activity of developing and maintaining an accurate mental model of the facility's state and the work situation based on knowledge of critical parameters, observations of system or equipment condition, work environment, team members, and recall of fundamental knowledge of the facility.

Skill-based performance: Associated with highly practiced actions under familiar situations with little conscious thought (for example, turning a switch to start a pump or open a valve or taking log readings); the actions required for a familiar activity or task to be a complete, internalized script in our memories.

Slip: An error resulting from skilled behavior being performed at a time when it should not have been; lapses in concentration. Slips occur in the face of competing sensory or emotional distractions, fatigue, and stress.

Social loafing: The tendency for people to exert less effort when working as a team toward a common goal than when they are individually accountable.

Stop, think, act, review (STAR): Human performance tool; includes distinct thoughts and actions designed to enhance an individual's attention to detail. STAR is an expected, undocumented standard of performance for personnel at all times during their daily work

activities. An individual must be 100% sure that the action to be taken is correct before manipulating any equipment. The use of STAR by personnel must be recognizable by any observer at a distance.

Swiss cheese model: Illustrates the way in which analyses of major accidents and catastrophic system failures tend to reveal multiple smaller failures leading up to the actual hazard. In the model, each slice of cheese represents a safety barrier or precaution relevant to a particular hazard. No single barrier is foolproof: they each have "holes"; hence, the use of the term Swiss cheese.

Stressor: An event or object that causes stress in an individual.

Teamwork: Joint action by a group of people in which each person subordinates his or her individual interests and opinions to the unity and efficiency of the group.

Thumb rule: Loosely defined or informal rule often arrived at through experience or trial and error.

Time out: Human performance tool; refers to planned periods of quiet or interdisciplinary discussion (or both) focused on ensuring that key details of a task or activity have been addressed. Taking the time to focus on listening and communicating the plans as a team can rectify miscommunications and misunderstandings before a task or activity gets underway.

Two-minute rule ("take two"): Human performance tool; a technique in which an operator takes two minutes to evaluate the job site. The first step to safe and error-free operations is recognizing the error precursors (that is, hazards and abnormalities) that exist in the work environment. It is easy to be so focused on the performance of the task or activity that the error traps at the work site go unnoticed. Because procedures do not contain information about the conditions and demands of a task or activity, it is essential that the operator take time to look critically at the surroundings for potential hazards. Failure to identify error traps can make the task more difficult or lead to an error.

Violation: A deliberate, intentional act to evade or deviate from a known policy or procedure for personal advantage (such as comfort, expedience, or convenience). Violations are not errors and should not be tolerated.

1.4 Key Points

Throughout this guide, key information is summarized in "Key Points." Key Points are bold lettered boxes that highlight information covered in the text.

The primary intent of a Key Point is to emphasize information that will allow individuals to act for the benefit of their plant. Electric Power Research Institute (EPRI) personnel who reviewed and prepared this guide selected the information included in these Key Points.

The Key Points in this report are organized into two categories: human performance and O&M costs. Each category has an identifying icon to draw attention to it when quickly reviewing the guide. The Key Points are shown in the following way:

Key Human Performance Point

Denotes information that requires personnel action or consideration in order to prevent personal injury, equipment damage, and/or improve the efficiency and effectiveness of the task.

Key O&M Cost Point

Emphasizes information that will result in overall reduced costs and/or increase in revenue through additional or restored energy production.

The Key Points Summary section (see Appendix A) of this guide contains a listing of all Key Points arranged by category. The listing restates each Key Point and provides a reference to its location in the body of the report. By reviewing this listing, users of this guide can determine if they have taken advantage of key information that the writers of this guide believe would benefit their plants.

2
HUMAN PERFORMANCE PRIMER

This section provides a basic primer on human performance. It is intended to provide a brief introduction to human performance fundamentals, terminology, and techniques that have been used in the nuclear, medical, and aviation industries and in the military to address human error reduction.

2.1 Human Performance

What is human performance? Human performance has many definitions, some of which are long and complicated. Typically, one thinks of human performance in the context of human error and human error reduction. For the purposes of this report, *human performance* is defined as:

HP = B + R

Where:

HP = human performance
B = behaviors
R = results

A behavior—mental or physical—is an observable condition of the way in which individuals conduct themselves in a given environment during the performance of a task or activity. Results, good or bad, are the achievements or outcomes from performing the task. It is possible to achieve good results with poor or bad behaviors. However, poor behaviors do not lead to sustained, long-term consistent and good results.

Human performance is the set of behaviors exhibited or performed during the accomplishment of a task or activity (that is, results). This definition applies at all levels: the individual worker (operator), the leader (supervisor/manager), and the organization itself (Operations, unit, site, and company). From the formula, human performance can be affected by modifying either the behaviors or the output of the task or activity. Human performance improvement is designed to develop or modify behaviors using simple tools or techniques.

2.1.1 Behaviors

Behaviors have their foundations in our thoughts. These thoughts in turn are affected by the mind-set (that is, mental attitude or inclination) at a given time and by the perception of what is believed to be happening around us. These thoughts trigger feelings, which are typically internalized (that is, not outwardly visible) and occur with little or no conscious thought. During the performance of a task or activity, these feelings react with the situational environment. How an individual reacts to the situational environment manifests itself as observable behavior. That behavior may lead to satisfactory performance of a task or activity or lead to a mistake. Behaviors can be driven by several needs, including individual, team, departmental, cultural, organizational, and political.

Human performance improvement is defined as the process of developing and implementing tools and techniques that assist in either developing or modifying behaviors. With a basic understanding of some fundamental characteristics of human nature, team dynamics, and simple human performance tools, progress in human error reduction can be achieved.

2.1.2 Results

Results are typically associated with the characteristics of a given task. In most cases, the task or activity has little flexibility in whether it can be modified. The task may be constrained by factors such as design, physical location, or plant conditions. However, the task itself should not be overlooked as a component of human performance that can be modified. When investigating possibilities for changes in results, the organization must look at its goals, values, priorities, programs, and processes. It is within these that latent organizational weaknesses (described later in this report) can affect overall human performance efforts.

The effective implementation of a human performance improvement program works. The number of errors is reduced. Day-to-day success can be difficult to measure and realize, but long-term benefits can be achieved. Figure 2-1 represents data from a three-unit fossil generating station after the implementation of a human performance improvement program.

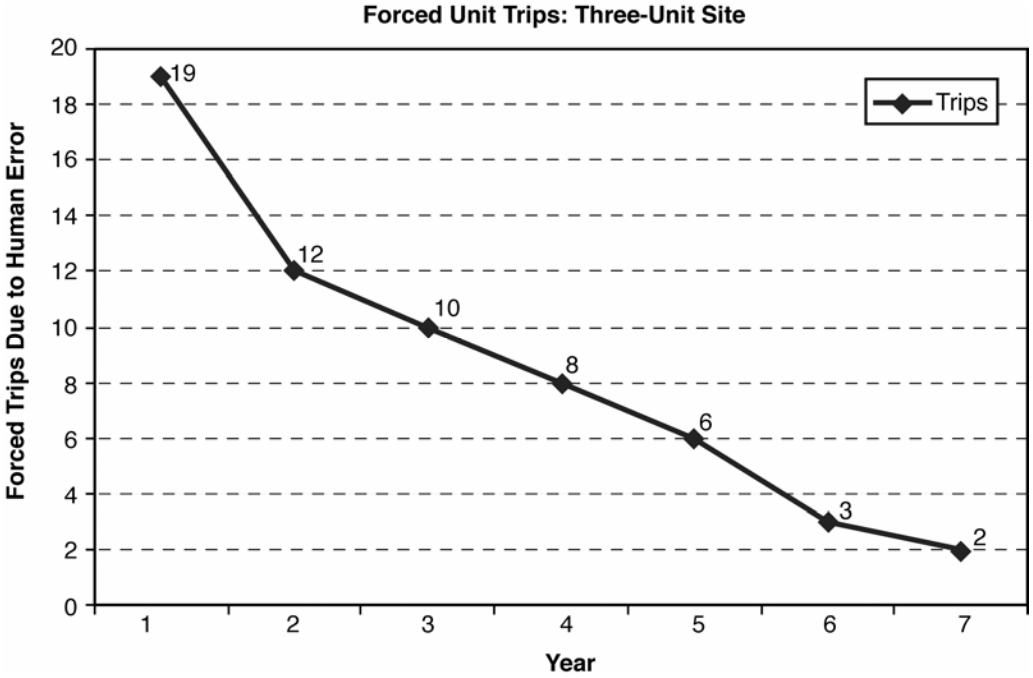

Figure 2-1
Improvement After the Implementation of a Human Performance Program

Key O&M Cost Point

The effective implementation of a human performance improvement program works. The number of errors is reduced. Day-to-day success can be difficult to measure and realize, but long-term benefits can be achieved.

2.2 Errors and Violations

It is necessary to understand the difference between errors and violations (see Figure 2-2). An error is an action that unintentionally departs from an expected behavior or given standard. A violation, however, is a deliberate, intentional act to evade or deviate from a known policy or procedure for personal advantage (such as comfort, expedience, or convenience). Human performance initiatives can reduce human performance errors but have no effect on violations. Violations must be handled using other methods, the most effective of which is removing the source of the violation.

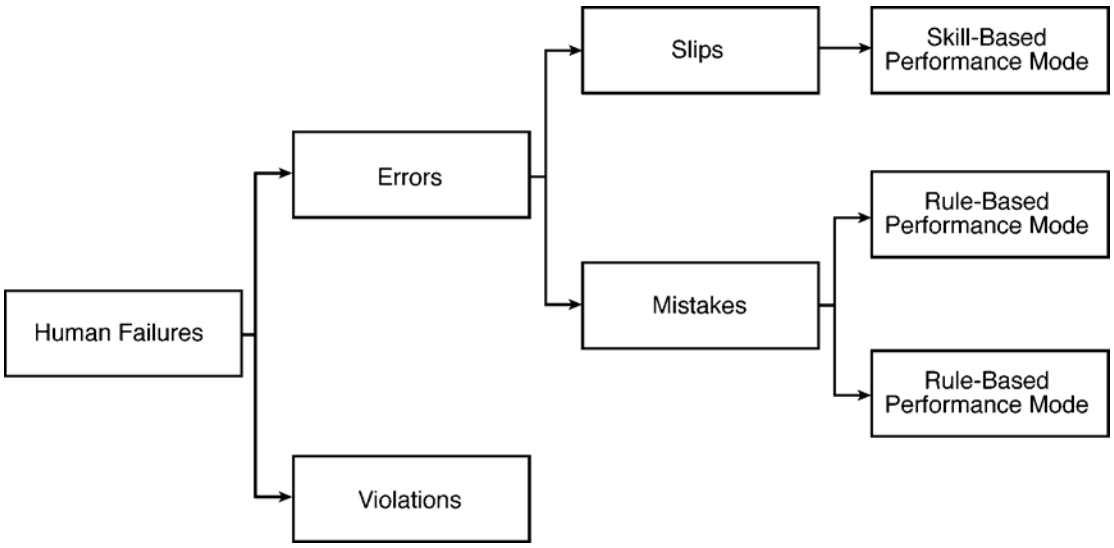

Figure 2-2
Classification of Errors

2.2.1 Errors

When speaking of errors, it is necessary to describe error types and classifications. Error types are active and latent, which are described in this section; error classifications are slips and mistakes, which are described in Section 2.5.1, "Skill-Based Performance."

2.2.1.1 Active Errors

Active errors typically involve personnel (as is the case with safety), equipment, systems, or the plant. The active error changes the state of one or more of these in an undesired way, and it results in undesired consequences. An *active error* is an act of either commission or omission that is typically the responsibility of the worker performing the task or activity (for example, the worker turned the wrong switch, missed a step in a procedure, or misread an instrument). Active errors are difficult, if not impossible, to foresee or predict. They seem to happen as "random acts of nature." When an active error is committed, it is usually visible—and its effects are immediate. The operator committing an active error is usually aware that an error was committed when it occurs. In most cases, skill-based active errors result in little or no consequence and are known only to the operator who committed the error.

2.2.1.2 Latent Errors

Latent errors are undetected deficiencies in organizational processes or values that create workplace conditions that provoke or degrade the integrity of defenses designed to minimize the occurrence of errors (for example, an error in a procedure or a drawing or design error). They exist to some degree in virtually all organizational processes and values, including the following:

- Processes (structure)
  - Training
  - Accountability policy
  - Design
  - Procedure development
  - Reviews and approvals
- Values (relationships)
  - Priorities
  - Coaching
  - Teamwork
  - Measures and controls

Latent process weaknesses can exist within organizational processes and values for years before they contribute to an event. Events associated with latent errors do not lend themselves to readily identifiable causes. In-depth analysis is usually required to identify the errors. The best defense against latent organizational weaknesses is a proactive approach that identifies them before they can contribute to an event. Latent errors can be identified through the following processes:

- Self-assessments
- Performance trending
- Observations
- Document reviews
- Post-job reviews
- Benchmarking

2.2.1.3 Classification of Errors

Errors are classified as either slips or mistakes, a distinction made by D. A. Norman in "Categorization of Action Slips." A *slip* is an error in which the intention was correct but a failure occurred during performance of the task or activity, for example, the worker meant to start the "A" condensate pump but started the "B" condensate pump instead. Slips are commonly

associated with a skill-based performance mode. A *mistake* is an error in which the intention was incorrect. The incorrect intention may result from a misapplication of a rule, a lack of knowledge, or a misdiagnosis of a situation.

2.3 Anatomy of an Event

To better understand the causes of a human error event, one must understand the components that contribute to an event. Typically, when a root cause analysis is performed on events characterized to have been caused by human error, the cause is attributed to inappropriate actions by the front-line worker. Although it is possible that worker performance issues are involved, plant events caused by human error can often more appropriately be characterized as organizational failures. Problems within the organization are primary contributors to failed defenses that contribute to the severity of events. A study conducted by the U.S. Nuclear Regulatory Commission (NRC) of plant events in the nuclear industry over a six-year period, *Review of Findings for Human Error Contribution to Risk in Operating Events* (NUREG/CR-6753), supports this conclusion. The anatomy of an event (see Figure 2-3) illustrates the attributes that are present before an event occurs. Additional information related to an anatomy of an event is provided in Appendix B.

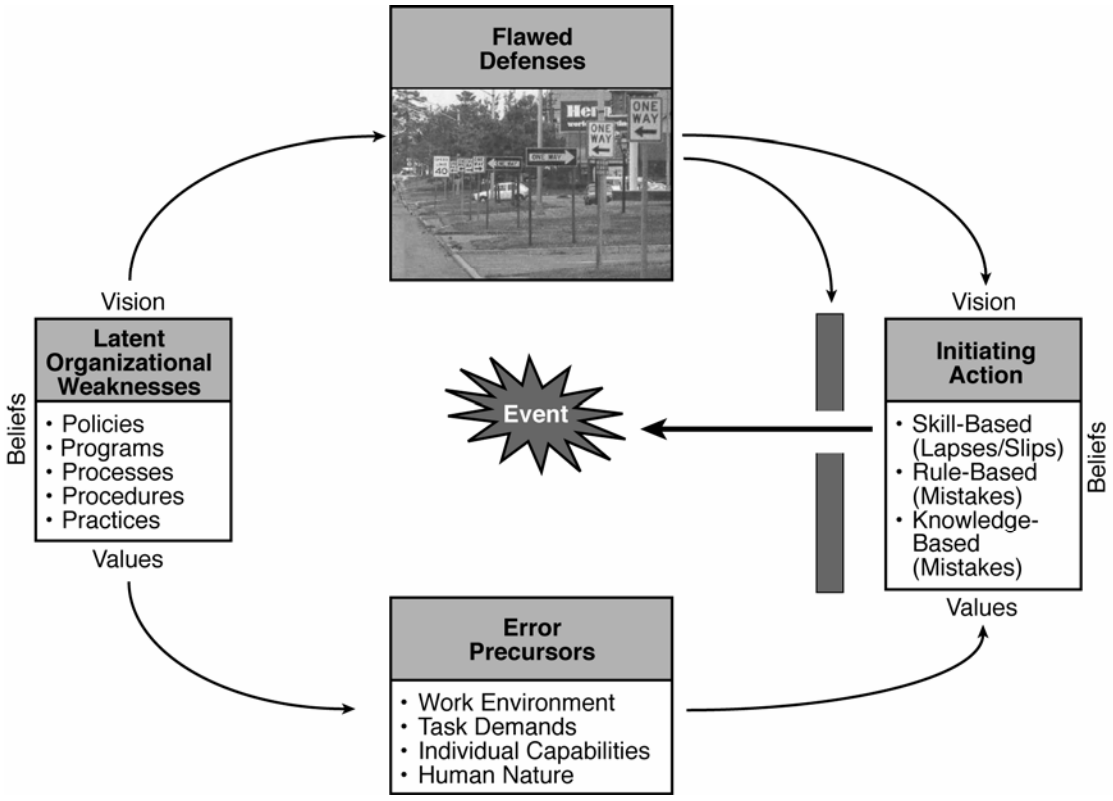

Figure 2-3
Anatomy of an Event

2.3.1 Event

Events can be characterized in a variety of ways. An *event* is an unwanted or undesirable change in state of a system, structure, or component. It can also manifest itself as an unwanted or undesirable change in a worker or an organization, such as industrial safety, environmental health, behavior, or administrative control. Event severity is characterized by how much the resultant change exceeds established criteria. Events are defined by results or outcomes that must be undone, plant conditions that do not achieve prescribed goals, and an undesirable consequence or simply a difference between what exists versus what should exist.

2.3.2 Initiating Action

An *initiating action* is an action that is performed, either intended or not, so that the action itself or the results of that action are not as intended. In other words, an event has occurred. Errors can be either active or latent. An active error is one with immediate, observable, and undesirable outcomes. Examples include starting the wrong pump or operating the wrong valve. A latent error is one in which the effects of the error occur after the occurrence of the error itself, for example, a mistake made either during the development of a procedure or in the engineering design of a modification implemented in the plant.

2.3.3 Flawed Defenses

Defenses are measures put in place to protect both people and equipment and may accomplish the following:

- Mitigate the consequences of an event
- Provide for consistent behaviors
- Protect against hazards

Defenses are synonymous with barriers. These defenses are typically in place to prevent the occurrence of active errors, for example, checklists for valve lineups or a cover over a critical switch. *Flawed defenses* are defects that, in certain circumstances, prevent the defensive measures in place from performing their intended function. When an event occurs, either 1) a defense has failed or is flawed or 2) the defense is not in place.

2.3.4 Error Precursors

Error precursors are synonymous with error traps. An *error precursor* or *error trap* is an unfavorable condition at a job site that increases the probability of an error occurring during the performance of a task. These precursors or traps lead to error-likely situations in which an error is impending. Typically, when this occurs, the demands of the task exceed the individual's capabilities, the work conditions aggravate the limitation of human nature, or a combination of both occurs (for example, a worker performing a task in a poorly lit environment misreading a component label).

2.4 Error-Likely Situation

An *error-likely situation* is a condition in which the likelihood for error is greater when the worker performs a specific action or task because of the presence of unfavorable job site conditions. Figure 2-4 illustrates an error-likely situation. An error-likely situation is an error waiting to happen. These errors typically occur when error precursors (task-related factors such as human, process, or physical conditions) exceed the capabilities of the individual performing the task.

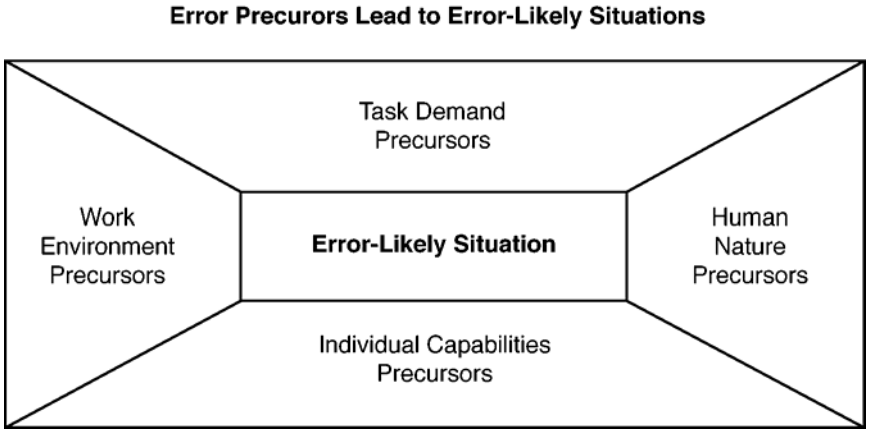

Figure 2-4
Error-Likely Situation

2.4.1 Error Precursors

Error precursors create a mismatch between the task or activity and the capabilities of the individual. Error precursors exist before the event, and they increase the probability for an error to occur. In many cases, the error precursor can be identified and controlled before the task is started. To accomplish this, the worker must know that these precursors exist, what they are, how to identify them, and how to resolve them prior to starting the task. In some texts, error precursors may be referred to as *behavior-shaping factors* or *performance-shaping factors*. Error precursors are typically categorized into one or more of the following groups:

- Task demands
- Individual capabilities
- Work environment
- Human nature

2.4.1.1 Task Demands

Task demands are the physical and mental demands required to perform an activity. When these demands exceed the capabilities or challenge the limitations of the individual, an error is likely to occur. Task demands include time pressure, simultaneous multiple actions, and unclear standards.

2.4.1.2 Individual Capabilities

Individual capabilities are specific mental and physical capabilities that are possessed by the individual performing the task. Whereas one individual may complete a task under a certain set of error precursors, a less experienced, less proficient individual may fail. Individual limitations include lack of knowledge, fatigue, and unfamiliarity with the task.

2.4.1.3 Work Environment

Work environment encompasses every aspect of the workplace that has affected or could affect an activity or task. These aspects include work location environment (for example, temperature, noise, lighting, or physical arrangement) and organizational and cultural conditions (for example, operator workarounds, changing routines, distractions, and interruptions) that affect the individual's behavior. Examples of work environment error precursors include distractions, personality conflicts, and differing interpretations.

2.4.1.4 Human Nature

Human nature, as previously described, deals with human limitations. The result is that humans are fallible and will commit errors if unfavorable conditions exist. Examples of human nature include stress, mind-set, and habits. (Human nature is further described in Section 2.8, "Human Nature and Its Limitations.")

2.4.1.5 Common Error Precursors

Error precursors exist at the job or task location prior to the start of work. They can be controlled if individuals know what to look for and then look for and resolve these precursors prior to performing the task or activity. Table 2-1 provides a short list of the most common error precursors. The effects of error precursors on the human performance tools is provided in Appendix C.

Table 2-1
Common Error Precursors

Time pressure (in a hurry)	Unfamiliarity with task; first time performing task
Heavy workload (memory requirements)	Lack of knowledge (mental model)
Simultaneous, multiple tasks	New technique not used before
Repetitive actions (monotony)	Imprecise communication habits
Irrecoverable acts	Lack of proficiency; inexperience
Interpretation requirements	Indistinct problem-solving skills
Unclear goals, roles, and responsibilities	"Hazardous" attitude for critical task
Lack of or unclear standards	Illness or fatigue
Work Environment	**Human Nature**
Distractions or interruptions	Stress (limits attention)
Changes or departures from routine	Habit patterns
Confusing displays or controls	Assumptions (inaccurate mental practice)
Workarounds or out-of-service (OOS) instruments	Complacency or overconfidence
Hidden system response	Mind-set ("tuned" to see)
Unexpected equipment conditions	Inaccurate risk perception ("Pollyanna")
Lack of alternative indications	Mental shortcuts (biases)
Personality conflicts	Limited short-term memory

2.5 Generic Error Modeling System

Generic Error Modeling System (GEMS), developed by James Reason, is based on the earlier work of Jens Rasmussen's work on skill-, rule-, and knowledge-based errors. The fundamentals are based on the premise that people switch among different levels of cognitive control when faced with different situations. Depending on the situation, an individual chooses an information-processing mode (performance mode) that appears sufficient to control the situation.

An individual processes information (that is, senses, thinks, and acts) in one of three performance modes: skill-based, rule-based, or knowledge-based). During any given situation, it is likely that the individual will move among various performance modes of information processing. Take, for example, an operator filling a tank. If the high-level alarm sounds, the operator moves from skill-based to rule-based performance. The performance mode of the individual is typically a function of the familiarity and level of attention required to perform the task or activity. The GEMS model, as shown in Figure 2-5, shows the performance modes and the movement among them that can occur.

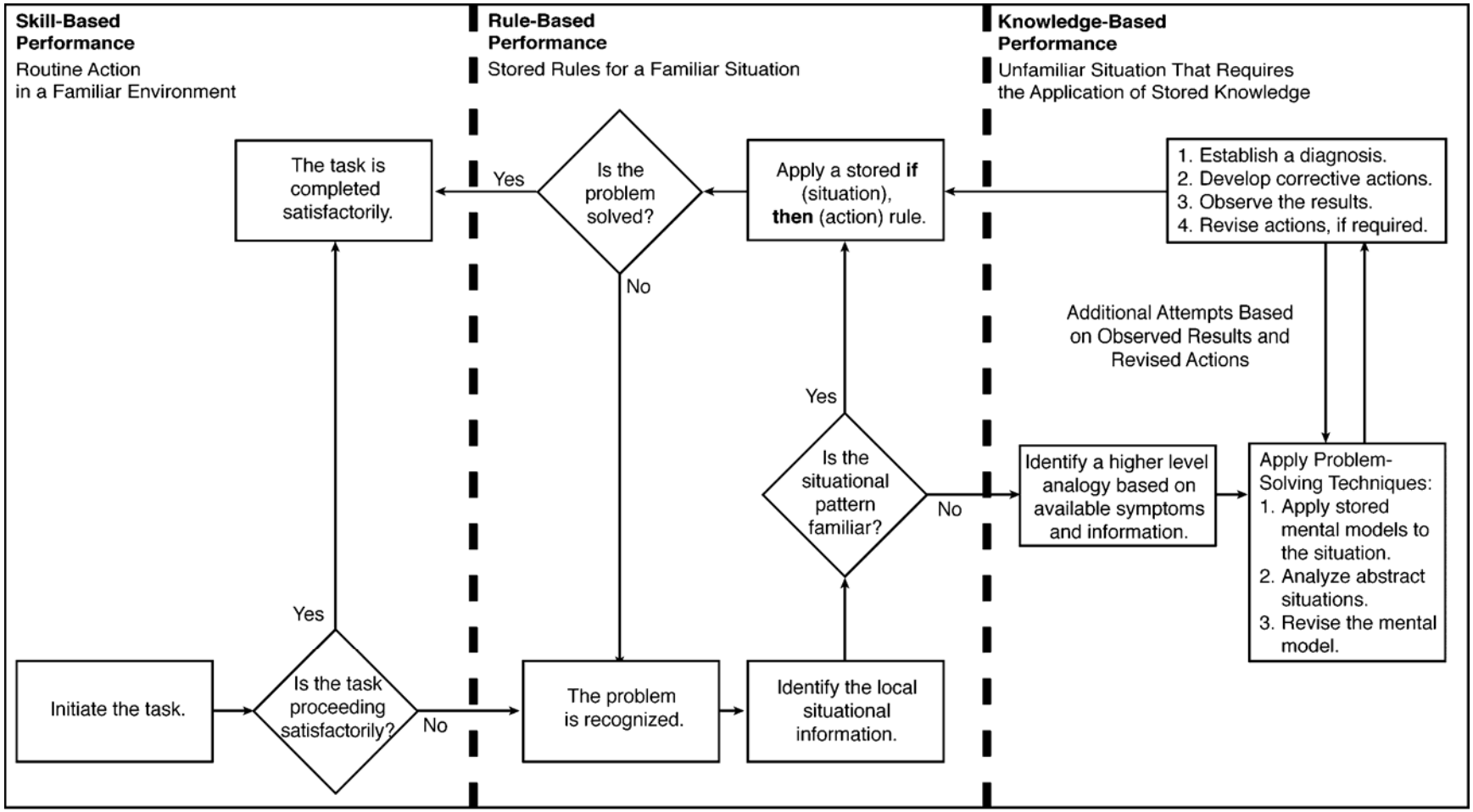

Figure 2-5
Generic Error Modeling System

During the performance of their tasks or activities, operators move among the various performance modes of operation without conscious thought. The following example demonstrates how that may occur.

While transferring water from a storage tank to a makeup tank, the operator notices during a scan of the control board that there is no indication of flow. (This is a skill-based performance mode activity.) In response to the no-flow condition, the operator checks the light indication that the pump is running and that a flow path exists from the storage tank to the makeup tank. (This is a rule-based performance mode, based on training, experience, and procedural guidance.) When the pump is indicated to be running and the flow path appears to be good, the operator then looks for other sources of information. (This is knowledge-based performance.) Tools available to the operator may include drawings and field operators. In this case, the operator receives word from the field that the coupling has sheared between the motor and the pump. With this knowledge, the operator reverts to rule-based performance and addresses this new problem with approved procedural actions. While implementing corrective actions, the operator may once again be in skill-based performance mode as other methods of transferring water are used or corrective actions are taken to repair the disabled pump. If the operator had not been able to determine the source of the problem, he or she would likely have remained in knowledge-based performance mode until the problem had been identified and a viable solution implemented.

As the level of information increases (improves), the uncertainty about the situation decreases (improves) with a resultant decrease in the probability of an error occurring. The level of uncertainty is improved through learning and practice (that is, training). As the individual becomes more familiar with the task (through knowledge, skill, and experience), the level of attention required to accomplish the task decreases. It is basic human nature that individuals heighten their attention when the level of uncertainty increases. With a heightened attention level, the possibility of detecting critical information increases. This assumes that there are no other stressors (for example, time pressure) present to affect the attention level. Similarly, people tend toward the lowest level of information processing necessary to perform a task or activity. Whenever possible, people avoid mental strain in performing a task. Under conditions of low-level information processing, attention may be reduced and the likelihood of missing critical information necessary for the successful performance of the activity is increased.

2.5.1 Skill-Based Performance

The skill-based performance mode is associated with highly practiced actions under familiar situations with little conscious thought (for example, turning a switch to start a pump or open a valve or taking log readings). The actions required for a familiar activity or task exist as a complete internalized script in our memories. They are preprogrammed instructions that have been developed through training and experience. After an individual decides to perform a familiar task, there is little need for external conditions or stimuli to complete the task. Additional conscious thought is required only when diverging from the familiarity of the situation (for example, the switch is turned to start the pump and the pump does not start).

Studies have shown that approximately 90% of a person's activities are performed in the skill-based performance mode. Studies from the nuclear industry reveal that only 25% of all errors are associated with skill-based errors.

The error mode associated with skill-based performance is inattention. Errors made at this level are referred to as *slips* or *lapses*. Slips and lapses occur as a result of a failure in the execution of a task or activity. Slips are typically observable actions (for example, the operator started the "A" pump instead of the "B" pump) in which the lapse is an internalized error involving a memory failure—for example, forgetting to announce to the plant that a pump was being started prior to starting it. Slips involve the inadvertent commission (that is, action taken) or omission (that is, action not taken) of an action during the performance of the task.

Skill-based activities can be accomplished reliably with little conscious thought. Typical skill-based activities include the following:

- Taking log readings
- Performing field rounds
- Manipulating switches
- Manually controlling processes (such as for tank levels, flows, and pressure)
- Performing a commonly used procedure

2.5.2 Rule-Based Performance

The rule-based performance mode is associated with more unusual situations or problems. In these situations, an individual looks to familiar patterns or solutions stored in his or her memory to resolve a problem. The cognitive thought process typically follows an "if-then" logic (for example, **if** the tank low-level alarm sounds, **then** the tank must be filled). An individual may find himself or herself in the rule-based performance mode when performing a familiar activity and an unanticipated problem occurs, requiring a different skill set than that required by the original task (for example, while filling the tank that received the low-level alarm, the high-level alarm sounds, yet the tank level is indicated to be half full). In some cases, the individual may not recognize that the task and required skill set have changed, for example, on performing a test or surveillance, the results are outside the expected range, and troubleshooting starts.

Initially, an individual may observe readily available indications of a problem and determine which stored response is appropriate (for example, the operator receives an annunciator alarm and selects the appropriate response procedure). If the first response is incorrect or does not resolve the problem, the operator may look for additional indications or other stored rules. The more training and experience an individual possesses, the more indications may be sought or the more stored rules may be available. Take, for example, an operator walking down the control board notices that the running light on a normally running pump is out. Even after changing the light bulb, however, the running light is still not lit. The operator now investigates further, based on the indications available, such as whether the pump is still running (checking for flow, pressure, amps, and so on).

The error mode associated with rule-based performance is misinterpretation. An individual may not fully understand or recognize conditions that require a particular response. Errors made in the rule-based performance mode are referred to as *mistakes*. A *mistake* is a failure in a mental process when selecting a solution to a problem or a way to find a solution to a problem. In other words, a mistake is a mismatch between what was intended and the intended consequence. Errors made in the rule-based performance mode include deviating from an approved procedure or applying the correct procedure to the wrong situation (for example, an operator uses a procedure for restaging pump seals under the incorrect initial conditions and blows the pump seals). In the nuclear industry, approximately 60% of errors occur while individuals are operating in the rule-based performance mode.

The strategy in rule-based performance is to improve an individual's interpretation of the situational model to increase the likelihood of selecting and using the appropriate response to the situation. In the GEMS model, *procedures* are predetermined solutions to known or anticipated situations that require a specific response. However, not all problems can be anticipated, and the knowledge-based performance mode is required in order to address these situations. Procedures are not developed solely for anticipated problems: they are also developed for less familiar operational tasks and activities in which it is impractical for the individual or team to keep them in stored memory (for example, plant startup and shutdown or a test or surveillance performed once every 18 months). Just because a procedure exists for a given task or activity does not me an that a task is performed in the rule-based performance mode. Some common and frequently performed activities for which procedures have been developed are actually skill-based performance for the experienced operator. Rule-based activities include the following:

- Responding to an annunciator alarm
- Checking equipment on operator rounds (for example, temperature and oil levels)
- Using emergency or off-normal procedures

2.5.3 Knowledge-Based Performance

The knowledge-based performance mode is associated with a situational model that is unfamiliar. As with rule-based performance errors, knowledge-based performance errors are referred to as *mistakes*. However, the mechanism for error is different. Rule-based mistakes are failures in which the solution to a problem is selected, but it is the wrong solution. Knowledge-based mistakes result from a cognitive limitation. Simply put, this is a failure in which knowledge, skill, and experiences are applied to find a solution to a never-before-seen problem. Individuals transition into the knowledge-based performance mode as soon as they realize that they are uncertain about a course of action to take. As the uncertainty level increases, the individual's need for additional information also increases. The level of uncertainty that prevails has a detrimental effect on the probability that the individual will be successful in resolving the problem. As with most situations, the additional stressor of time pressure reduces the probability of success.

The error mode for knowledge-based performance is an inaccurate mental model. Knowledge-based performance relies on having accurate information to apply solid problem-solving skills in order to properly diagnose the situation. In most cases, decisions are made with limited information; that is, either its availability is limited or there is insufficient time to acquire it. When the situation is one with limited information, the problem solving may rely on shortcuts or assumptions or both, resulting in a negative outcome. The possibility of error is very high: there is a probability of a one in two chance of success. In the nuclear industry, approximately 15% of all errors are a result of knowledge-based performance.

It is not feasible to anticipate all possible scenarios in a dynamic situational model (for example, a power plant). As a result, there will be situations for which there is no procedural guidance to assist an individual, who then fully relies on the knowledge, skills, and experience acquired and how these are applied with the data available. It is a situational model full of uncertainty, stress, and conflicting data, too much data, or insufficient data to apply with problem-solving skills. In this situation, individuals tend to make erroneous assumptions, which ease the mental workload and stress of the situation.

The knowledge-based performance mode involves problem solving. In most situations, operators spend the majority of their time in skill- and rule-based performance modes. Managers and supervisors spend the majority of their time in rule- and knowledge-based performance modes. Activities requiring knowledge-based performance include the following:

- Responding to an unknown plant transient
- Resolving conflicting plant or equipment indications
- Determining whether a procedure change alters the intent of a procedure

2.5.4 Mental Models, Shortcuts, and Assumptions

In cognitive reasoning, there are three areas of note: mental models, shortcuts, and assumptions.

2.5.4.1 Mental Models

A *mental model* is a structured organization of knowledge (that is, facts and assumptions) an individual has about how something works. They can be models of real, hypothetical, or imaginary situations. Mental models are used in all performance modes and allow the individual to detect deviations between desired and undesired system responses. (An example of the former is water added to a tank and the tank's water level going up the correct amount.) The ability to detect the system response is based on a mental model that answers the following questions:

- How does the system work?
- Why does the system work the way it does?
- What is the current state of the system?
- What is the expected state of the system?
- What fundamental laws of nature apply to the system?

Mental models do contain inaccuracies, however: human limitations. Humans tend to break complex models into simpler models to fit a mental image that can be remembered. The simple models will not typically contain all of the information of the more complex model.

2.5.4.2 Shortcuts

A mental model may contain a mental bias caused by shortcuts, which are easy to remember and reduce mental strain. In breaking down a complex or ambiguous situation, the individual seeks recognizable patterns or solutions, which creates problems during problem solving and decision making. Shortcuts fall into four categories:

- Close-in-time
- Confirmation
- Frequency and similarity
- Oversimplification

Close-in-time shortcuts are characterized by the tendency to correlate a relationship between two situations because they occur at the same time. For example, during plant trips, some alarms are received as a result of the trip and others may not be. The alarm may be written off as trip related when in fact it is not—it signifies another condition.

Confirmation shortcuts are characterized by a reluctance to change one's mind in view of conflicting information. For example, a plant is not responding as expected in response to current actions, but the course of action regarding plant operations is not changed. This is a mind-set capable of seeing only the information that supports the original solution.

Frequency and similarity shortcuts are characterized by the tendency to recall familiar solutions from similar situations or solutions that have proven effective in the past. Greater emphasis is typically given to information that is more frequent and current. For example, valve checks require hands-on verification, but the operator has always used the position indicator. But if the position indicator is broken, the actual position of the valve may be wrongly determined.

Oversimplification shortcuts are characterized by the tendency to accept simple solutions that appear satisfactory, for example, a procedure is used to accomplish a task although current plant initial conditions differ from those prescribed by the procedure. Emphasis on information that is readily available or "information overload" may stimulate this shortcut.

2.5.4.3 Assumptions

Because knowledge-based performance can be stressful, individuals use assumptions to reduce mental strain. Assumptions lead to trial-and-error problem solving. The problem with assumptions, however, is that they are often treated as fact. Individuals and team members must challenge these assumptions when they arise. The role of the "devil's advocate" is an effective tool for challenging assumptions. Although this approach may not always be recognizable, in many cases it is associated with "I believe," "I think," or "We've always done it this way." Assumptions may be challenged by taking one of the following actions:

- Ask for the data supporting the assumption and leading to the conclusion being drawn.
- Ask for the mental model that connects the data to the conclusion.
- Test the assumption: "What I hear you saying is…."

2.6 Swiss Cheese Model

The Swiss cheese model is based on work developed by Dr. James Reason. The model allows the concept of latent organizational weaknesses to be explained, which is not taken into account in the GEMS model. This model has been adapted by the military, both aviation and afloat, to assist in their accident investigations; theirs is the Human Factors Analysis and Classification System (HFACS). The model provides a graphical representation of how a trigger event manages to pass through several defensive layers within an organization and cause an event (see Figure 2-6). The defensive layers of the organization are represented by slices of Swiss cheese, each slice representing a different defensive strategy or mechanism. The holes in the cheese represent opportunities for failure, or weaknesses, within the defenses that allow an error to pass through. An error may pass through one defensive layer only to be stopped by another. However, when the error is able to pass through all of the defensive layers, the result is an event. In a dynamic work environment, the holes are constantly moving and changing in size (for example, activity in the control room or work performed in the plant).

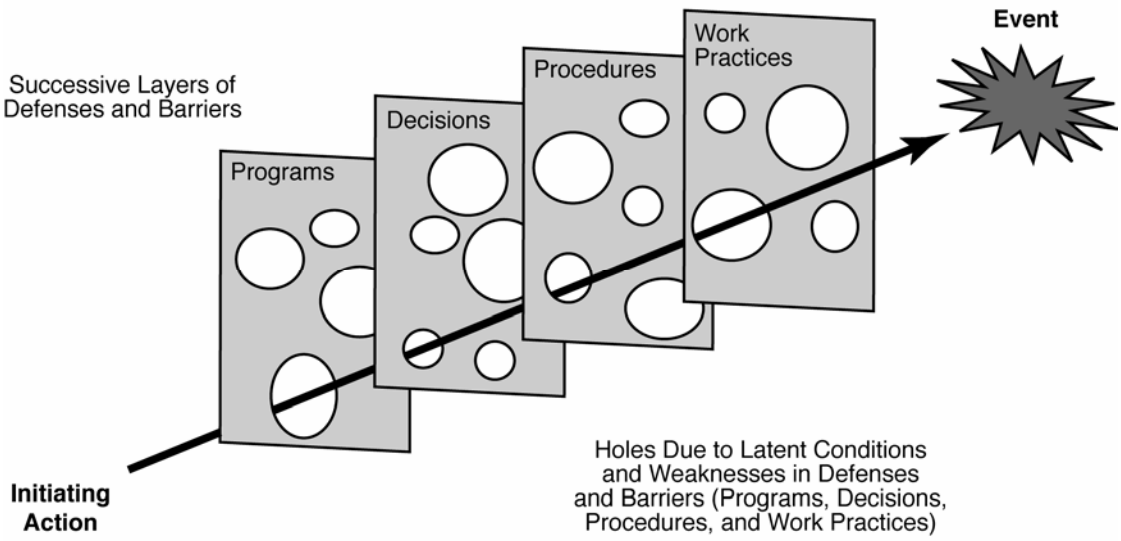

Figure 2-6
Swiss Cheese Model

An organization may have many layers of defense. Obviously, the greater the number of defensive layers, the lower the likelihood that an error will pass through. However (unlike Swiss cheese), these defenses represent real programs and processes that must be managed—and this requires resources in order to accomplish. It is therefore to the benefit of the organization to make the defenses as sound (that is, without holes) as possible. It is easier to manage a few well-developed defenses, and it is also easier for an individual in the field to understand and implement these defenses. The Swiss cheese model in Figure 2-6 has five defensive layers of interest. Each of these defensive layers may in turn contain defensive sublayers and so on. Each organization will have its own set of defenses. The following are the four defenses of interest in the HFACS model:

- Unsafe acts
- Precondition for unsafe acts
- Unsafe supervision
- Organizational influences

Unsafe acts are actions (that is, failures) of the individual, typically at the point at which the event occurs. The failures are caused by the actions or inactions (that is, commission or omission) of the individual believed to have caused the event. The other defensive layers represent latent organizational weaknesses at various levels in the organization. The “holes” exist and may have existed for some time. The holes are constantly moving, based on external and internal influences. Under certain external and internal influences, the holes align themselves, and the active error committed by the individual results in the event. Therefore, it is necessary to identify the holes in the model in order to reduce their number and size. Although this may seem to be an endless task because each event is unique, in fact, events are not as unique as they may first appear. Most have similar underlying causes. An examination of each defensive layer in the HFACS model follows.

2.6.1 Unsafe Acts

Unsafe acts (that is, failures) are caused by the individual at the scene of the error. These failures take on two forms: error and violation. An error, as previously described, may be a slip, lapse, or mistake, depending on the cognitive mode in which the individual is operating. The violation, on the other hand, is a willful disregard for the rules. The error is typically the more common failure. Typical errors may result from task fixation, missing steps in a procedure, operating the wrong piece of equipment, incorrectly responding to an off-normal condition, and using the wrong procedure for the plant conditions.

2.6.2 Preconditions for Unsafe Acts

Preconditions for unsafe acts are latent weaknesses that exist in the human condition. (These are described in greater detail in Section 2.8, "Human Nature and Its Limitations.") Among these weaknesses are adverse mental states (such as fatigue, loss of situational awareness, and distraction) and attitudes (such as overconfidence, complacency, and motivation). Other weaknesses, such as physical fatigue and illness, are physiological. Finally, there are physical or mental limitations in which the requirements of the task exceed the capabilities of the individual. This is apparent in situations in which quick responses are coupled with time pressure (for example, a plant trip).

2.6.3 Unsafe Supervision

Unsafe supervision may result from several factors, including inadequate supervision, planned inappropriate operations, inappropriate behavior, or failure to enforce expectations and violations. A supervisor is expected to look out for the well being of his or her team. This includes providing guidance, training, leadership, motivation, and role modeling. Failure to provide any of these to the team results in inadequate supervision. Planned inappropriate operations in a supervisor may include assigning inexperienced operators to the same crew or failing to request an additional operator to support a complex task during a shift. Inappropriate behavior or failure to enforce expectations may include failure to correct two-handed operations in the control room or working at heights without a proper restraint. It can also include a failure to apply discipline when required, which establishes an atmosphere in which inappropriate behavior is condoned. Finally, supervisory violations do occur in which the supervisor willfully disregards rules, policies, and processes while managing the assets entrusted to him or her.

2.6.4 Organizational Influence

Organizational influences affect all levels of the organization and directly affect supervisory practices and the actions of the individual. These influences include resource management (such as staff, training, funding, and equipment), organizational climate (including structure, policies, and culture), and operational processes (such as time pressure, production quotas, and schedules).

2.7 Error Prevention

Reducing the error rate can minimize the frequency of events. From an operational perspective, the error rate can be reduced through thorough task preparation, proper task execution, and post-task review to gain lessons learned. During each phase of this strategy, every attempt is made to anticipate and remove error precursors. The ultimate goal is to ensure that the operator maintains "positive control" of the activity or task: in other words, what is intended to happen, happens—and that is all that happens. To better understand this strategy, it is necessary to understand the fundamentals of human nature and why people make errors. Positive control can be achieved by understanding and practicing some basic human performance techniques.

2.7.1 Self-Checking

Self-checking is an error-prevention technique designed to reduce human errors, and it is effective during skill-based tasks that are performed with little conscious thought. During a shift, an operator can perform hundreds of tasks, from log readings to manipulating plant equipment. Also during a shift, it is not uncommon for an operator's attention level to vary. This is especially common during the performance of tasks that may be perceived as "automatic" or "routine." For these tasks, the challenge for the operator is to regain and maintain his or her attention at a level conducive to performing the task correctly and in which any unanticipated changes in the task can be detected promptly. Self-checking is a technique that the operator can use that is specifically designed to heighten his or her attention to important or critical points prior to the execution of the task. When the operator has focused his or her attention, he or she can take a moment to think about the intended task and its expected outcome. If there is uncertainty or if questions arise during this thought process, the operator should stop and resolve any issues before proceeding.

There is a weakness with self-checking, however. The operator may not recognize when to use the technique, what to pay attention to, or even where to pay attention. Self-checking relies on an operator's fundamental knowledge of the task (including its performance, indications, and cues), important decision points, and the desired outcomes or results. It is in a worker's best interest to be specific with self-checking practices. Self-checking works best when the operator knows the critical step(s) or phases of a task.

The following situations are appropriate for self-checking:

- Before and during the manipulation of any component or piece of plant equipment.
- Before and during the performance of any activity in which the improper performance of the task can result in 1) an undesired response or 2) either an inconsequential or consequential event.
- During critical steps that are identified during a pre-job briefing. This may forewarn an operator of an area in which his or her attention must be maximized.
- Before impending changes in equipment, system, or plant status.
- During periods in which error precursors are know to exist (for example, time pressure and task interruption).

The operator should pay attention to the following:

- The correct equipment or system is being operated.
- The proper procedures for the task are being used.
- The expected results are achieved.
- The unexpected is anticipated and contingencies are available.

The operator's attention should be focused on the following:

- The task to be performed. If distracted or interrupted during the performance, the operator should stop and refocus.
- The indications available to verify that the task was completed successfully. These indications may be either direct or indirect. A direct indication could be that motor amps are proper after a pump start; an indirect indication could be an unexpected lowering in tank level after a series of valve manipulations.

Pre-job briefings can assist in identifying where and what should be self-checked during the performance of a task.

The operator can implement the self-checking technique using a simple process or tool. This tool has taken on many acronyms in recent years, but the one most commonly used is STAR: stop, think, act, review. STAR is a human performance tool that can assist the operator in reducing skill-based errors during the performance of operational tasks.

Stop: An operator pauses prior to performing any operation or manipulation. This is especially important for any critical steps or decision points. Distractions should be eliminated.

Think: An operator focuses attention on the task or step to be performed. The operator must understand exactly what is to be accomplished and should verify that the action to be taken is appropriate for the equipment or system status. The operator should anticipate the expected result of the action and be aware of the indications available to ensure that the expected result is achieved. Consideration should also be given to actions that should be taken in the event of an unexpected result or response.

Act: If, during the performance of this step, the operator is distracted to the point that visual or physical contact with the equipment to be manipulated is lost, he or she should **stop** and re-verify that the proper component is about to be operated by doing the following:

- The operator confirms that the correct component is selected using a checklist, procedure, step, or drawing.
- Without losing eye contact, the operator touches the component or component label.
- The operator performs the action.

Review: The operator verifies that the anticipated result was obtained by comparing the actual with the expected response. If the expected result was not obtained, the appropriate contingency actions should be performed.

2.7.2 Peer Checking

Peer checking is an error-prevention technique that is similar to self-checking. Whereas self-checking involves a single individual, peer checking involves two individuals. With peer checking, an agreement is made between two individuals prior to the performance of a specific action or task. According to this technique, one individual (peer checker) observes or checks the behaviors or performance of the second individual (performer) to prevent an error from occurring.

The peer checker must be an experienced operator with experience and knowledge that are equivalent to or greater than those of the performer. Peer checking can be used to prevent an error from occurring during a specific task (for example, performing a critical valve alignment) or to verify that a plan of action is appropriate prior to implementation (for example, preparing a tag-out or clearance).

Peer checking is self-checking in parallel and results in an agreement between the performer and peer checker that the action or task is capable of being performed without error. It should be viewed as an error-prevention technique that augments self-checking but does not replace it. Peer checking provides the advantage of a second set of eyes and behaviors without being encumbered by the performer's task-oriented mind-set. The checker is given the opportunity to identify hazards, flawed defenses, or potential consequences the performer may not see or be aware of. The technique of peer checking is not infallible, however, and two heads may not always be better than one. A trap referred to as "social loafing" (described in Section 2.9.1, "Social Loafing") may result.

When should peer checking be used? In most cases, peer checks are performed at the request of an individual when he or she believes that the risk or conditions warrant it (for example, starting an emergency diesel generator and paralleling it to an electrical bus). Management may require peer checking for certain high-risk evolutions (for example, maneuvering the plant during power changes). When peer checking is accepted and ingrained in the culture, it may occur without a request from the performer. Often this is referred to as a "challenge peer check." It is not meant to challenge an individual's skills or abilities; rather, a supervisor typically issues the challenge when he or she anticipates that the risk associated with performing the task may be greater than the risk anticipated by the performer (for example, an infrequent plant test is being performed by an individual who has performed the test only once).

During periods of high activity, it is possible either that peer checking may not be able to be performed or that a peer checker may be performing a task of equal or greater risk and should not be distracted. It is the role of the supervisor to ensure that a peer checker is not distracted from an equally important task. Failure to do so may actually worsen a situation.

How is peer checking performed? As stated previously, peer checking is similar to self-checking. Peer checking may be described as self-checking with an observer. The following is the sequence to be performed for peer checking:

1. The performer requests or the situation warrants a peer check.
2. The performer goes through the first two steps of the self-checking process (that is, stop and think).
3. The peer checker verifies the task or action (including component and position identified) and understands both the reason for the action and the expected outcome and communicates agreement to the performer.
4. The performer then carries out the remaining steps of the self-checking process (that is, act and review).

2.7.3 Procedure Use and Adherence

2.7.3.1 General Information

Poor procedures can be a source of latent organizational weakness. To minimize human error in operations, it is essential that procedures be clear and accurate. This reduces an individual's reliance on skill and memory to perform a task or activity error free. In addition, it enhances an individual's decision making and ensures that a task or activity is performed consistently. The development and writing of procedures with error-reduction techniques is an entire human performance course in itself. However, procedures should contain certain attributes to increase their effectiveness or usability by an operator. From a human performance perspective, these attributes include the following:

- The procedure style should be usable. It should flow logically and use familiar terms that properly communicate the information.
- The procedure should contain the appropriate level of detail. If the detail is insufficient, the novice operator may find it unusable. Too much detail may discourage the experienced operator from using it. (For example, if a procedure for a commonly performed task is full of skill-of-the-craft information, the newly qualified operator may find it useful, but it will not appeal to the experienced operator.) A procedure's level of detail must correspond to the amount of training received by the user and not require the user to remember large quantities of detail in order to properly complete the procedure.
- The procedure must be accurate. Procedure development teams should be balanced with both experienced and less-experienced operators.
- Each procedure step should involve only one action. Multiple actions within a single step can lead to errors.
- Procedures should be periodically reviewed.

A subcategory of procedures is the "job aid" or "operator aid." These are permanent or semipermanent instructions, typically posted near a piece of equipment, that provide details regarding operation, checks, and so on. These should contain the same attributes as procedures do. If job aids are used, a process should be in place that tracks their existence and reviews them periodically to ensure that they are still applicable and correct.

Procedures communicate operating practices and experience, policies, programs, technical requirements, and safety considerations related to a task or activity. Procedures are intended to direct an individual's behavior so that positive control is maintained. This is accomplished by designating an appropriate level of use and proper sequencing and by reducing decision-making requirements. A procedure minimizes interpretation by the user, thereby ensuring consistency in the performance of the task or activity; minimizing interpretation also reduces the possibility of an error occurring during a procedure's use.

2.7.3.2 Use and Adherence

Expectations for procedure use differ, based on the complexity of the task or activity being performed. Procedure use specifies the minimum required expectation regarding how it is to be used. Three levels of procedure use widely used in the nuclear industry are continuous, reference, and information.

A continuous-use procedure requires that the user have the procedure in-hand while performing the task. Continuous-use procedures are designed for (but not limited to) complex evolutions or tests.

Reference-use procedures are used prior to or during the performance of a task to verify that the task is performed in accordance with the procedure (including initial conditions, operating parameters, and step sequence). Reference-use procedures are typically used for simple, short, familiar activities or tasks.

Information-use procedures typically communicate policies, programs, processes, and practices. These procedures are typically pulled and reviewed when a situation arises that requires clarification. Procedure "adherence" means that the intent of the procedure is followed regardless of the level of use. This requires that the user understand the intent of the procedure and what it is trying to accomplish. Common traps associated with procedure adherence include the following:

- Malicious compliance. This occurs when the user follows the procedure step by step as written, regardless of whether he or she knows that the procedure is incorrect. This behavior cannot be accepted.
- Deviations. Users may deviate from procedure steps based on their experience level, "tribal knowledge," or occasions in which a system or piece of equipment has a deficiency that does not allow the procedure to work as designed. The operator works around the problem.
- Nonprocedure use. This can become an accepted norm; it occurs over time when the standards of procedure adherence are not supported and upheld by supervisors and managers.

If a procedure cannot be used as it was intended, a formal process should be in place that allows the procedure to be modified. This process typically allows for temporary or "on-the-spot" changes as well as permanent changes to the procedure.

Procedure quality is paramount. Quality will degrade if procedure adherence is not supported and enforced at all levels of the organization. Casual use has several downsides. It may lead to required changes going unnoticed. Changes in user experience caused by turnover can result in procedures that do not have the level of detail required for their safe and effective use. Plant systems and equipment are continuously modified over the life of the plant. If procedures are not adhered to during equipment operations, these changes could become transparent and may result in equipment damage.

Additional considerations for procedural development to minimize error precursors include the following:

- Minimize mental and physical barriers as well as risk (for example, check procedure flow and logic and note the importance of key procedure steps).
- Reduce interpretation (for example, include the proper level of detail based on training and experience).
- Delineate key decision points or critical steps (including proper use of notes, cautions, and symbols to flag critical steps).
- Do not place actions in "note boxes." Notes are for information only.
- Eliminate technical inconsistencies within a procedure and among procedures.
- Use good human factors principles (such as references, graphics, flow charts, tables, logic and flow, and style).
- Eliminate drawing errors.

Additional ways to improve procedure effectiveness include 1) training on transitioning between procedures and 2) using placekeeping.

2.7.4 Procedures: Placekeeping

Some plant operations (such as power changes, plant startup and shutdown, and emergency/off-normal conditions) require extensive and detailed procedures that include branching and multiple decision points. If the procedure is not followed correctly (for example, steps are omitted or performed out of sequence), the plant may be placed in jeopardy, with significant consequences. During complex plant operations, multiple activities (such as placing equipment in/out of service, taking log readings, performing equipment monitoring, and effecting communication) are ongoing. People have difficulty processing more than a few pieces of information simultaneously. In this type of diverse and constantly changing environment, the technique of placekeeping is a proven error-prevention technique that aids the operator in managing multiple tasks successfully.

Placekeeping is the act of marking steps in a procedure as they are completed or marking the steps not applicable. This technique enables the operator to maintain positive control of the activity or task(s). Its benefit is increased when the task is interrupted or delayed (for example, because of shift turnover). Placekeeping is not appropriate for all procedures, however. It is different for each procedure based on the complexity of the task or activity, the procedure's logic path, or the relationship of the task to plant safety or reliability.

The physical practice of placekeeping varies. It is not necessary that all practices be used. However, when various practices have been chosen and agreed on, they should be used consistently across the organization. Some practices are required to be implemented during procedural development whereas others are implemented during procedure use. These practices include the following:

- Procedure development:
  - Proceduralize peer checks for risk-significant or critical steps.
  - Provide initial or signoff locations for steps within the procedure.
  - Identify the last page of the procedure.
  - Designate whether steps are required to be performed sequentially.
  - Present the procedure flow so that it is always progressing forward, if possible.
- Procedure use:
  - Verify that all of the pages of the procedure are included prior to use (that is, "page check").
  - Flag (using self-stick removable notes or dog-earring pages) monitor steps that require periodic verification of a plant condition(s).
  - Place a mark through procedure steps that are not applicable. Most prefer to label the step as N/A during actual performance; some have required that when a step is marked N/A, the reason for the marking is annotated in the margin and initialed.
  - Circle a step in progress and slash through the circle to indicate step completion.
  - Show that a procedure page is completed by flagging or marking it with some annotation at the bottom of the page.
  - If distracted, re-read the previous two or three steps prior to the current step to refocus attention.

Whenever a technique or practice is established, the potential of creating one or more error precursors or traps exists. Various at-risk placekeeping practices that should be avoided include the following:

- Using checkmarks versus initials or signatures to show step completion. (Checkmarks or similar marks can be mistaken for completion marks.)
- Use of "ditto" marks. (These can be mistaken for completion marks.).
- Requiring placekeeping on less complex procedures (for example, procedures that are marked as reference or information.) (This reduces the significance of the technique.)

- Signing off on steps before they are reported and verified to be complete. (This could result in undesired plant or equipment results.)
- Use of a single set of initials with a line extending through additional steps down the procedure. (This may result in the incorrect marking of a procedure step as completed.)

2.7.5 Communication

Communication is a fundamental activity required to accomplish almost any task, whether that communication is oral or an action. Ineffective communication plays a role in almost every event: the wrong message was sent, the wrong message was received, or the message was misunderstood. Effective communication can reduce errors that cause events and can be realized by understanding the barriers that prevent it and by using some human performance communication tools.

The three barriers to effective communication are sender, receiver, and physical. It is necessary to understand how these barriers affect communication in order to overcome them. Figure 2-7 illustrates the relative effect that a barrier has on communication as well as the ease with which a barrier's existence can be detected.

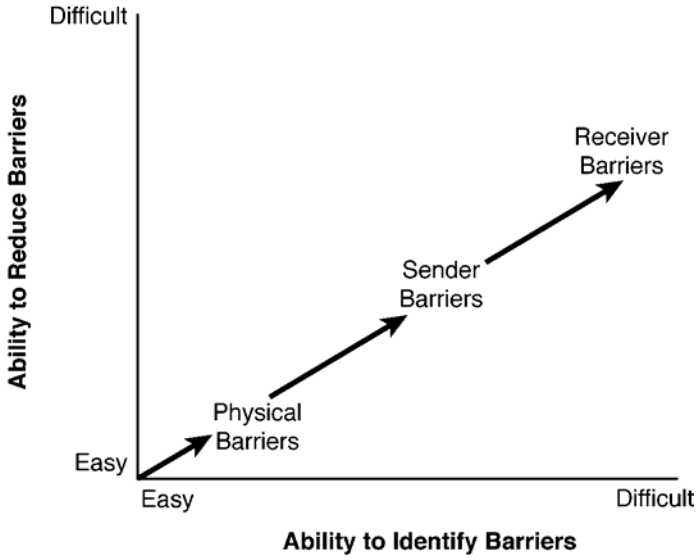

Figure 2-7
Relative Strength of Communication Barriers

2.7.5.1 Physical Barriers

Physical barriers are associated with the environment where the communication takes place and are the easiest to overcome. They are readily recognized by both the sender and the receiver, and correcting physical barriers does not pose a risk to the ego of either. Typical examples of physical barriers include the following:

- Noise
- Temperature (which can make the communication setting uncomfortable)
- Distractions

2.7.5.2 Sender Barriers

Sender barriers are typically associated with the way in which the message is communicated as well as its content. Examples of sender barriers include the following:

- The sender assumes that the receiver has the appropriate knowledge to understand the message.
- The sender uses terms unfamiliar to the receiver when communicating with the receiver.
- The communication is too wordy, thus confusing the receiver about what the real message is.
- Multiple actions are included in a single message.

Often the sender is not aware that the communication barriers exist. It is also possible that the sender is aware of the barrier but fails to do anything about it because he or she either does not know what to do or does not want to take the time to fix it. It is the sender's responsibility to achieve the necessary understanding from the receiver.

2.7.5.3 Receiver Barriers

Receiver barriers are related to mind-set. The most common of these barriers are not paying attention and daydreaming. Examples of receiver barriers include the following:

- Receivers tend to see and hear what they want to see and hear.
- Receivers say that they understand when in fact they do not, and they do not ask questions (for fear of looking or feeling stupid).
- Receivers' minds are preoccupied with other things (for example, personal issues).

As with the sender, the receiver may not be aware of the barrier's existence. Likewise, if the receiver is aware of it, he or she may not know what to do about it or even want to do anything about it.

2.7.5.4 Communication Tools

Communication tools such as three-way communication and use of the phonetic alphabet assist in alleviating many of the barriers of both the sender and the receiver. Three-way communication establishes a common framework within which both the sender and receiver work. Three-way communication ensures that the correct message is sent and received, but it does not guarantee that the receiver understands what to do with the message after it is received. In conjunction with other human performance tools (such as a questioning attitude and stopping in the face of uncertainty) and along with effective teamwork, message understanding can be achieved. The phonetic alphabet is a first step toward achieving clarity in a message. Some letters sound similar (for example, B, C, D, and E) and could be confused in a noisy environment, and the phonetic alphabet addresses this. The second part of message clarity is having commonly used names for equipment. The use of certain words should also be avoided; for example, instead of "increase" and "decrease," use "raise" and "lower," respectively.

2.7.6 Questioning Attitude

As humans, we prefer certainty and order in our environment. There is a tendency to explain away or ignore the abnormalities or uncertainties that disturb our surroundings, especially when we are performing routine or familiar tasks or activities. During the performance of these tasks, we tend to relax mentally; performance reverts to an "unconscious" state (that is, we don't think as we act). The task may have been performed thousands of times without error, so we develop the attitude that nothing can happen. The technique we can use to prevent this type of thinking is to have a questioning attitude.

A questioning attitude is one in which individuals question their actions before they act. When confronted with uncertainty, an individual should stop what he or she is doing and ask, "Based on the current conditions and circumstances, is this the right thing to do?" Stopping and thinking through that question can help to ensure that subsequent actions will be performed using facts rather than assumptions. Knowledge of facts promotes alertness and minimizes the potential for error. Cues that should trigger an individual to stop and ask questions before proceeding include the following:

- The individual has conflicting information.
- The individual is uncertain about what to do.
- The individual is in an unexpected situation.
- The individual needs to perform a critical or risk-significant action.
- The individual needs to make a significant decision.

Embracing a questioning attitude during the performance of tasks or activities promotes awareness of uncertainty and hazards.

A questioning attitude can be used at any time but is predominantly observed during rule-based situations. Using "if-then" logic or asking "what if?" raises the alertness level of an individual or team, which is a beneficial tool for the devil's advocate working in team situations. The questioning attitude meter is illustrated in Figure 2-8.

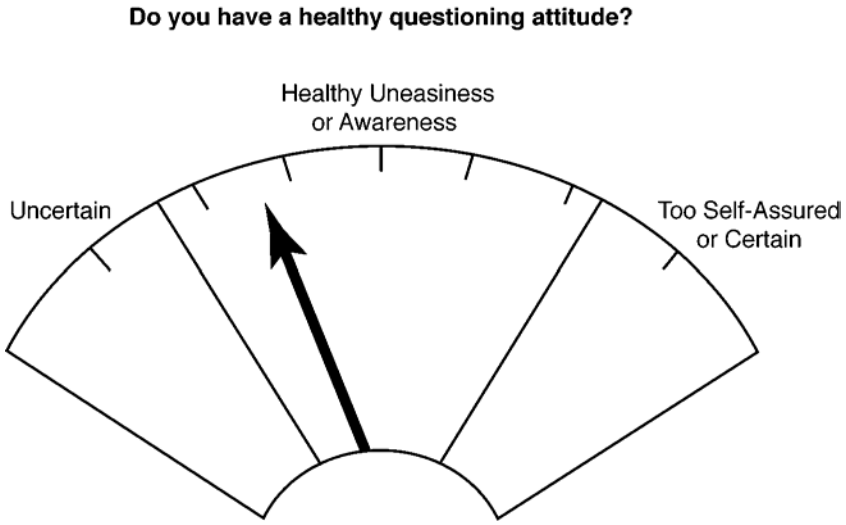

Figure 2-8
Questioning Attitude Meter

If a healthy questioning attitude does not exist within the individual or team, it is extremely difficult to develop either an intolerance for uncertainty or an awareness of error precursors. A healthy questioning attitude assists in overcoming the temptation to rationalize away uncertainty using familiar solutions or a simple "gut feeling." A questioning attitude fosters looking ahead for error traps and uncertainties prior to performing a task or activity. Two error traps often used by operator that undermine a questioning attitude are "cook booking" and "thumb rules." Cook booking occurs when an operator mindlessly follows a procedure without thinking about his or her action or looking ahead. "Thumb rules" are familiar, often simple, solutions that an operator applies to familiar problems. However, because of human nature, the operator may be applying a familiar solution to a problem that is similar to but not the same as the problem from which the "thumb rule" was derived. A difference exists, and an error trap and error-likely situation is in place. One error-prevention technique that can assist the operator with a questioning attitude is qualify, validate, and verify (QV&V).

2.7.6.1 Qualify, Validate, and Verify

QV&V is a systematic mental process used to confirm raw information as fact. The use of QV&V promotes the development of critical-thinking skills, allowing an individual or team to perceive information correctly and thereby ensure that actions taken are based on fact and are

the best for a given situation. QV&V is especially useful in the prevention of rule-based mistakes involving the misinterpretation of information or situational conditions. It can be categorized as follows:

Qualify: Qualifying is a test of the information's relevance and reliability. Is the information from the right source?

Validate: Validation is a "gut check" to test the information's accuracy and reliability. Does the information make sense based on the current situation and conditions? If the source of the information is suspect or the information does not "feel right," it is necessary to verify the information.

Verify: Verification is the act of testing the information using one or more external sources of information to verify its correctness. If the information cannot be verified by revealing facts that support the initial information or address the questions of uncertainty, **stop**.

QV&V provides an individual or team member with a consistent methodology for processing information into facts. The probability of committing decision-making errors can therefore be minimized.

An operator facing uncertainty should stop and get help. Take, for example, an operator filling a tank. If the level indication is not going up, the operator should not continue to fill the tank.

The error-prevention technique of pre-job briefs enhances a questioning attitude. A good pre-job brief includes risk-significant and critical steps, error-likely situations, and failures and their contingencies as well as provides a forum in which "what if?" and "if-then" questions can be answered.

2.7.7 Coaching

Coaching is a behavior-control technique used by supervisors and peers to provide informal guidance and instruction, follow an individual's progress, and provide constructive feedback. Coaching provides an opportunity for training, feedback, and recognition. It is an effective method of personnel development that focuses on the core skills necessary for a person to perform his or her job. It also provides an effective platform for clarifying and reinforcing expectations and assisting personnel in achieving them. If properly implemented, coaching can improve overall job performance.

Key Human Performance Point

Coaching provides an opportunity for training, feedback, and recognition. It is an effective method of personnel development that focuses on the core skills necessary for a person to perform his or her job. If properly implemented, coaching can improve overall job performance.

Coaching is an informal training method that does not have the inflexibility and generic approach to learning that is characterized by classroom instruction. Rather, coaching provides one-to-one flexibility for just-in-time training to improve an individual's skills and behaviors. The supervisor or peer has the opportunity to pass along skills and experience to increase the overall knowledge of the person coached. It is an active, hands-on technique that gives the supervisor or peer the opportunity to observe and guide performance. Effective coaching develops high performance, commitment, competence, and morale in addition to motivating behavior.

Although the steps in the coaching process are straightforward, coaching requires a variety of skills and knowledge. To be an effective coach, the supervisor or peer must possess understanding and knowledge of the process and be proficient in a variety of skills and techniques. They should also receive training in coaching and observation techniques to make this process effective. The coaching steps are as follows:

1. Prepare the participant for the coaching experience.
2. Establish a positive atmosphere for the coaching experience.
3. Demonstrate proper performance of the task or activity.
4. Observe the participant performing the task or activity.
5. Provide feedback.

Each of these steps is explored in more detail next.

1. **Prepare the participant for the coaching experience**. The coach should establish the realistic expectations of the task and why they are important. This should include expectations regarding successful completion of the task as well as the requisite behaviors (such as human performance and personal safety). The coach should establish a positive atmosphere that is conducive to a good learning experience and put the participant at ease during questioning. Starting with simple questions and working toward more difficult ones helps build the participant's confidence and lessens the fear of being incompetent. The coach should provide encouragement and empower the participant to feel confident in acting independently. Communication should be such that the participant is not placed in a defensive posture.
2. **Establish a positive atmosphere for the coaching experience**. This starts with putting the participant at ease with the coaching experience and carries throughout the process. The coach should exhibit empathy, be approachable, and provide positive reinforcement rather than blame or criticism. Guidance should be subtle; a good coach knows when to step in and help (see Section 2.7.7.3, "Some Do's and Don'ts of Coaching"). A good coach also avoids being a "crutch" or creating an unhealthy dependence and rather, lets the participant find his or her own way.
3. **Demonstrate proper performance of the task or activity**. The coach must first possess the skills and behaviors necessary to perform the task and demonstrate how the task should be performed. During the performance, the coach should explain critical task steps and associated behaviors and provide opportunities for the participant to ask questions. A great

deal of responsibility is involved with being a coach: a coach must avoid an attitude of "do it just like me and you'll be fine."

4. **Observe the participant performing the task or activity**. The coach should use good observation techniques (described in Section 2.7.8, "Observation"). Details the coach should be aware of include the following:
   - Does the participant possess the knowledge of what to do?
   - Does the participant demonstrate the basic skills required to perform the task?
   - What is the participant's interest level?
   - Is the participant confident in his or her performance?
   - Are there barriers that are limiting the participant's performance?

   If difficulties arise during the performance of the task, a good coach knows when to step in. (This is, in fact, the opportunity to coach.) A coach should give the participant good advice, show how the task is performed, create challenges for the participant, and remove barriers that may be limiting the participant's effectiveness. The setting should be conducive to the coach's providing a solid evaluation of the participant's progress. In addition, the coach should ask questions to enhance the evaluation process.

5. **Provide feedback**. This may be the most important step in the process: it can provide the greatest benefit, yet—if not performed properly—can do damage in many areas. A coach should provide constructive feedback that informs the participant of the areas in which he or she can improve. It is not criticism. The feedback should be directed at the actions and not at the participant. The participant must be receptive to feedback and not take a defensive posture when honest feedback is received. This step also provides the opportunity for positive feedback and recognition. A coach should tell the participant if his or her performance was good, using specific comments. A good coach remembers to never underestimate the power of recognition: it can be a powerful motivator if it is appropriate, honest, and timely.

Key Human Performance Point

Never underestimate the power of recognition. It can be a powerful motivator if it is appropriate, honest, and timely.

2.7.7.1 Coaching As Teamwork

Coaching is teamwork between the coach and the participant. The coach's responsibilities have been thoroughly explained, and the participant also has responsibilities in this process. Behaviors that should be exhibited by the participant during the coaching process include the following:

- The participant should be motivated and demonstrate an interest in learning new skills and improving on those that he or she already possesses.
- The participant should take initiative and be prepared for the coaching experience. Reviewing the knowledge, skills, and behaviors necessary for successful performance makes the coaching experience more beneficial.

- The participant should be a good communicator because frequent face-to-face communication is an essential component of the coaching process. Developing and maintaining open lines of communication generates trust and commitment between the coach and the participant and provides the opportunity to share information, ideas, and feedback. Listening should be non-defensive.
- The participant must be "coachable," that is, must be receptive to feedback and willing to act on it. The feedback process should be a non-threatening experience for both the coach and the participant.

2.7.7.2 Peer Coaching

Peer coaching is an often overlooked form of coaching. The techniques that have been previously described are applicable to peer coaching as well. This approach is especially useful with operators who need qualification and also during the introduction of new processes or changes (for example, human performance techniques). As stated, the process is the same except that the coach is now a peer with equal status and competency. The participant therefore experiences a greater comfort level because he or she feels freer to express himself or herself and is open to discussion. Peer coaching reduces the negative aspect of "power" in the learning experience: the participant feels more confident, demonstrates a greater willingness to learn, and generally exhibits better performance.

2.7.7.3 Some Do's and Don'ts of Coaching

Effective coaching is a skill if not an art form. It takes a great deal of skill, technique, and practice to be good at it. Recommendations for both the coach and the participant to enhance the overall success of the coaching experience include the following:

- Stay neutral: don't blame or criticize.
- Know what you are talking about: you must be good at the task you are coaching.
- Ask questions.
- Don't be intimidating, and the participant should not feel intimidated.
- Be organized, patient, and understanding.
- Be a good listener.
- Keep an open mind to other points of view.

2.7.8 Observation

Observation is defined as the act or practice of noting and recording facts and events. A well-implemented observation program is a vital component of a human performance program. There is no substitute for personal observation: it gives the supervisor an opportunity to obtain critical information about people, processes, and systems. Field observation allows the supervisor to

gather firsthand knowledge about how well standards are understood and are being followed. Direct knowledge can be obtained regarding the following:

- Human performance. Use self-checking, peer checking, procedure use, and QV&V.
- Industrial safety practices. Do people understand and follow safe work practices?
- Procedural adequacy. Do procedures contain sufficient detail for the level of knowledge, skill, and experience of the operator?
- Communication. Use three-way, phonetic alphabet, and active listening.
- Personal skills. Is training adequate? Is the operator confident in his or her work?
- Housekeeping. Look for cleanliness, safety hazards, lighting, and error-likely situations.

An effective observation program benefits everyone—the operator, the observer, and the organization—as follows:

- The operator has the opportunity to receive feedback on his or her performance. Constructive feedback can improve work performance and reinforce behavior. In addition, recognition (in conjunction with positive feedback) can increase morale.
- The observer obtains firsthand knowledge of both the way in which policies are being implemented as well as the work practices and skills of the operator.
- The organization obtains lessons learned from the observations. These lessons can be communicated throughout the organization in order to improve performance and reinforce standards.

Key Human Performance Point

An effective observation program benefits everyone: the operator, the observer, and the organization.

The observation process is implemented in four major steps:

1. Prepare for the observation.
2. Conduct the observation.
3. Follow up and provide feedback on the observation.
4. Prepare a report of the observation.

2.7.8.1 Prepare for the Observation

The preparation phase consists of three major activities. First a determination must be made regarding what should be observed. The observed task, activity, or process should be important to the organization or to the supervisor. Considerations for observations may include tasks or activities important to plant reliability, operator performance, follow-up on plant problem areas identified through the corrective action program (CAP) or from monitored performance indicators, follow-up on the effectiveness of corrective actions, or reviews of understanding of a program or process.

After the determination of what should be observed has been made, the next step is to gather all information related to every aspect of the task, activity, or process to be observed. Information may include the following:

- Programs (such as human performance, industrial safety, and the clearance/tag-out process)
- Procedures (such as operating and administrative)
- Expectations and standards
- Drawings

When all of the information has been gathered, the next step is to become familiar with it. It is beneficial to construct a plan or checklist of items to observe during the observation.

2.7.8.2 Conduct the Observation

The second step of the observation process is conducting the observation. Similar to coaching, the observer should prepare the operator(s) being observed, and the observer should put the operator(s) at ease by doing the following:

1. Establish a rapport.
2. Brief the operator(s) about the observation before going into the field.
3. Explain to the operator(s) what you are doing.
4. Explain why you are doing it.
5. Explain that you will be taking notes and that you will review the notes with the operator if he or she requests.
6. Tell the operator that you will make every attempt to be a minimal distraction. Stay out of the way and keep questions to a minimum. Questions can be pursued after the task or activity performance.

During the course of the observation, an observer should remain aware of items that may keep a problem or area for improvement from being recognized, called “blinders.” Examples of these include the following:

- Excuses: “It’s not my job.”
- Traditions: “That’s the way it’s always done here.”
- Friendships: “I know him and he always goes by the book.”

Certain skills can increase the effectiveness of an observer, including the following:

- Increasing your patience: slow down and watch.
- Paying close attention to your physical surroundings: who, what, where, and how.
- Being aware of people’s reactions, emotions, and motivations.
- Asking questions that can be answered through observing.

- Being yourself.
- Observing with optimistic curiosity.
- Being ethical.

2.7.8.3 Follow Up and Provide Feedback on the Observation

Step three in the observation process is follow-up and feedback. During the observation, it is likely that a potential problem or area for improvement may have been observed. The process of follow-up is designed to answer the following questions:

1. Does a problem or area for improvement exist?
2. Is it significant?
3. What are the probable causes?

The first important item to review is the notes from the observation, which should be the "facts" of what was observed. The second item to review is the source documents for the observed facts. It may be necessary to conduct follow-up interviews with the operator(s) involved with the observed task or activity to clarify notes or gain additional information. Similar to coaching, setting the proper tone during these fact-finding interviews is crucial. The observer must avoid criticizing or placing blame.

Providing feedback from the observation is as important as conducting the observation itself. The techniques used in providing feedback are the same as those presented in Section 2.7.7, "Coaching." The feedback should be timely and should be performed, if possible, at the completion of the task or activity. If there are items known to require additional follow-up, it is permissible to inform the observed that follow-up will be required and feedback will be provided when the follow-up has been completed. The observer should not miss the opportunity to provide positive feedback and recognition if appropriate. Feedback is not a lecture or a monologue; it requires two-way communication.

It is also possible to provide feedback in a more formal setting, such as in a classroom or meeting. In this setting, the observation can be used as a training tool and widely disseminated throughout the organization. Lessons learned are communicated, and positive aspects of the observation are reinforced. Again, this feedback setting also requires good two-way dialogue. The observer should take this opportunity to both ensure that all individuals understand the results and to solicit ideas.

2.7.8.4 Prepare a Report of the Observation

The last step of the observation process is the report. The report should contain the facts of the observation, problems, areas for improvement, why they are problems or areas for improvement, and their basic causes and significance. The report should also include the positive aspects of the observation. A sample observation report may follow a format such as this one:

I. Executive Summary

A. Scope

- What was observed.
- Number and types of people observed: **do not use names**.
- Date and time of observation.
- Any special considerations surrounding the observation.

B. Conclusions

II. Observation Details

2.7.9 Devil's Advocate

The technique of devil's advocate can be an effective error-prevention technique in a team or group situation. The individual's role as devil's advocate is to continuously monitor and challenge the actions, decisions, and behaviors of the team. As individuals, we can easily become focused on accomplishing a task or activity rather than considerations that could prevent us from accomplishing the task or the consequences resulting from improper performance of the task. The role of the devil's advocate can be a challenging one. It is best that the devil's advocate has not been a part of the planning process in order to avoid being drawn into "groupthink" (that is, excessive degree of group cohesiveness) as well as to ensure objectivity. He or she should also be familiar with team error traps and challenge the team when any of these traps is observed. Tools or methods available to assist the devil's advocate in his or her role include the following:

- Be observant for any contradictions or inconsistencies in the plan or activity.
- Ensure that the plan or activity is proper for the conditions under which it will be performed (that is, initial conditions and prerequisites).
- Ensure that proper resources are available to successfully accomplish the task (such as personnel and communication and test equipment).
- Observe whether the situational awareness of the team is properly focused on the task or activity (including perceptions and assumptions).
- Determine whether error precursors have been thoroughly considered to prevent error-likely situations.
- Determine whether the consequences of failure have been thought through and that contingencies have been developed, if required.

A technique that the devil's advocate can use to challenge the team is called "pre-mortem," in which the team is required to go "back to the future." The team conducts a pre-mortem on the plan, task, or activity under the assumption that the plan was implemented and was not successful. The team critically examines the reasons that the plan failed. This technique forces the team to examine the plan as well as factors that affect the plan's outcome. Each decision point should be challenged with "what if?"

The role of the devil's advocate can be especially beneficial when the team is operating in knowledge-based space, including problem-solving and decision-making situations.

2.8 Human Nature and Its Limitations

Reducing the error rate can minimize the frequency of events. From an operational perspective, the error rate can be reduced through thorough task preparation, proper task execution, and post-task review to gained lessons learned. During each phase of this strategy, every attempt is made to anticipate and remove error precursors. The ultimate goal is to ensure that the operator maintains positive control of the activity or task: in other words, what is intended to happen, happens—and that is all that happens. To better understand this strategy, it is necessary to understand the fundamentals of human nature and why people make errors.

2.8.1 Human Nature

On any given day, anyone can and will make a mistake. One approach to reducing human error is to remove the human element. The automation of systems and tasks has done this in many industrial applications. However, this approach is not a viable alternative for all situations or activities in our lives. When dealing with the human element, the focus must shift to human factors and processes.

As humans, we are all subject to the limitations of human nature. Human nature can be categorized into five basic groups: physical, biological, intellectual, emotional, and social. Even though these groups can be individually explored, complex relationships exist between one or more of them. For the purpose of this discussion of human performance, the intellectual, emotional, and social groups will be explored to determine their effect on human error.

> "The ability to detect error likely situations to head off preventable events depends largely on how well these factors are understood regarding their role in human error."
> James Reason, *Human Nature*

An understanding of human limitations 1) creates an awareness that aids an individual in identifying when these conditions exist during the performance of an activity or task and 2) reduces the likelihood of an event occurring. Some of the limitations that all humans possess that set up these error-likely situations are explored next.

2.8.2 Limitations

2.8.2.1 Awareness of Mental Strain

It is a natural tendency for individuals not to engage in concentrated thinking. Concentrated thinking requires heightened attention levels that may be required to be maintained for long periods of time. The thinking process itself is slow and laborious, requiring much effort on the part of the individual. As a result, humans tend to rely on and apply familiar patterns and experiences. They apply these learned solutions to solve problems, even though the situation and circumstances may differ from the original situation. Under these conditions, it is also possible that an individual will settle for a satisfactory result rather than try to achieve the optimum result (that is, take a shortcut). Shortcuts are formed in a variety of ways, including the following:

- Habit
- Assumptions
- Reliance on previous similar situations
- Reliance on frequent and well-used solutions
- Reliance on readily available information
- An unwillingness to change one's mind

2.8.2.2 Inaccurate Mental Models

Humans remember previous situations, but they do not necessarily recall all of the information pertaining to the situation. Details are difficult to remember. Humans tend to break things (ideas and concepts) down into less complex elements, pictures, or key components. When this happens, it is likely that not all of the relevant information is transferred from the basic situation from which it was originally derived. One way to prevent errors caused by inaccurate mental models is to follow procedures.

2.8.2.3 Limited Working Memory

Humans have a limited ability to recall information. An individual's short-term memory is limited to handling only a few bits of data at one time. Most people can remember only three or four things concurrently. People therefore dissect complex problems into simpler problems that can be handled in a logical, sequential process. This prevents the limited conscious reasoning capabilities from becoming overloaded with information. The use of checklists, procedures, and placekeeping techniques allows the operator to perform complex tasks with a lower probability of error occurring.

2.8.2.4 Limited Attention Resources

This human limitation involves the inability to focus on multiple challenges. Humans have difficulty processing information received simultaneously from various sources. Typically, the mind is capable of focusing on only two or three things simultaneously. At best, the mind is capable of focusing on only two or three things simultaneously. Trying to focus or concentrate on multiple tasks or activities induces stress that causes "tunneling" or "vagabonding." An individual involved in tunneling will focus on one information source or task, excluding all others. This is also referred to as "tunnel vision." *Vagabonding* is a process in which an individual looks at all of the sources of information but without a clear understanding of what each piece of information means—either individually or collectively, which leads to information being overlooked. Attention to activities can be improved through training, experience, and following procedures.

2.8.2.5 Mind-Set

Human are goal oriented. This causes an individual to focus his or her attention on activities or tasks that he or she wants to accomplish, excluding things that should also be receiving attention. In this condition, the individual sees only what he or she wants to see. An individual who has developed a mind-set either blocks out information of value or brings in information with little or no relevance. The individual misses the unexpected and can see that which does not exist. This limitation can be addressed through pre-job briefs that assist an individual in recognizing those things necessary to accomplish the activity error free.

2.8.2.6 Limited Perspective

This limitation exists because humans cannot see everything that must be seen. Humans possess values, skills, experiences, training, and a host of other attributes that act as filters and therefore present challenges to the processing of information needed to solve problems. Because of these filters, only parts of a problem may pass through—contributing to an inaccurate mental picture and possibly resulting in underestimating the risk. If an organization has a comprehensive and well-tested problem-solving method, this limitation can be managed.

2.8.2.7 Fatigue

Fatigue degrades a person's ability to work effectively. Humans experience physical, emotional, and mental fatigue. Alone or collectively, any of these can lead to poor judgment and error. A major cause of fatigue is sleep deprivation. Sleep deprivation has the following effects:

- Reduced reaction time
- Reduced motivation
- Impaired short-term memory
- Decreased vigilance

- Increased irritability
- Increased likelihood for errors

Studies have determined that sleep-deprived individuals may have reaction times as poor as those of individuals approaching legal intoxication limits. A study published by the *British Journal of Occupational and Environmental Medicine* reported that getting less than 6 hours of sleep a night may affect coordination, reaction time, and judgment. It also reported that sleep-deprived individuals may have higher levels of stress, anxiety, and depression and may take unnecessary risks.

Fatigue can also be affected by job demands (such as production, environment, and staffing) as well as lifestyle demands (for example, diet and sleep). It would be difficult to control lifestyle demands, but job demands can and should be controlled by managers and supervisors. Operating staffs should be given adequate rest time when rotating from day-to-night or night-to-day shifts. The shorter the time between rotations, the more fatigued the operator feels. Inadequate rest time between rotations has been found to cause fatigue-related errors. Adequate staffing, restrictions on overtime, and production pressures can be and have been controlled by regulation in the nuclear power industry to address fatigue. Other causes of fatigue include time on duty, time since awakening, task difficulty, and environmental factors such as noise, temperature, and vibration.

2.8.3 Shift Work and Fatigue

The invention of the light bulb in 1883, coupled with the industrial revolution, resulted in a new breed of worker: the shift worker. More than 25% of the total work force work shifts outside the normal daylight working hours of 8:00 a.m. to 6:00 p.m. And to "keep that lightbulb burning," operators at electric power production facilities are among the shift workers.

With the advent of shift work, a whole new set of problems was born. When work is performed outside normal work hours, physical and psychological problems can compromise a worker's well being. Humans are biologically day-oriented, functioning best during daylight hours and sleeping at night. Many bodily functions seem to occur more or less on some sort of schedule. These bodily cycles are controlled by our circadian rhythm (our biological clock). Shift work disrupts the circadian rhythm that regulates many physiological processes, including sleep and wake patterns. When the "clock" is "out of sync" because of shift work, many of these processes can be affected. Some studies suggest that a change in work period of more than 3 hours can cause these cycling internal functions to become desynchronized. Biological functions affected by a disruption in circadian rhythm include the following:

- Body temperature
- Digestion
- Hormone levels
- Sleep patterns

Through the circadian cycle, the various biological processes go through maximums and minimums, with maximums occurring during the day and minimums during the night. The body is at its lowest temperature between 3:00 a.m. and 6:00 a.m. This is a period of low alertness and greatest risk for mistakes. Processes undergoing these swings include the following:

- Body temperature
- Heart rate
- Blood pressure
- Respiration
- Adrenaline production

The disruption of the circadian rhythm obviously results in many undesired effects within the body. The one of greatest concern with respect to human behavior and error reduction is the sleep pattern. Working night shifts results in less sleep and poorer quality of sleep. Simply stated, night-shift problems are rooted in on-duty sleepiness and off-duty insomnia. The optimum amount of sleep varies from one individual to another. However, the average amount of sleep expected for an adult is 7–8 hours per night. Less than this amount results in *sleep debt*, which is the difference between a person's required amount of sleep and the actual sleep obtained. Sleep debt leads to fatigue and accumulates until the person gets enough sleep to recover it. As the sleep debt accumulates, the individual's performance worsens. Many studies have been conducted on sleep debt, fatigue, and human performance. There appears to be agreement that sleep debt and the resulting fatigue does affect human performance. However, there is disagreement about whether more events occur on the night shift than on other shifts. Even with this disagreement, it should be noted that some of the most recent significant events have occurred on the night shift:

- Three Mile Island, 1979 (approximately 4:00 a.m.)
- Chernobyl, 1986 (approximately 1:30 a.m.)
- Exxon Valdez, 1989 (approximately 12:00 a.m.)
- Bhopal, 1984 (approximately 12:00 a.m.)

When a person gets fewer than 5 hours of sleep over a 24-hour period, his or her peak mental abilities begin to decline. A person can function for two or three days with 4 hours of sleep per 24-hour period, but it is at less-than-peak levels. Changes are observed in judgment, performance, response times, tolerance of errors, decision making, and motor skills. After one night of missed sleep, cognitive performance can decrease 25% from baseline. After a second consecutive night of missed sleep, cognitive performance can fall to nearly 40% of baseline. Getting 2–3 hours less sleep per night over a 5–10 day period may result in a degradation of general and cognitive performance.

There is also considerable debate about the correct shift length. Which is better: an 8- or a 12-hour shift? Some studies suggest that after the ninth hour, accident risk increases exponentially—especially for night-shift workers. Shifts longer than 8 hours may result in worker fatigue. Other studies have determined that there is no difference in sleepiness or fatigue

between 8- and 12-hour shifts. Another study concluded that changing from 8- to 12-hour shifts leads to increased alertness on the job and better recovery time after night shifts. The studies did not provide any information about the work situations and industries studied, and therefore, the type of work that is suited for an extended workday is not known. Some considerations include environmental conditions on the job (such as temperature, noise, and vibration) and job characteristics (for example, boredom and repetitive work). It is best to let the shift workers and their supervisors, with final approval by Operations management, determine what they believe is best for their operations. A trial period of extended hours would allow the operators to determine whether they prefer extended hours and the opportunity to monitor the health and safety aspects of the extended-hours shift. To assist in making this decision, the following are some of the considerations, advantages, and disadvantages of extended shifts:

- Considerations
  - Consult workers about their desire to change work schedules, especially an extended workday.
  - Consider the physical demands of the job.
  - Consider the mental and emotional demands of the job.
  - Consider the workers and other demands that may be placed on them outside the job.
  - Under trial periods, look for changes in injury rates, health levels (fatigue), and changes in absenteeism rates (a decrease may show that the extended workday is successful; an increase may indicate problems other than health). Follow up with workers' reactions and comments.
- Advantages
  - More days off and more consecutive days off.
  - More family and leisure time.
  - More rest days to recover from fatigue.
  - Fewer consecutive workdays.
  - Improved morale.
  - Increased job satisfaction.
  - Reduced absenteeism.
  - Reduced commuting overall.
- Disadvantages
  - More days off and more consecutive days off (that is, operators may lose touch with the plant).
  - Possible decline in safety and alertness.
  - Slower pace of work.
  - Workers need more breaks.
  - Workers may be more tired during commutes.

Extended work hours can occur in ways other than a scheduled 12-hour shift. A person may be held over after a normal 8-hour shift or called in early prior to a scheduled 8-hour shift. In both cases, the individual has not had an opportunity to prepare for the extended hours. The likelihood of decreased performance from individuals working in these situations increases. Typically, the extended shift is 4 hours before or after the regular shift, and in some cases, it may go beyond these time periods. Many industries (for example, airlines, nuclear plants, air traffic control, and ground transportation) regulate extended hours by limiting the number of consecutive hours worked and the number of hours worked in a given time period. Studies have shown that when work hours exceed 12 continuous hours, there is a significant decrease in performance.

There are definitely costs associated with long working hours. The following data are from a shift-work study conducted by Circadian Technologies:

- Non-exempt employees are usually compensated at a rate of one-and-one-half times their regular pay. This can typically be justified by the reduction in additional costs associated with an extra employee.
- Excessive overtime can compromise safety, health, and productivity through indirect costs.
- A study of white-collar workers showed that performance decreased by as much as 20% when the work week exceeded 60 hours.
- In 18 manufacturing industries, a 10% increase in overtime resulted in a 2.4% decrease in productivity.
- A total of 31% of operations with high overtime (greater than 25%) had low morale compared to 13% of those with low overtime.
- Facilities that reported severe fatigue-related problems had average workers' compensation claims of $4037 compared to moderate fatigue-related problems ($2240), minor fatigue-related problems ($981), and no fatigue-related problems ($276).

Key O&M Cost Point

There are definitely costs associated with long working hours. Facilities that reported severe fatigue-related problems had average workers' compensation claims of $4037 compared to moderate fatigue-related problems ($2240), minor fatigue-related problems ($981), and no fatigue-related problems ($276).

The effects of shift work on the circadian rhythms and the fatigue that may result from shift work are only a few of the effects of shift work. It is a complicated topic, and shift work affects people in different ways. Supervisors should be aware of other effects of shift work that may manifest themselves as performance problems, including the following:

- Higher absenteeism rate
- Higher error rate
- Physical and psychological problems
- Increased injury rate

- Poor morale
- Lower productivity
- Higher attrition rate

Shift work is a part of Operations associated with electric power production. However, the problems associated with shift work can be managed if both the organization and the individual are educated about the hazards of shift work, the signs of fatigue, and the implementation of techniques to minimize the fatigue associated with shift work. Surveys or questionnaires are often used to help managers to determine the impact of shift work on their employees. These must be administered anonymously, and they can provide valuable insight about the need for some sort of change or management of a problem. In addition, some considerations to help the organization and the individual manage the fatigue caused by shift work are provided in Appendix D. A sample questionnaire is provided in Appendix E.

2.9 Team Errors

"Are two heads better than one?" It would appear that a "second set of eyes" would provide an additional barrier against human error; however, this is not always the case. Errors that occur when two or more individuals perform a task together are known as *team errors*, and they occur when shortcomings in performance are triggered by the social interaction among team members. In a team situation, an individual may not apply full attention to the task or may be influenced by the presence of another team member. Therefore, two or more individuals performing a task together is no guarantee that the task will be performed error free.

2.9.1 Social Loafing

Social loafing is defined as the tendency for people to exert less effort when working as a team toward a common goal than when they are individually accountable. In the broader sense, it is presented by Latane in "Many Hands Make Light Work: The Causes and Consequences of Social Loafing" as follows:

- Individuals in a group may slack off because they feel they are not getting their fair share of the rewards.
- Individuals may feel that the other members of the group will make up for their lack of effort.
- Individuals may think that they can hide in the group and that their loafing will go unnoticed.

Within the context of this description, social loafing is characterized by five different forms:

- Pilot/co-pilot
- Halo effect/drop your guard
- Free riding
- Groupthink
- Risky shift

2.9.1.1 Pilot/Co-Pilot

The subordinate team member does not feel that it is his or her place to challenge the actions of the senior team member. The subordinate member may unwillingly accept what the senior team member says without thinking or challenging the senior member's actions or conclusions. Pilot/co-pilot is also referred to as "follow the leader" or the "lemming effect."

2.9.1.2 Halo Effect/Drop Your Guard

The subordinate team member trusts or has high confidence that the senior team member will perform a task correctly, and the subordinate team member will consequently "drop [his or her] guard." The subordinate team member's vigilance to check the "haloed" member's actions is lessened and may cease altogether.

2.9.1.3 Free Riding

The team member benefits from the effects of the other team members although contributes little or nothing to the task. The team member simply "tags along" for the "free ride" without questioning the actions of the team or any team member. Common excuses offered by the team member in the situation include "The other person is thinking about the task." or "It's not my job."

2.9.1.4 Groupthink

There is a tendency on the part of the team members to adhere to shared views and ignore information that is inconsistent with team views. The group is striving for unanimity, which overrides their motivation to realistically appraise alternative courses of action. The result is that critical information may be hidden from the group: there is reluctance on the part of a team member to share contradictory information in order to maintain group unanimity. Highly cohesive or tight-knit teams (for example, an Operations shift team) exhibit this type of team error.

2.9.1.5 Risky Shift

The team exhibits a tendency to gamble with decisions more than they would as individuals making decisions on their own. Individuals are typically not held accountable for a team's performance. The individual team member believes that there is "safety in numbers." This is also referred to as a "herd mentality."

2.9.2 Defenses to Social Loafing

Leaders must strive to remain impartial, instructing all team members to critically evaluate situations and encourage the exposing of objections and doubts by using the following approaches:

- Solicit outside opinion.
- Break the group into subgroups; remind them that members of subgroups are free to disagree with each other.
- Have second-chance meetings.
- Heighten the team's awareness of the concept of groupthink. A dynamic and forceful team leader can very easily lead a shift crew to an excessive degree of group cohesiveness. Practicing open communication and using the devil's advocate technique can help to minimize the potential for a crew to fall into the team error trap of groupthink.

3
HUMAN PERFORMANCE PROGRAM IMPLEMENTATION CONSIDERATIONS

3.1 Introduction

As Operations prepares to implement a human performance improvement program, it is setting out to change not only processes but the human aspect of the organization as well: its culture, values, behaviors, and attitudes. It is a process that requires a long-term commitment. Short-term rewards are achievable, but the long-term effects will not be realized until human performance is embraced at every level of the organization.

Implementation of the human performance initiative creates "people issues." It is somewhat unsettling at all levels of the organization, especially as employees realize that the change involves a new way of thinking and performing their jobs. New skills, training, and different approaches are developed and implemented, which creates uncertainty and possibly a measure of resistance. Operators question why the change is necessary and to what extent they are going to be affected. Timely and effective communication play an important role in alleviating many of these worries. Operations should remember that it is never possible to over-communicate during this change.

Leadership also plays a key role in effective implementation. Plant and Operations leadership must be the first to not just "buy in" but "own" the human performance program. Leadership must speak with a singular voice and follow up with "walking the talk." It is the leadership that challenges and motivates the organization throughout the change. The creation of a concise and direct vision statement assists the leadership's efforts. Organizational leaders' embracing program ownership creates an environment that gets the operators involved.

Key Human Performance Point

Leadership also plays a key role in effective implementation. Plant and Operations leadership must be the first to not just "buy in" but "own" the human performance program.

The greatest impact of the human performance improvement program on the organization is a cultural shift. This shift goes beyond the normal organizational culture that exists and is commonly referred to as "safety culture." Because of its significant impact, this subject is explored in more detail in Section 3.5, "Safety Culture."

Operations should prepare for the unexpected: no change has been implemented in which all expectations at the start were met. Close monitoring at every stage of the process allows for the opportunity to recognize and quickly resolve problems that arise.

The implementation of a human performance improvement program within Operations is a major undertaking for the organization. It could be one of the most important and significant changes that Operations undertakes. As such, it must be properly managed during every aspect, from initiation to implementation to follow-up. Many organizations have a "change management" policy or procedure that is used to develop and implement large-scale programmatic or process changes. If such a policy or procedure exists, it should be used to implement the human performance initiative. It is not the intent of this report to describe any particular change management philosophy. There are few differences among change management programs. Most differences lie in the details within its major framework, and any change management program should be helpful in the implementation process.

This report explores several key considerations that should be considered prior to and during the human performance initiative, including the following:

- Making the case for change
- Vision and mission statements
- Leadership behaviors in human performance
- Safety culture
- The blame cycle
- Communication
- Training
- The human performance team
- Monitoring and reinforcement

If an organization has a change management process, it should be relatively straightforward to integrate these considerations into the existing process.

Each phase contains numerous program attributes to be considered. Because the implementation of a human performance improvement program is a complex process change, extensive organization resources— including staff, time, and money—may be required. It is not necessary nor is it recommended that all of the concepts be introduced as a full package for implementation. Rather, the recommended approach is a "shopping cart" implementation method. Tools and techniques should be chosen based on the needs of the organization as well as the resources available to implement the tools desired. With this method, a few human performance tools are chosen that could provide the greatest benefit with the least impact on resources. Parts of a human performance program can be implemented quickly—with minimal impact on resources—yet still provide effective and noticeable results.

Key O&M Cost Point

Parts of a human performance program can be implemented quickly—with minimal impact on resources—yet still provide effective and noticeable results.

If the human performance program initiative is to be successful, it is necessary to gain the buy-in (that is, commitment) and support of all major stakeholders (including management, Operations personnel, and training personnel). This is best accomplished by an effectively communicated, clear, and concise vision that will create a shared need within the organization. To mobilize commitment, the vision must be actionable and measurable. The vision will be more effective if it is communicated with a focus on the individual: show the individual what the change is going to do for him or her specifically. If the individual can see the benefit to "self," commitment is more easily achieved.

It is also important to ensure that communication is focused on the correct audience group. Audience groups are described in detail in Section 3.7, "Communication." At the onset of the initiative, it is probable that the resistance to change will come from within the organization. The initial communication should not be designed to win over the dissenters. However, during implementation, knowledge of this group will enable a strategy to be developed that can minimize its influence.

Initial considerations in the human performance initiative are important because they provide the first opportunity to grasp the magnitude of the human performance program and what it is intended to accomplish. These considerations include the following:

- Making the case for change (management commitment)
- Developing the human performance program team
- Developing the vision and mission statements
- Initially communicating the human performance initiative

These efforts should not be taken lightly because they will lay the foundation on which the remaining portions of the program are built. Communication is the cornerstone and will be the major structural support throughout the process. Effective communication (including the message, audience, quality, and delivery) is of utmost importance. If the human performance program initiative fails, it will be because of one or more of the following major contributors:

- Poor clarity of vision (that is, mission with loss of commitment)
- Poor communication
- Poor implementation

3.2 Making the Case for Change

After the decision has been made to move forward with implementing a human performance program, the next step involves "making the case" or justifying the need for change. Certainly the change will need to be justified to senior management, but it is just as important to justify the need to the people who will be directly affected by the implementation of the change.

3.2.1 Identifying the Gap

In making the case for change, one must know the current situation and the direction or the end point to which the human performance initiative will lead. To accomplish this, the "gap" must be determined. Numerous methods are available to determine the gap, including the following:

1. Define the current performance.
2. Define the desired performance.
3. Determine and describe the gap.
4. Write the performance gap statement, which is a statement that reflects the discrepancy between the current and desired performance.

3.2.2 Determining the Gap

Various sources of information and techniques to determine the gap are available. Depending on the organization, some of these may be readily available, while others may not. The first place to look is within the organization.

If the organization has a CAP, this will be helpful in the gap determination. A CAP is a program that investigates events, equipment issues, and program or process deficiencies. Depending on the severity of the consequences of the event or issue, the investigation will determine an apparent or root cause. Whether an apparent or root cause is generated, one or more causal codes is typically assigned to an event. If the CAP is online, many programs allow for searches by causal code. The organization's causal codes may not be extensive but should provide useful information nonetheless. A potential drawback with causal codes may exist, however. If the organization has not been involved with human performance analysis, knowledge of the human error causes could be limited or nonexistent. In these cases, a manual review of the database and assignment of causal codes would be required. On the other hand, many events may be coded as human error if an organization has not explored the nature of human error. In this case, the human error causal code may be labeled as human error based on the active error that triggered the event—but not capture the latent errors that led to the event. The more well-defined the information, the better the determination of the gap's location and the better the development of subsequent action plans.

If the organization is part of a larger organization that includes nuclear power, this will prove to be another valuable source for gap determination because all nuclear facilities have both human performance programs and CAPs. Although the information obtained through these sources will

not be specific to events at each site, the similar nature of power production means that events can be related to the types of problems at each site. The CAP will relate those events to causal codes. In addition to the CAP, the existence of a human performance program will provide metrics (that is, indicators) that show the benefits that have been realized through the implementation of an effective program.

Information may also be available from various industry groups, including the Nuclear Energy Institute (NEI), DOE, and EPRI. In most cases, the source of this information may be the nuclear industry, but again—the similar nature of power production can be useful in determining the gap.

Because human error affects any industry in which people are involved, another source of information is available outside of power production. Organizations within the airline and medical industries as well as the military have made excellent strides in reducing human error. Although the correlation of information from these industries may be more difficult, it should not be overlooked. It will be readily apparent that the underlying causes for human error are similar.

A technique widely used in the nuclear industry is benchmarking. *Benchmarking* is the process of searching for and analyzing the best practices that lead to superior performance. Numerous resources are available on how to conduct successful benchmarking; the following is a general approach to benchmarking in this phase of the program:

1. Planning
    a. Identify what is to be benchmarked.
    b. Identify the companies to be benchmarked.
    c. Identify the data to be collected.
    d. Conduct a benchmarking trip and collect data.
2. Analysis
    a. Determine the performance gap.
    b. Project the future performance level.
3. Integration
    a. Communicate the benchmark findings.

3.2.3 Communicating the Gap

With the gap determined, it is now time to communicate the findings and gain approval from senior management. Some considerations for that meeting are provided in Appendix F. In achieving approval, one of the more difficult requirements is justifying the return on investment. It is difficult to quantify the gains achieved by human performance when most gains come as a result of small, unnoticed successes. However, every organization has examples of cases in which human error, both active and latent, has resulted in a significant consequential event.

Every organization is likely to have had one or more events related to human error that have resulted in financial or emotional outcomes. These in-house examples should be used to communicate the gap because of the great impact that was made on the organization.

3.3 Vision and Mission Statements

Developing the vision and mission statements can be one of the most important steps in the human performance improvement process, and the human performance team should not take this task lightly. These statements define the past, present, and future of human performance within the organization. Because vision statements and mission statements are often confused with one another, it is worthwhile to ensure that there is a clear understanding of the distinction between the two. A vision statement defines why an organization exists. A mission statement defines what an organization does, how the organization does it, and for whom the organization does it.

3.3.1 Vision Statement

The vision statement can be a powerful communication tool. It is likely to be the first piece of communication to the organization that change is imminent. A properly constructed vision statement can provide a strong sense of purpose and direction. Take, for example, the following two powerful vision statements.

> "I believe this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to earth." John F. Kennedy, May 25, 1961

> "I have a dream." Martin Luther King, Jr., August 28, 1963

The human performance improvement team should not take the development of the vision statement lightly or underestimate the impact it can have on an organization. It is recommended that a member of the senior management team, who is a "stakeholder" in the success of this initiative, be available to the team. This will ensure alignment of the human performance vision with any other organizational visions that may exist.

Examples of typical vision statements for well-known organizations are provided in Appendix G.

3.3.2 Mission Statement

A mission statement defines the what, how, and who for the organization and should define clear direction for the human performance initiative. Defining that direction requires looking at the current situation and the projected view of the future and establishing the timeframe to complete the journey. A clear vision statement coupled with a well-defined mission statement can create long-term commitment within the organization. Although a member of senior management may define the vision statement, it is recommended that the human performance team develop the mission statement. The mission statement adds the all-important "how" to the vision. A team with the proper composition of multi-discipline personnel can better define the "how" because

they are the ones who will be most directly affected by the change. The team will be more apt to provide a concise and meaningful mission statement and will have a greater sense of commitment to its success.

Examples of typical mission statements for well-known organizations are provided in Appendix G.

3.4 Leadership Behaviors in Human Performance

Leaders exist at every level of an organization, and anyone within an organization can assume a leadership role. A leader can be a manager, a supervisor, or a peer who is seen as a role model. There exist all types of leaders with various leadership styles. General George S. Patton and Mahatma Gandhi were both great leaders with extremely different leadership styles whose styles were appropriate for their circumstances.

The concept of a leader has been defined in many ways. Leadership characteristics have been studied, and the findings that have been published have filled volumes. A *leader* is any individual who takes responsibility for his or her own performance and that of the organization. The characteristics identified in these studies are applicable in a general sense to leaders. In 1997, a special review committee identified actions necessary to bring about continued improvement in human performance, specifically in the nuclear industry. Five distinct leader behavior characteristics that promote excellence in human performance were presented in the report. The following characteristics are applicable to a leader at any level in the organization:

- Facilitates open communication
- Promotes teamwork to eliminate error-likely situations and strengthen defenses
- Searches for and eliminates organizational weaknesses that create conditions for error
- Reinforces desired job site behaviors
- Values the prevention of errors

The leadership of an organization that is committed to these principles can motivate and lead the organization to a new level of human performance.

3.4.1 Facilitate Open Communication

Communication is recognized as probably the most effective defense against events. If an organization can communicate freely at all levels with respect, trust, and honesty, it possesses the ability to maintain safe and reliable operations. Open communication does not just happen; leaders must promote an atmosphere conducive to it, and it is the responsibility of the leader to build that healthy relationship. Leaders accomplish this by encouraging individuals to identify problems and by actively listening to identified issues in a framework of trust and respect.

Because communication does not just happen, leaders should develop a communication plan (see Section 3.7.2, "Communication Plan," and Appendix F). The communication plan provides a vehicle for guiding a leader's formal and informal communication. It also helps to ensure that a consistent message is sent. The plan should identify and take advantage of all communication forums or media available, for example, newsletters, plans of the day, posters, bulletin boards, e-mails, and shift briefings.

3.4.2 Promote Teamwork

Individuals cannot always identify their own mistakes, especially when working alone. In that circumstance, the individual must use the human performance tools STAR (see Section 4.1.1, "Self-Checking [STAR]), SAFER (see Section 4.2.1, "Pre-Job Brief"), and a questioning attitude. However, when working in a group, the advantage of teamwork should be used to assist in the identification of errors. Teamwork enhances the team's ability to collectively observe one another and thus identify human performance problems. For a team to work effectively, there must be trust among the members. If trust is absent, open communication among the members will suffer and team error will rise (see Section 2.9, "Team Errors"). It is the leader's role to promote an atmosphere conducive to effective teamwork. This can be accomplished in several ways, including the following:

- Actively consult and challenge the team about error-likely situations.
- Value adherence to standards by demonstrating and promoting a feeling of uneasiness toward potential error (that is, a questioning attitude).
- Ensure that individuals accurately perceive the consequences of unsafe behavior.
- Resolve conflicts between individuals and work groups.
- Minimize unfamiliarity among members of an operating crew or work team.

3.4.3 Search for and Eliminate Organizational Weaknesses

Organizational weaknesses are weaknesses in defenses (for example, policies, programs, procedures, design, and training) established by an organization to ensure consistency in performance and minimize errors. Through proactive methods for identifying these weaknesses, factors that contribute to errors and events can be minimized or eliminated. Leaders accomplish this by the following activities:

- Soliciting feedback from workers about work conditions (including work packages, procedures, personal safety, and job site conditions)
- Identifying, determining, and resolving the fundamental causes of performance problems
- Monitoring plant and human performance trends

Performance improvement begins with monitoring. Without monitoring, leaders do not know where the organization is with respect to human performance improvement or even whether the organization is on the right path. The issues that managers and supervisors give attention to are the issues that get resolved (in other words, the "squeaky wheel gets the grease" syndrome).

Managers have many types of monitoring tools at their disposal, including CAPs with causal analysis, self-assessment programs, observations, coaching, post-job reviews, equipment trending, and industrial safety trends.

After an issue is identified, the next step is follow-through. Leaders must act to resolve these issues when they are identified. The resolution must be either a correction of the issue or a justification of why the issue could not be resolved. Simply put, there must be closure. Leaders should communicate these small successes that assist in reducing or preventing events and demonstrate that this type of behavior is preferred over waiting for the next event caused by an organizational weakness to occur.

3.4.4 Reinforce Desired Behaviors

In order for individuals to be responsible and held accountable for their performance, they must know what is expected of them. It is the leader's role to specify the behaviors required to achieve success and to reinforce these behaviors at every opportunity. Expectations explicitly define acceptable and unacceptable practices. Operations should have these well defined and documented in a "conduct of operations" procedure. Appendix H provides examples of expectations for human error reduction for control room operators. A well-defined expectation has the following characteristics:

- Specific (a concise definition)
- Observable
- Objective (does not require interpretation)
- Achievable
- Able to be communicated easily

Behaviors determined to be unacceptable or undesired and not meeting expectations must be corrected immediately. If a manager or supervisor allows a behavior that does not meet expectations to go uncorrected, he or she has tacitly defined and accepted a new behavior and standard. Coaching is a valuable tool in this regard. It is not enough just to point out that a behavior is incorrect. As a coach, the supervisor must explain or demonstrate the proper behavior. When correcting behavior, a supervisor should consider the following guidelines:

- Apply these guidelines to anyone exhibiting incorrect behavior.
- Specifically identify the incorrect behavior, and explain or demonstrate the proper one.
- Correct "on the spot" at the time of occurrence, if possible.
- Treat the individual with respect.
- Correct the inividual in private, if possible.

3.4.5 Value the Prevention of Errors

Managers and supervisors must set high standards in order to promote consistent adherence to expectations. Managers set the organizational tone with respect to behavior through their own behavior, and they must demonstrate a healthy attitude toward hazards and errors and create the same awareness in their workers. Managers must monitor and modify their own behavior to be consistent with the values of the organization. There is a direct cause-and-effect relationship between a manager's actions and an individual's behavior. Workers observe their managers' and supervisors' behaviors—positive or negative—and adjust their own behavior accordingly. Workers readily recognize a leader's values and beliefs in the following:

- What leaders pay attention to, measure, or control
- Reaction of the leader to incidents and crises
- Coaching interactions of the leader
- Criteria used by the leader for positive reinforcement and discipline

A reliable organization is one in which the leaders promote event-free operations through error-free behaviors. This kind of organization is characterized by the following:

- Open communication
- Rigorous use of error-prevention tools
- Uneasiness toward human error
- Alertness to hazards

3.5 Safety Culture

"Safety culture" is not a new concept. It was first described in H. W. Heinrich's "Domino Theory" in the 1930s. Safety culture is based on the premise that an environment conducive to accidents was the first of five dominos (representing an accident sequence) to fall. The other four in the sequence are fault of the person, unsafe act, accident, and injury. This concept is mentioned here because although the Domino Theory is taught in some human performance training, it is not addressed in this report. The more familiar concept of a safety culture lies in some of the initiatives taken in the industrial health and safety arena in the 1970s. However, it was not until after the Chernobyl accident in 1986 that safety culture found widespread use, especially in the nuclear industry. Although the concept has been thoroughly embraced by the nuclear industry (with an emphasis on nuclear safety), the attributes of a safety culture are directly applicable to human performance. The nuclear industry uses safety culture as a measure of its human performance efforts.

Safety culture is not an easy concept to understand. It is even more difficult to evaluate because of the complexities of its attributes, which becomes evident when attempts are made to define it. There are almost as many definitions of "safety culture" as there are individuals, groups, and organizations that have studied and attempted to understand it. For the purposes of this report, the definition of safety culture is provided by The British Health and Safety Commission and

incorporates key aspects necessary to support human performance improvement. *Safety culture* is defined 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. Exploring the key elements of this definition yields the following:

- It is a collection of behaviors and processes that drive the attitudes of everyone in the organization.
- It transcends every level of the organization. Everyone has a role and a responsibility to influence the organization's behaviors.
- Safety is viewed by all as a high priority.

As stated previously, safety culture is not an easy concept to understand and evaluate. One key reason is that it contains so many diverse and complex influencing factors, both internal and external. In some cases, it is difficult to determine the magnitude of the impact of any given factor on the safety culture. In addition, many factors influence others in a synergistic fashion. Some typical influencing factors on safety culture include the following:

- National and regional origin of people
- Politics
- Technology
- Regulation
- Past organizational success and failures
- Corporate and plant management policies and processes
- Training
- Labor contracts

These and numerous other influencing factors make it difficult to define exactly what a "good" safety culture is. It is sufficient to say that the safety culture is unique for each organization.

However, even with the uniqueness of a given safety culture, studies have shown that common attributes predominantly appear in organizations that have been determined to have a good safety culture. Although an organization will likely not possess all of the attributes listed, there will also likely be varying degrees of effectiveness of the attributes within and among various organizations. The following are attributes of a good safety culture:

- A strong and clear vision in which everyone in the organization understands the goals and their roles and responsibilities in achieving them.
- Communication that flows multi-directionally throughout the organization: top to bottom, bottom to top, and across the organization.
- The free flow of information. People can raise issues without fear of reprisal and offer solutions that will be acted on.

- Reporting and documentation of performance errors and safety issues and incidents. Lessons learned from these events are incorporated into procedures and training.
- A high level of commitment to safety. Safety is not taken for granted at any level. Safety information is gathered, and safety performance is measured—and this is all used in helping the organization to operate more safely. There is a high level of commitment both to safety processes and personal safety behaviors as well as common concern for one's own safety and that of coworkers.
- A strong CAP for the identification and resolution of problems. Root causes focus on organizational processes, not people. See note.
- A strong self-assessment program for the proactive identification of latent organizational weaknesses. See note.

  Note: These two items are part of the organization's self-improvement culture, that is, the organization's ability to self-identify and self-correct its weaknesses. Weaknesses in this area can have a broad effect on many other attributes of a good safety culture. Healthy corrective action and self-assessment programs are key to preventing or minimizing the effects of complacency in an organization.
- The effective use of operational experience from in-house staff, across the organization, and within the industry. The organization is characterized as a "learning" organization that learns from its own mistakes and those of others. Operating experience is incorporated into procedures and processes.
- A strong commitment to employee training: job- and skill-related, safety, and error and risk prevention. This training is a critical aspect of human performance. Fundamental knowledge and skills along with continuing learning are important to the overall self-improvement of the individual and the organization.
- A strong commitment to the readiness and reliability of plant equipment. Backlogs are maintained low. Equipment work priorities are proper. Operations should be judicial with respect to "letting equipment go" but not at the expense of performing required maintenance. Operations should have the best possible plant to operate at all times.
- A strong commitment to procedural compliance. Details in procedures are sufficient, based on worker skill and knowledge, in order for workers to be successful in task performance.
- Work performed with a questioning attitude. Work is planned and contingencies are thought through in advance. Work processes are simple and commensurate with the level of knowledge and skill of the worker.
- The use of human error tools and techniques to minimize errors.
- A high degree of accountability displayed by all. There is ownership of work.

Certainly, this list of attributes of a good safety culture collectively appears to define a utopian organization that does not exist. In reality, even if these attributes exist within most organizations, they are present with varying degrees of success.

How does an organization know the condition of its safety culture? How is it measured, and what is it measured against? These questions are related to the second key issue surrounding safety culture, that is, how it is assessed. What methods are available to measure the organization's improvements and declines in safety culture? There is not a single indicator or standardized process that measures safety culture. Rather, consulting organizations may enter an organization and measure safety culture using various processes and indicators. Most of these measures involve the use of surveys in conjunction with informal interviews. Surveys are conducted throughout the organization, and the interviews are conducted at various levels within the organization and its departments. Most surveys are not standardized, but they do share common areas surveyed, including the following:

- Teamwork
- Safety awareness
- Communication
- Leadership and supervision
- Procedural compliance
- Training
- Plant facilities

Samples of survey subject areas are provided in Appendix I.

Sometimes it is not as necessary for an organization to measure the "goodness" of its safety culture as it is to recognize signs that indicate a poor or failing safety culture. Some key indicators of a poor or failing safety culture are easily observable.

Key Human Performance Point

Sometimes it is not as necessary for an organization to measure the "goodness" of its safety culture as it is to recognize signs that indicate a poor or failing safety culture. Some key indicators of a poor or failing safety culture are easily observable.

Key indicators of a poor or failing safety culture may include the following:

- Plant condition (might be the key indicator). Poor housekeeping results in poor appearance. High maintenance backlogs and improper prioritization of work activities contribute to degraded equipment or unreliable performance of that equipment. A plant that looks dirty or disorganized and poor equipment performance or reliability are manifested in a second symptom of a poor or failing safety culture: worker mind-set.
- Lack of ownership. When a worker's mind-set is affected by a poor-looking and improperly maintained and operated plant, the worker develops a lack of ownership. Common phrases in the workplace include "I don't care" or "It's not my job." Workers find it easier to ignore the problem than to get involved trying to solve it, and they may develop one or more of the following characteristics with respect to their work:
  - Silence. Workers recognize problems but display little or no interest in resolving them. They hope that, with time, the problems will go away.
  - Denial. Workers deny the existence of problems. This is also observed in managers and supervisors.
  - Malicious cooperation. This characteristic can be extremely detrimental to any organization. Here, workers falsify records or documents and/or fail to look for alternative solutions or opinions. The prevailing attitude is "Get the job done—whatever it takes."
- Inadequate procedural compliance. When workers fail to follow procedures, errors are made and the reliability and performance of the plant are affected. In addition, procedures not followed typically lead to their not being maintained. Workers are not identifying errors in the procedures or incorporating their experiences into them.

If one looks closely at these symptoms of failure, it is clear that the symptoms feed off one another, leading to a downward-spiraling trend in safety (both of individuals and equipment) and plant reliability. When this downward trend gains momentum, it is extremely difficult to reverse it. It is also a very painful and expensive proposition to reverse the negative trend when it is ingrained in the organization's culture.

There is no "silver bullet" that can be used to achieve a good safety culture. If the organization cannot expend the resources to have its safety culture evaluated, it should (at a minimum) look within the organization for signs of a poor or failing safety culture. If the signs are there, they will be readily observable. (Appendix I provides insight regarding subject areas a management team can pose to itself without conducting a full-fledged survey.) If the safety culture is not healthy, the organization will find it difficult to implement a human performance improvement program. Some or most of the attributes of a good safety culture must be present and functioning satisfactorily. The road to a good safety culture starts at the top level of management by developing a clear vision toward safety with effective processes and programs to support the vision. However, the organization's safety culture will not be fully realized until workers' attitudes and behaviors embrace every aspect of safety in their work.

3.6 The Blame Cycle

Human error is in our nature. Humans are fallible and commit errors. Anyone—at any time and under any situation—can commit an error. Studies in the nuclear industry have shown that, of errors resulting from human performance, 70% are a result of latent organizational weaknesses and the remaining 30% are from individual errors. In high-reliability organizations that facilitate open communication, a high probability exists that when an error occurs it will be reported, regardless of the significance or consequence. Conversely, if the organization does not foster an environment of open communication—exemplified by fairness, honesty, and respect—in which individuals believe that errors will be punished, error-related information is likely to remain unreported.

Leaders must remember that to err is not a sin and that punishment or discipline for an honest error will not reduce the fallibility of the individual to err again. It will happen. However, individuals must be held accountable for inappropriate behaviors that are purposely, knowingly, or recklessly committed. Under these circumstances, punishment or discipline is a justifiable tool to correct behavior.

An organization in which punishment or discipline is administered for honest errors sets up what Dr. James Reason calls the "blame cycle," described in *Managing the Risks of Organizational Accidents* and shown here in Figure 3-1.

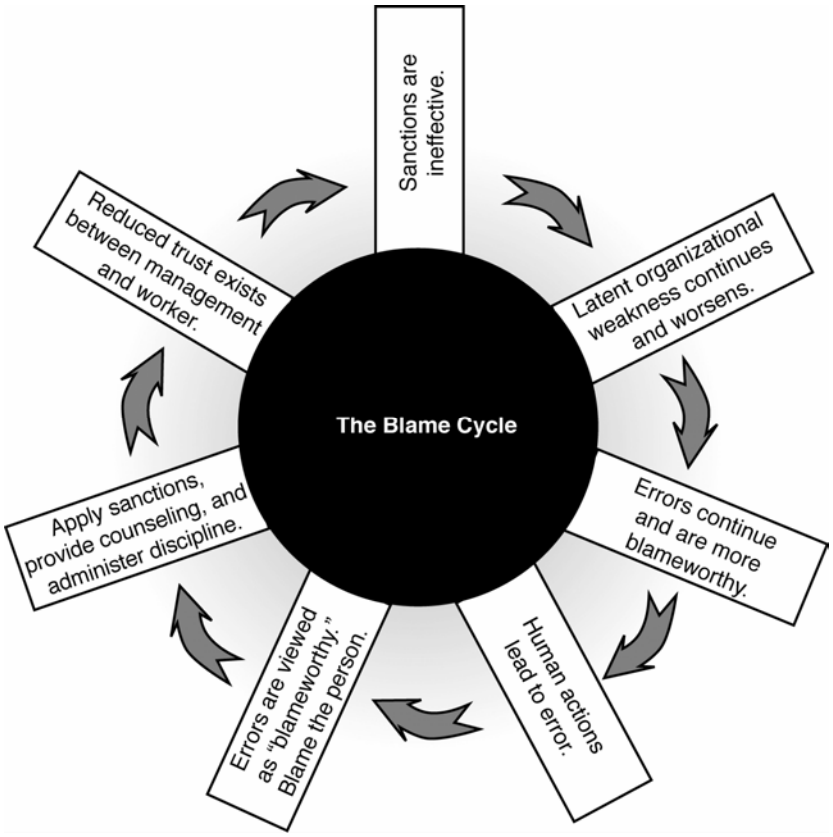

Figure 3-1
The Blame Cycle

The blame cycle starts with the belief that individuals are not motivated to do a good job and therefore commit errors. When the individual is blamed for the error, it implies that the individual knew the error was going to occur before the action was taken and therefore voluntarily contributed to the error. Error information goes undetected, latent organization weaknesses persist and grow, another error is committed, and the cycle continues.

Dr. James Reason developed a "culpability decision tree" to assist managers in determining a person's guilt regarding an error that was made. Within this culpability tree exists a "substitution test." It is simple to administer. Considering the set of circumstances under which the individual committed the error, the manager mentally substitutes some of the individual's peers into the same situation. If most of the peers could have committed the same error, the individual passes the test. If an individual did not knowingly violate expectations, did not intend for the consequences to occur, and voluntarily reported the error, the error should be considered a "blameless" one. A caution to this includes the individual's history with respect to errors and inappropriate behavior. If a pattern of errors and inappropriate behavior exists, discipline would be appropriate and the manager should question that individual's aptitude for the job.

The manager walks a fine line with respect to accountability, discipline, and the blame cycle. Moving too far in either direction sends the wrong message about the organization's values, beliefs, expectations, and behavior.

3.7 Communication

Effective communication is essential to the successful implementation of a human performance program. No single item is more important to the change. It is so important to the overall outcome that it is not possible to over-communicate. Communication accomplishes many things:

- It informs the organization of the reason for change.
- It involves the organization with the change.
- It creates opportunities for people to get involved.

A common mistake is the belief that the organization's stakeholders understand the issues, feel the need for change, and see the vision. Communication creates a strong sense of purpose and helps align the change with the organizational culture through a solid communication plan. A communication plan conveys the reason for change, helps build commitment to the change, and assists in managing resistance.

Key Human Performance Point

Effective communication is essential to the successful implementation of a human performance program. No single item is more important to the change. It is so important to the overall outcome that it is not possible to over-communicate.

3.7.1 Know the Audience

A communication plan to address all audiences within an organization must be developed. The audience is different at various levels within the organization and also within a distinct level of the organization. When management delivers communication, it must provide the "big picture," including milestones, schedule adherence, and the budget. Communication at the department level requires more-detailed discussion of near-term items (such as training, error-prevention techniques, and expectations) that directly affect Operations personnel.

Communicating with the department about the impending process change will result in a mixture of enthusiasm, skepticism, and concern. The challenge is addressing all of these feelings that are contained within the group. A critical mistake that is often made during communication is designing a communication plan that focuses on the persistent critics of change, but this approach must be avoided. The primary focus of the communication plan—especially during the early phases—is to develop quick support and build initial momentum for the change. To do this, the plan must be directed at the right people. An old "thumb rule" divides a change group into three groups: 20% will accept the change immediately, 60% will follow with time, and 20% may or may not get on board. Everett Rogers, in *Diffusion of Innovation*, has extensively developed the thumb rule to aid in identifying the various groups within the process change. Recognizing the people who are in each of these groups will aid in developing a communication plan that will gain quick support and momentum as well as getting the right message to the right people at the right time. Rogers divides the organization into five basic groups as described in the subsections that follow:

- Innovators
- Early adapters
- Early majority
- Late majority
- Confirmed traditionalists

3.7.1.1 Innovators

This is a small group (~2.5%) within the organization. This group is almost always willing to try new ideas and processes. In many cases, they desire change before the change is even conceived. Early communication must enlist and demonstrate this group's support and solicit the group's ideas.

3.7.1.2 Early Adapters

This is a slightly larger group (~13.5%). This group is composed of recognized leaders (by title) and the unrecognized leaders (those who have earned the respect of their peers) within the organization. The unrecognized leaders exist at various levels within the organization (for example, control room operators and field operators) and are typically recognized by their peers for their judgment, personal character, and credibility. These are the people to whom the

majority migrate to learn more about the process change. It is therefore essential that a communication plan be developed that will capture their influence. They need as much information as can be provided to aid them in communicating to the majority. Failure to influence this group can have a significant impact on the process change. This group should be specifically targeted for their commitment and buy-in.

3.7.1.3 Early Majority

This is a larger group (~34%). This group lags behind the early adapters as they seek information and opinions. They will follow, but it is unlikely that they will take the lead.

3.7.1.4 Late Majority

This is another group significant in size (~34%). This group follows the early majority in realizing that the change is inevitable. They accept change out of necessity rather than belief. This is an excellent group on which to test the process. They tend to be objective and observe the best and the worst that the process change has to offer. This is a true group of followers, and it does not take much effort to win them over after the preceding groups have "bought into" the change. This group will follow with time.

3.7.1.5 Confirmed Traditionalists

This is a relatively small group (~16%). This group thinks that the "old way is better." Early communication should not focus on or attempt to convert this group to the process change. Avoid conceding to "the squeaky wheel gets the grease." Let it squeak. This group can be addressed during later stages of the implementation. It may be possible to change the minds of some of this group, but full acceptance is highly unlikely. Implementers of the change should be aware that some members might feign compliance but actually resist in subtle ways.

3.7.2 Communication Plan

A communication plan provides a framework that ensures that information is shared with the appropriate audiences, in a timely fashion, using the most effective methods. Without a communication plan, there is increased risk that the affected stakeholders will be in a state of reaction rather than support. A well-structured communication plan addresses all audiences affected by the process change. The plan should convey a concise, clear, and easy-to-understand reason for the necessity for change. The reason for change should be communicated such that it emphasizes the benefits that the process has to offer the operators. The communication plan should also provide the process and methods that will be used to minimize the impact of the change.

Communication plans are living action documents that convey commitment to the process. The success of the process change depends on how well that commitment is delivered. The process change evolves as it moves through the various phases, and the communication plan must be flexible enough to accommodate the process's evolution.

The following should be considered in establishing a communication plan:

- Clarify purpose and goals.
- Identify the target audience (see Section 3.7.1, "Know the Audience").
- Summarize the key message.
- Identify the setting of the communication (for example, meeting, training, or plan of day [POD]).
- Clearly define what should be paid attention to, measured, or controlled.
- Expect the unexpected. What questions will arise? What reactions might the communication evoke? Think through the responses.

3.8 Training

For the Operations human performance improvement program to be successful, the operators must be trained in human performance fundamentals, tools, and techniques. In addition, the managers, supervisors, and training personnel who interface with Operations should also be trained in the same fundamentals. The initial emphasis in human performance training should be the knowledge and comprehension of basic human performance fundamentals because these fundamentals provide the foundation for the tools and behaviors necessary for the program to be effective. In addition to the human performance fundamentals training, there should also be focus on developing operational behaviors and skills, including the tools and techniques chosen for implementation.

Each group—operators, managers, supervisors, and Operations training personnel—should receive training on its respective human performance tools and techniques. In addition, the managers and supervisors should receive some form of abbreviated training on the operators' tools so that they can recognize them as expected behaviors during observation or coaching. When managers and supervisors receive this training alongside the Operations personnel, a powerful message is sent: This training is important and has the full support of management. During this training, all personnel must understand that the ideas and positions taken by all are to be respected. This should be made clear to all trainees at the beginning of training.

3.8.1 Training Development

Several options are available for the development of training materials (for example, lesson plans, instructor skills, and handouts). Any number of factors—time constraints, human resources, monetary resources, and in-house human performance expertise—can affect the option chosen, which include the following:

- Contract the human performance training to an outside consultant group.
- Have the materials developed by an outside consultant group, and then train the trainers within the organization.
- Develop the training in-house.
- Obtain training from the nuclear organization (if the fossil organization is part of a larger organization with nuclear facilities).

Advantages and disadvantages associated with each of these options include the following:

- Contract for consultant training (full program)
  - Advantages:
    - It provides a comprehensive human performance training package designed to the needs of the organization.
    - The time to develop training materials is short compared to in-house development.
    - Consultant instructors bring a vast amount of experience to the classroom.
  - Disadvantages:
    - It can be very expensive.
    - Human performance expertise leaves when the program has been delivered.
- Contract for consultant training ("train the trainer")
  - Advantages:
    - Human performance technology resides in the organization through the in-house trainers who receive "train the trainer."
    - This is typically less expensive than consultant-provided training, but the cost may be offset through the purchase of a license to use the consultant's materials.
  - Disadvantage:
    - It is still relatively expensive.

- Develop training program in-house
  - Advantages:
    - This develops an in-house human performance expert.
    - It is less expensive than hiring a consultant.
  - Disadvantages:
    - It typically requires a longer time to develop the training program and materials.
    - The in-house training person is not available for other training activities throughout the development period.
    - If human performance skills do not currently reside in-house, the training developer(s) need to attend an off-site human performance workshop to receive training.
- Obtain training from the nuclear organization (if the fossil organization is part of a larger organization with nuclear facilities)
  - Advantages:
    - A human performance program is already developed within the larger organization.
    - It is less expensive.
  - Disadvantages:
    - There is still no immediate in-house expert.
    - It requires some modification of human performance training materials.

A sample training program and schedule is provided in Appendix J.

3.8.2 Facilitative Training

A certain amount of knowledge, adequate skills, and the proper behaviors and attitudes are required for an operator to be competent in his or her job. In the typical training situation, instruction is focused on providing the operator with the necessary knowledge and skills to perform the tasks and activities associated with being able to perform the job. Little effort is typically given to developing the behaviors and proper attitudes. One reason is that it is difficult, if not impossible, to instruct on proper behaviors and attitudes. In an instructional setting, the instructor is placed in a position in which the behaviors and attitudes of the students are often misunderstood. People do not like to be told that their behaviors and attitudes are wrong. In an instructional setting, the instructor tells the students what they must know. The knowledge and skills are communicated directly or through demonstration. The technique of instruction is not conducive to encouraging appropriate behaviors and attitudes. Therefore, another training approach or technique is required: facilitative training.

In this technique, the instructor becomes a facilitator whose role is to encourage the students to draw on their experiences, knowledge, and skills in a particular area of focus. In this way, the students themselves identify any shortcomings that may exist in their behaviors and attitudes. The facilitator can then guide them toward the behaviors that are available, effective, and desired.

This method of training is more difficult than traditional instruction because the facilitator must be skillful in getting the students involved. In many cases, it takes only one student to "open up" and get the others involved. When the students are engaged, they bring forth experiences, values, and beliefs that can then be acted on. They must feel assured that they can assess their behaviors and beliefs openly, without fear of disrespect or retribution. This form of teaching is proven to achieve results in modifying behaviors and attitudes. Examples of facilitative training are provided in Appendix K.

3.9 The Human Performance Team

3.9.1 Assembling the Human Performance Team

A key aspect in the development of a successful human performance program is assembling the right development team. Using teams to solve problems or develop new ideas within an organization is not a new concept. However, not all teams are successful. They fail in their assignment for a number of reasons. Therefore, it is important that the right team with the proper skill sets and work ethic be formed the first time. Items that should be considered when forming a team as well as special considerations for teams outside Operations include project scope and skills. Teams should not be formed based on the convenience of availability or other easy factors.

3.9.2 Project Scope

What is the duration of the project? Having a clear understanding of the scope of the project is essential. The scope of implementing a human performance program within an Operations organization can vary. The scope should be based on the magnitude of the existing problem, the resources available, the timeframe allotted for implementation, and the degree of human performance initiative planned. Many error-reduction techniques can be implemented with few resources in a relatively short period. A sample implementation plan that uses a phased implantation approach is provided in Appendix L.

Typically, Operations resources are extremely limited. Their job is 24/7, and many situations (for example, illness, vacations, training, and operational administration) draw on their time and availability. Even so, it is essential that the team be composed largely from Operations. It is easier if a team can be formed within an individual operating shift crew, which will enable the team to schedule and attend meetings more easily. However, the skills and other attributes the team will require should not be sacrificed for ease in attending meetings. Duration is a key factor in an Operations team. Because of the many demands placed on Operations, the duration must be controlled so that the team will not lose focus or enthusiasm through the process.

The size of the team is another variable to consider. How much work will be required of the individual members? How specialized are the tasks? Team size does not guarantee success. If it is too large, it is difficult to manage (for example, problem resolution, many feelings, and many points of view to resolve). If it is too small, the team can be overwhelmed by the amount of work required and lose interest. Most teams are typically composed of 5–10 people for the initial scope of a project such as this. A typical team may consist of the following:

- Mentor: either a senior management representative or an Operations manager
- Team lead: Operations supervisor
- Alternative team lead: shift manager
- Control room staff: 1 or 2 members
- Field operators: 1 or 2 members
- Training department: 1 or 2 members (Operations training and/or training development)
- Human performance consultant: either in-house or consultant

3.9.3 Project Skills

In assembling the team, it is important to consider the various skill sets. What skill sets will be required? Are they available within the department or organization? Some of the skill sets that the team will require include knowledge of human performance fundamentals, training and development skills, communication skills, and computer skills. When the skill sets are factored into the team's development, the required skills may not be available from the Operations Department. If this is the case, the number of Operations personnel on the team will need to be reduced. A key point is that Operations personnel have a stake in the success of this program. It is essential that Operations be adequately represented on the team, if for no other reason than that Operations team members are a valuable communication tool—to the team and for the project—that will ensure that the Operations Department is aware of the new program being implemented.

The last factor to consider when assembling an effective team is group dynamics. The team is likely to be composed of different learning, working, and personality styles. Past observations of an individual's team skills, if available, should be considered. However, it is desirable to have a team that feels free to express feelings openly and fosters an environment in which disagreement is viewed as a positive contribution, criticism is constructive and comfortable, decisions are made with general agreement among members, and each individual pulls his or her weight.

3.10 Monitoring and Reinforcement

3.10.1 Monitoring

Monitoring is typically thought of with respect to monitoring for results. Is the human performance initiative meeting its objective and overall vision? Certainly monitoring for results is necessary to measure the results obtained from all of the effort and time spent on implementing the human performance program. However, it is also necessary to monitor in the broader sense throughout the overall human performance improvement initiative. Monitoring the overall plan is a form of communication. Tracking the effectiveness of the process through all phases of the change communicates to the organization (including all stakeholders, operators, training, and senior management) that the change is important to the success of the Operations Department and that it is being managed properly. Effective monitoring throughout the change process serves the following purposes:

- It provides opportunities to adjust and correct identified problems encountered.
- It can assist in identifying and responding to resistance to change.
- It allows recognition of desired behaviors and successes so that they can be communicated, rewarded, and reinforced.
- It provides a way to gather and evaluate data to determine if the process implementation is producing the desired results.
- Determinations (based on results) can be made concerning adjustments, corrections, or further process change.
- It supports the mechanism for institutionalizing the process in the long term.

An effective monitoring tool is the performance indicator. The performance indicators chosen should be meaningful to the organization. In addition they must be reflective of desired improvement, objective and achievable. Some performance indicators typically used by an Operations department are provided in Appendix M.

3.10.2 Recognition and Reinforcement

In order for the human performance initiative to be self-sustaining, it is essential that successes and desired behaviors, no matter how small, are recognized, communicated, and reinforced (for example, meeting performance indicator targets on a consistent basis, setting new records for event-free days, and rewarding “good catches” that may have otherwise resulted in an event). It is through recognition, reinforcement, and standardization that the successes become institutionalized and lead to overall continuous improvement.

Key Human Performance Point

For the human performance initiative to be self-sustaining, it is essential that successes and desired behaviors, no matter how small, are recognized, communicated, and reinforced.

The effort is not complete just because the program has been implemented in the field. It requires constant monitoring and nurturing with new insights and ideas to keep it fresh and invigorating. Several ideas that have been used in the nuclear industry that can be implemented to maintain a focus on human performance improvement are the following:

- Human performance themes. These themes may be developed around events at the facility and may be communicated through a POD, Operations night orders, or bulletin boards in the Operations spaces. However, it is not enough to display the themes only in these documents or areas. They should be talked about in POD meetings, during shift crew briefs, and prior to performing complex evolutions on the plant. Changing the theme monthly appears to be a good frequency.
- Human performance days. Approximately once every six months, designate a day that human performance receives primary focus and consideration. This can be done in conjunction with continuing training. It is also an excellent opportunity to reflect on successes and the future of human performance in the department.
- Human performance promotions. One organization had special chocolate-flavor energy bars made with human performance information on the wrappers.
- Shift crew human performance toolbox. Each crew is provided with a toolbox, and operators are encouraged over a week's period to place "items" in the toolbox. An item may be a note about a human performance tool that is working well for them. Suggestions for opportunities for improvement may also be placed in the toolbox. This is an easy and effective way to obtain feedback.

These are a few examples that can be used to frequently reinforce the human performance effort. Each organization should look for innovative methods and techniques to reinforce the program and the desired behaviors for long-term success. This does not happen overnight: it can take two to three years to develop a culture that does not return to the "old ways" of doing business.

Monitoring during every phase of the human performance initiative plays a key role in the overall success of the program. People respond to things that are given attention. After the overall program schedule is developed, one cannot sit back and expect that all will go according to plan. "Plan your work and work your plan" is more than a catchy phrase. The human performance plan requires attention and adjustment throughout the process. When the plan is closely monitored, opportunities for early identification and timely resolution of problems are created. Is the right progress being made? Are milestones being pushed time and time again? Problems with these types of issues have both overt and covert consequences. Failure to meet milestones and deliverables can result in a loss of management interest and support, especially in the area of resources. The operators sense that the overall commitment to the program is lacking. They begin to view this, like other failed attempts, as a situation in which if they just "bow their heads and stay low," it will eventually go away.

Effective monitoring of the plan brings clarity to the process in the form of deliverables (for example, a communication plan and training products), deadlines (for example, completion of training development), and accountability at all levels (including the Operations manager, human performance team, informal team members, and stakeholders). Monitoring is important to stakeholders because it helps build and sustain support and reduces resistance to the process change. Through close monitoring, the human performance team is more prepared for the unexpected; after all, even the best plans go astray. The human performance team is also better prepared to respond to deviations because their focus has remained at a high level throughout, and the lessons learned to this point in the process provide a framework for expecting and anticipating change—thus making the problem appear more controllable and less threatening.

4
THE HUMAN PERFORMANCE TOOLBOX

Errors can be prevented or mitigated. Most human performance tools or techniques are designed to prevent errors. The human performance tools presented in this section are "defenses" that can be used to identify and prevent active errors. Because humans are fallible and err, the tools are designed to help the operator maintain positive control of a task or activity, especially during critical steps in which an error is unacceptable and the consequences can be significant.

Human performance tools are specific defenses that are optimized to prevent or mitigate errors when specific tasks are performed. The human performance tool used for a task or activity must be adapted for that specific task or activity. Self-checking is not an appropriate human performance tool to be used in response to an unfamiliar situation, just as QV&V is not a human performance tool that should be applied to a commonly performed task or activity.

Key Human Performance Point

Human performance tools are specific defenses that are optimized to prevent or mitigate errors when specific tasks are performed. The human performance tool used for a task or activity must be adapted for that specific task or activity.

The human performance tools presented here have been used in the nuclear, medical, and airline industries as well as in the military. They can be used in a variety of applications, and the description of each tool includes the following information:

- The tool itself, with a brief explanation (basis) of the tool or technique
- When to apply the tool
- The reason(s) that the tool should be used
- Behavior standards that should be applied when using the tool
- Activities that should be avoided when using the tool
- How to evaluate the use of the tool

Because of the differing performance modes (that is, skill-, rule-, and knowledge-based) in which operators and supervisors/managers primarily operate, separate toolboxes are provided for each, one is an operator toolbox and the other is a supervisor/manager toolbox. Depending on the situation, however, either group may use either toolbox.

The following tools are provided in the operator human performance toolbox:

- Self-checking
- Peer checking
- Procedure use and adherence: placekeeping
- Effective communication: three-way
- Effective communication: phonetic alphabet
- Take two
- Time out
- Flagging

The following tools are provided in the supervisor/manager human performance toolbox:

- Pre-job brief
- Post-job review
- Questioning attitude (QV&V)
- Problem solving
- Coaching
- Observation

The components of the human performance toolbox are illustrated in Figure 4-1.

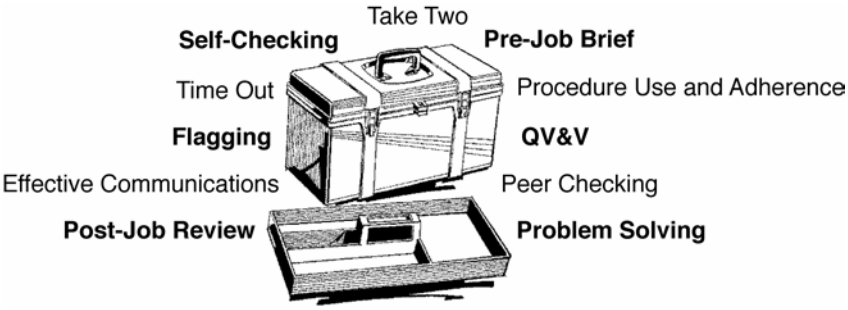

Figure 4-1
The Human Performance Toolbox

4.1 Operator Toolbox

4.1.1 Self-Checking (STAR)

Table 4-1 explains the self-checking tool, STAR, in the operator human performance toolbox, and Figure 4-2 illustrates the STAR tool.

Table 4-1
Operator Toolbox: Self-Checking (STAR)

Application	Description, Use, and Anticipated Outcomes
Technique: self checking	Error mode: inattention. Self-checking is applied during specific acts of skill-based performance (for example, switch manipulations and changing tank level). Operators should instinctively know when to self-check and what to focus their attention on.
Tool: STAR	Self-checking assists in the prevention of errors when plant equipment is manipulated to change its status. Self-checking is an effective technique used during the skill-based performance of tasks or activities that are performed with little conscious thought. STAR is an effective tool used by operators to help focus their attention on an activity before it is performed. When an operator's attention is focused, he or she takes a moment to think about the intended action and results prior to performance. If the operator is uncertain, the uncertainties should be resolved before proceeding. When the operator is physically and mentally prepared, the action may be performed. On completion of the action, the results of the action should be reviewed.
When to use	Before and during manipulation of any plant equipment. During time pressures (for example, operator feeling rushed). When identifying components (for manipulations, hanging tags, and so on). During task interruptions. During distractions. Before critical or risk-significant steps identified during a pre-job brief.
Reasons to use	To ensure, before taking action, that the right action is performed on the correct component. To consider the results of an action (know what indications are available). To verify that the desired results were obtained. To minimize the potential for making an error.

Table 4-1 (continued)
Operator Toolbox: Self-Checking (STAR)

Application	Description, Use, and Anticipated Outcomes
Behavior standard	**Stop**: An operator pauses prior to performing any operation or manipulation. This is especially important for any critical steps or decision points. Distractions should be eliminated. **Think**: An operator focuses attention on the task or step to be performed. The operator must understand exactly what is to be accomplished and should verify that the action to be taken is appropriate for the equipment or system status. The operator should anticipate expected result(s) of the action and be aware of the indications available to ensure that the expected result(s) were achieved. Consideration should also be given to actions that should be taken in the event of an unexpected result or response. **Caution: If a distraction or loss of visual or physical contact occurs, the operator should repeat the process to re-verify that the proper component is about to be operated.** **Act**: 1) The operator confirms that the correct component is selected by using a checklist, procedure, step, or drawing. 2) Without losing eye contact, the operator touches either the component or component label. 3) The operator performs the action. **Review**: The operator verifies that the anticipated response was obtained by comparing the actual response with the expected response. If the expected response was not obtained, the appropriate contingency actions should be performed.
Activities to avoid	Performing more than one activity while manipulating plant equipment (for example, talking on the telephone, engaging in conversation, or two-handed operation). Continuing when there is uncertainty about questions that have not been resolved. Failing to focus attention on the equipment to be manipulated.
How to evaluate	Supervisor observation while the operator verbalizes the technique. If monitored, a reduction in skill-based errors. Peer checker observation.

Figure 4-2
Stop-Think-Act-Review (STAR)

4.1.2 Peer Checking

Table 4-2 explains the peer checking tool in the operator human performance toolbox.

Table 4-2
Operator Toolbox: Peer Checking

Application	Description, Use, and Anticipated Outcomes
Technique: peer checking	Error mode: inattention.
Tool: peer checking (parallel self-checking)	Peer checking is an error-prevention technique involving an agreement between two operators (performer and checker) prior to the performance of a specific task. It has been described as two operators performing self-checking in parallel. Peer checking does not replace self-checking; it augments it. The advantage of peer checking is the fresh perspective of the checker who is unencumbered by the performer's task-oriented mind-set. Note: Remember self-checking, STAR, and good observation skills.
When to use	When performing manipulations, steps, or actions that—if performed incorrectly—could have significant consequences. When required by procedure. When pre-determined by the pre-job brief. When operating experience has shown that a particular step or action has resulted in an unfavorable outcome. At the request of the operator if he or she feels that risk or conditions warrant it. During a peer checker "challenge" if the checker believes that the actions to be performed present a risk. As determined by the shift supervisor.
Reasons to use	To provide a second set of eyes and cognitive skills to the intended action. To minimize the potential for making an error that has a significant consequence. To verify that the desired results were obtained. To minimize the potential for making any kind of error.

Table 4-2 (continued)
Operator Toolbox: Peer Checking

Application	Description, Use, and Anticipated Outcomes
Behavior standard	1. The performer and peer checker agree on the intended action prior to the action being taken. 2. The performer and peer checker independently confirm that the correct component is about to be operated and the desired action using self-checking techniques. 3. The performer takes only the action intended. 4. The peer checker observes the performance and ensures that he or she is in a position to stop the action if it is about to be performed incorrectly (for example, on the wrong component). Communication between the performer and checker should be three-way and should use the phonetic alphabet. **Caution: Peer checking should not be used in lieu of independent or second-party verification.**
Activities to avoid	Using a peer checker who does not possess qualifications equal to or greater than those of the performer because the peer checker must do the following: 1. Focus his or her attention on the performer. 2. Place himself or herself in a position to view the component being manipulated. 3. Be in a position to prevent an incorrect action by the performer. 4. Avoid the mind-set trap that the performer will not err because of skills and experience. During periods of high activity, peer checking may not be practical. The proposed peer checker could be engaged in an activity of equal or greater importance.
How to evaluate	Supervisor observation while the operator verbalizes the technique. If monitored, a reduction in skill-based errors.

4.1.3 Procedure Use and Adherence: Placekeeping

Table 4-3 explains the placekeeping tool in the operator human performance toolbox.

Table 4-3
Operator Toolbox: Placekeeping

Application	Description, Use, and Anticipated Outcomes
Technique: procedure use and adherence	Procedure use cites the minimum required reference to a procedure during the performance of a task or activity. Procedure use applies at all times, consistent with the level of use of the procedure: continuous, reference, or information: • Continuous use: step-by-step performance with the procedure in hand and signed/initialed/checked-off as it is completed. • Reference use: referred to periodically to ensure familiarity with the task. • Information use: may be performed from memory; reviewed as necessary to ensure compliance with administrative requirements. Procedure adherence is to follow the intent of the procedure regardless of the level of use.
Tool: placekeeping	The act of marking steps in a procedure as they are completed or marking the steps that are not applicable. Placekeeping is not appropriate for all procedures. It is different for each procedure based on the complexity of the task or activity, the procedure's logic path, or the relationship of the task to plant safety or reliability.
When to use	Procedures: when equipment is manipulated or monitored. Placekeeping: during complex tasks or activities, a procedure's complex logic path, or when the task is related to plant safety or reliability.
Reasons to use	To ensure that the correct actions are performed in the proper sequence. To prevent missing or skipping procedure steps. To minimize the potential for making an error.
Behavior standard	1. The operator verifies that the working copy of the procedure is the current revision by comparing it with a controlled copy. 2. Prior to starting the procedure, the operator verifies that all initial conditions, prerequisites, precautions, and limits are met. 3. The operator should follow procedures as written. If a procedure is deemed to be incorrect or cannot be followed as written, the operator should **stop** and bring the discrepancy to the attention of the supervisor. 4. Procedure steps should be followed in sequence unless the procedure specifies otherwise. 5. Steps shall not be marked as "N/A" without supervisor approval. Steps marked "N/A" should be initialed and the reason given. 6. The actions of a procedural step should be completed before they are signed off as complete. 7. Placekeeping should be used when a procedure does not require signoffs. 8. If unexpected results are observed after a procedure set, the operator should **stop** and **should not** proceed. The operator should notify supervision.

Table 4-3 (continued)
Operator Toolbox: Placekeeping

Application	Description, Use, and Anticipated Outcomes
Activities to avoid	Following a procedure "blindly." Because procedures contain errors, events caused by latent error precursors may result. Assuming that a procedure is written for all experience levels. Failing to stop in the face of uncertainty leads to errors. Assuming that a procedure is not required to perform an activity or task. Skipping steps in a procedure because they were not required during the last performance of the procedure (for example, when an instrument was OOS). Using a procedure maliciously with the knowledge that it is incorrect. Using ditto marks or initialing and lining through several steps.
How to evaluate	Supervisor observation during task or activity performance. Procedure review after task completion to verify signoffs or initials or that placekeeping techniques were used.

4.1.4 Effective Communication: Three-Way

Table 4-4 explains the three-way communication tool in the operator human performance toolbox.

Table 4-4
Operator Toolbox: Three-Way Communication

Application	Description, Use, and Anticipated Outcomes
Technique: effective communication	The reporting lines and communication within a shift crew should be simple and clearly established. Communication should be such that the control room staff has positive control of the plant at all times.
Tool: three-way communication	Mutual understanding is essential to communication, and three-way communication assists in developing that understanding. The two parties in the communication chain are the sender and the receiver. 1. The sender gets the attention of the receiver using his or her name or position. When the receiver acknowledges by either verbal or visual cue, the sender states the message using appropriate equipment noun names and unique identifiers. **Slang terms should not be used.** 2. The receiver repeats the message, either paraphrased or verbatim, to the sender, again using proper equipment noun names and identifiers. 3. The sender acknowledges that the message was received correctly by repeating, either paraphrased or verbatim, along with "Correct." 4. If at any time during the process, the message is "Incorrect," **stop** and **restart** the process.

Table 4-4 (continued)
Operator Toolbox: Three-Way Communication

Application	Description, Use, and Anticipated Outcomes
When to use	During any verbal exchange between Operations personnel, whether by face-to-face, telephone, radio, page, or other communication device routinely used by Operations personnel. When providing direction or information about plant equipment. During all communication with the control room. During any communication that involves personnel, plant, or equipment safety. During the exchange of any critical communication regarding the plant.
Reasons to use	To provide the clear, concise, and complete transfer of information. To ensure that the intended message is received and understood. To minimize the potential for making errors because of poor communication.
Behavior standard	1. When initiating a communication, the sender identifies the recipient by name or position and receives acknowledgment through visual contact or verbal acknowledgment. The sender then states the message. 2. The receiver acknowledges receipt of the message by either paraphrasing the message or repeating it verbatim, including the equipment name, its identifier, and the action required. 3. The initiator of the message acknowledges the receiver's response through either paraphrasing or repeating it verbatim. 4. If the message is not understood, it should be acknowledged by saying, "I didn't understand" or "Say again." 5. If at any point in the process the message is not correct, the process should be repeated.
Activities to avoid	Sending multiple actions in a single message unless dividing the actions is detrimental to accomplishing the task or activity. Speaking in low tones, in which case the message may be misunderstood or not received at all. Attempting to communicate with someone already engaged in another communication unless the communication is to ensure the safety of personnel, equipment, or the plant itself. Failing to identify oneself as either the sender or receiver of a message when communicating by a means other than face-to-face.
How to evaluate	Observation during all communication activities.

4.1.5 Effective Communication: Phonetic Alphabet

Table 4-5 explains the phonetic alphabet communication tool in the operator human performance toolbox.

Table 4-5
Operator Toolbox: Phonetic Alphabet

Application	Description, Use, and Anticipated Outcomes
Technique: effective communication	The reporting lines and communication within a shift crew should be simple and clearly established. Communication should be such that the control room staff has positive control of the plant at all times.
Tool: phonetic alphabet	Mutual understanding is essential to communication. Use of the phonetic alphabet to distinguish the difference between two components in which the only difference is a single identifying letter facilitates clear communication. The phonetic alphabet used is referred to as the NATO phonetic alphabet (adopted in 1956).
When to use	For equipment, train, channel, or other identifiers. Phonetics is not required for systems with approved acronyms that cannot be confused with another acronym, for example, “C-C-W” versus “Charlie-Charlie-Whiskey” for component cooling water. As a minimum, the phonetic alphabet should be used whenever a single letter is the only difference in the identifier of two pieces of plant equipment. When communicating alphanumeric identifiers for plant equipment (for example, under-voltage device “3UV16F” is stated as “Three-UV-sixteen-FOXTROT). Whenever the possibility of misunderstanding may exist, for example, in sound-alike systems, high-noise areas, or where there is poor communication reception. Whenever information is transferred or received so that—if misunderstood—it could adversely affect the desired outcome.
Reasons to use	To provide clear, concise, and complete transfer of information. To ensure that the intended message is received and understood. To minimize the potential for making errors because of poor communication.
Behavior standard	Phonetic alphabet: A = Alpha, H = Hotel, O = Oscar, V = Victor B = Bravo, I = India, P = Papa, W = Whiskey C = Charlie, J = Juliet, Q = Quebec, X = Xray D = Delta, K = Kilo, R = Romeo, Y = Yankee E = Echo, L = Lima, S = Sierra, Z = Zulu F = Foxtrot, M = Mike, T = Tango G = Golf, N = November, U = Uniform
Activities to avoid	Avoid using phonetic words other than those designated (for example, “dog” versus “delta” or “indigo” versus “India”).
How to evaluate	Observation during all communication activities. Listening for phonetic identifiers when equipment, train, channel, or other identifiers are required.

4.1.6 Take Two

Table 4-6 explains the "take two" tool in the operator human performance toolbox.

Table 4-6
Operator Toolbox: Take Two

Application	Description, Use, and Anticipated Outcomes
Technique: "take two"	The "take two" technique is simply taking two minutes to evaluate the job site.
Tool: "take two" for safe, error-free operations	The first step to safe and error-free operations is recognizing the error precursors (that is, hazards and abnormalities) that exist in the work environment. It is easy to be so focused on the performance of the task or activity that the error traps at the work site go unnoticed. Because procedures do not contain information about the conditions and demands of a task or activity, the operator must take time to look critically at the surroundings for potential hazards. Failure to identify error traps can make the task more difficult or lead to an error.
When to use	Prior to beginning any task or activity (for example, hanging a clearance tag in the overhead or racking out a breaker).
Reasons to use	To ensure that the work area is free of safety concerns or error precursors that could prevent the effective performance of the task. To minimize the potential for making an error that may affect the safety of personnel or the equipment.
Behavior standard	1. The use of "take two" should be discussed in pre-job briefings. 2. At the job site, the operator should take two minutes to look around the area to identify potential error traps: • Work area conditions: lighting, cleanliness, inconsistencies with procedures, and pre-job briefing. • The correct unit, train, and equipment that are about to be operated. • Error-likely precursors at critical steps (such as labeling or indicators). • Industrial safety concerns. 3. If unexpected hazards or error traps are identified, the operator should discuss the condition with supervision before continuing. If a personal safety issue is identified, the operator should inform other operators on shift. 4. Any error traps should be eliminated or appropriate defenses put in place prior to continuing with work.
Activities to avoid	Time pressure: do not rush into a task or activity. Failing to bring poor work site conditions to the attention of supervision or coworkers. Treating a job as simple: no job is routine.
How to evaluate	Supervisor observation while the operator verbalizes the technique. Peer checker observation.

4.1.7 Time Out

Table 4-7 explains the "time out" tool in the operator human performance toolbox.

Table 4-7
Operator Toolbox: Time Out

Application	Description, Use, and Anticipated Outcomes
Technique: time out	Error mode: inattention or uncertainty.
Tool: time out	The time out technique can be used in a variety of situations: normal, abnormal, and emergency operations. An individual or a team may use it. As plant conditions change, it is useful to focus the team on the current situation and provide direction on the course of action to be taken. It is also useful when uncertainty arises. When uncertain or unsafe conditions are identified, a time out can be used by an individual or team to assist in verifying that the most accurate information about the current situation is available before proceeding. The team takes a brief moment to assess the situation and discusses specific conditions and assumptions. This establishes a shared understanding of the situation using facts. A time out is effective at key decision points and critical steps in a task or activity. Communication in a time out should be conducted face to face.
When to use	When a task, activity, or plant conditions change. When there is uncertainty with regard to intended actions. When results from actions taken are not as expected.
Reasons to use	To avoid errors when uncertainty or unsafe conditions are identified. To prompt individuals or teams to stop and get help if task, activity, or plant conditions change and uncertainty prevails or if results are not consistent with expectations. To minimize the potential for making mistakes.
Behavior standard	A time out is used at critical steps and key decision points. As plant conditions change, a time out is used to focus the team (shift crew) and discuss available information and assumptions. A time out is conducted using face-to-face communication.
Activities to avoid	Proceeding in the face of uncertainty. Failing to stop a task or activity when the outcome is not as expected.
How to evaluate	Supervisor observation. If monitored, a reduction in skill-based errors.

4.1.8 Flagging

Table 4-8 explains the flagging tool in the operator human performance toolbox.

Table 4-8
Operator Toolbox: Flagging

Application	Description, Use, and Anticipated Outcomes
Technique: flagging	Error mode: inattention.
Tool: flagging	Flagging is a technique in which one or more components are identified in a unique manner to ensure that the correct component(s) are manipulated. It is an effective technique when several components in close proximity to one another possess similarities that could cause an error to occur during manipulations. If during the performance of tasks or activities, an operator was to become distracted and his or her attention was not refocused on the component, the wrong component could be manipulated. It is preferable to "flag" a component that is to be manipulated rather than one that should not be manipulated. If this technique is used, a facility should implement a standard convention or system using unique identifiers for manipulated versus nonmanipulated equipment.
When to use	When performing multiple manipulations on equipment in close proximity to other similar equipment.
Reasons to use	To raise awareness of one or more components in close proximity that are to be manipulated. To reduce skill-based errors caused by distractions.
Behavior standard	1. Component(s) to be manipulated are identified with the error-reduction tools of self-checking or peer checking. **Caution**: **It is preferable to flag component(s) that are to be manipulated versus those not to be manipulated. Do not flag both manipulated and nonmanipulated components during performance of the same task or activity.** 2. A flag should be attached on or near the component to be manipulated. The device used to flag the component(s) should be securely attached. 3. Component flags should not obscure component labels. 4. Flags should remain in place during task performance. 5. Flags should be removed after the performance of the task or activity is complete.
Activities to avoid	Flagging manipulated and nonmanipulated components during the performance of a task or activity. Failing to use self-checking or peer checking when placing flags on equipment.
How to evaluate	Supervisor observation during task or activity performance. If monitored, a reduction in skill-based errors. Peer checker observation.

4.2 Supervisor/Manager Toolbox

4.2.1 Pre-Job Brief

Table 4-9 explains the pre-job brief tool in the supervisor/manager human performance toolbox, and Figure 4-3 illustrates the pre-job brief (SAFER) concept. Examples of pre-job briefing checklists are contained in Appendix N.

Table 4-9
Supervisor/Manager Toolbox: Pre-Job Brief

Application	Description, Use, and Anticipated Outcomes
Technique: pre-job brief/task assignment	Error mode: inattention and uncertainty.
	The three primary reasons to conduct a pre-job brief are the following: • To ensure that the operator is qualified and familiar with the task or activity to be performed. • To heighten the attention levels of the operators and other personnel involved in the performance of the task or activity. • To sensitize all personnel involved with the task to critical steps, error-likely situations, and contingencies. The consequences of human error should be specifically discussed along with contingencies. This heightens the attention of personnel to task-related error precursors and improves the effectiveness of error-prevention tools before and during the task or activity. An effective pre-job brief gives participants time to review the task prior to attending the brief, which allows for the identification of critical steps, potential error traps, defenses, and consequences along with their contingencies. Reviewing operating experience enables the participants to benefit from the experience of others so that past errors are not repeated.
Tool: SAFER	**Summarize** critical steps: Identify those steps that—if performed incorrectly—will result in an intolerable error. **Anticipate** error-likely situations: Clearly and specifically discuss items that could lead to error. Consider complexity, risk, logistics, environment, and safety. **Foresee** consequences: Consider the worst case if an error is made. **Evaluate** defenses: Identify defenses that are in place to prevent and catch errors. Identify contingencies related to possible consequences. **Review** operating experience: Consider personal, plant, and industry experience.
When to use	Prior to performing a task or activity that is nonroutine. Prior to performing a task or activity that is considered routine—but for which an improper outcome cannot be tolerated. After shift or individual turnover or after significant time lapses while the task or activity is in progress.

Table 4-9 (continued)
Supervisor/Manager Toolbox: Pre-Job Brief

Application	Description, Use, and Anticipated Outcomes
Reasons to use	To focus the attention of all participants on the task or activity to be performed.
	To provide an opportunity to specifically discuss error-prevention tools related to critical steps and to the task in general.
	To heighten participants' attention levels to potential areas of uncertainty during task performance.
Behavior standard	1. All participants should be given sufficient time to review the task or activity prior to the pre-job brief.
	2. Participants should summarize the activity to be performed.
	3. Participants should review the critical steps of task or activity.
	4. Participants should anticipate challenges to human performance of critical steps using SAFER.
	5. Participants should be involved in a dialogue about the task or activity during the brief.
Activities to avoid	Talking in generalities about the task or activity. Failing to mention error-likely situations in relation to critical steps. Performing significant tasks without a pre-job brief. Allowing participants to leave the brief without an understanding of their roles and responsibilities in the task or activity.
How to evaluate	Questioning of participants during the pre-job brief. Field observations of task or activity performance. Post-job reviews.

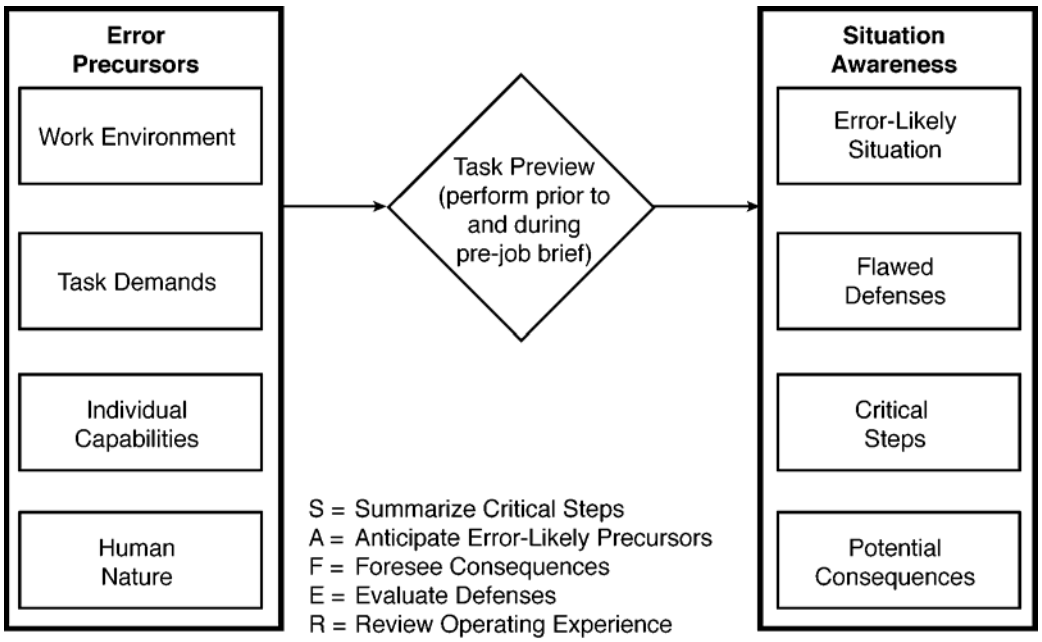

Figure 4-3
Pre-Job Brief (SAFER)

4.2.2 Post-Job Review

Table 4-10 explains the post-job review tool in the supervisor/manager human performance toolbox.

Table 4-10
Supervisor/Manager Toolbox: Post-Job Review

Application	Description, Use, and Anticipated Outcomes
Technique: post-job review	Post-job reviews are a valuable source of information. They are conducted to determine if the planning, briefing, and execution of the task or activity were effective. Post-job reviews 1) aid in identifying opportunities to strengthen defenses against errors and events and 2) eliminate error precursors embedded in the task or procedure.
Tool: post-job review checklist	See Appendix O for a sample post-job review checklist.
When to use	After high-hazard tasks or activities. At the shift supervisor's discretion. After activities in which the outcome was not as expected in order to determine factors that contributed to the unsuccessful performance of a task or activity.
Reasons to use	To determine whether planning, briefings, and performance of a task or activity were effective. To identify error precursors in tasks or procedures. To give an opportunity for participants in the task to provide feedback.
Behavior standard	1. The post-job review is conducted with all participants of the task or activity, if possible. If a participant is unable to attend, feedback should be solicited as soon as practical. 2. The supervisor completes a post-job review checklist. 3. The supervisor records and assigns responsibility for resolving identified deficiencies for problems or issues that are identified. 4. The supervisor ensures that all deficiencies are resolved prior to the next performance of the task or activity.
Activities to avoid	Performing a task or activity if previous deficiencies from the last performance have not been resolved. Failing to solicit feedback from all participants in the task or activity. Failing to document identified deficiencies.
How to evaluate	Review of post-job checklists. Follow-up on resolution of identified deficiencies. Field observation of conduct of a post-job review.

4.2.3 Questioning Attitude: QV&V

Table 4-11 explains the questioning attitude (QV&V) tool in the supervisor/manager human performance toolbox.

Table 4-11
Supervisor/Manager Toolbox: Questioning Attitude (QV&V)

Application	Description, Use, and Anticipated Outcomes
Technique: questioning attitude	Error mode: uncertainty about a new, unfamiliar situation. Possessing a questioning attitude will heighten awareness to uncertainty and the significance of action(s) before performance of a task or activity. It will assist an operator in ensuring that the planning, conclusion, and problem-solving processes were appropriate for the situation. The ability to recognize error-likely situations and error traps relies greatly on this technique. Use of this tool enhances an operator's ability to anticipate error-likely situations before and during task or activity performance. A healthy questioning attitude will assist in suppressing the temptation to rationalize "gut feeling" or the sense that something "doesn't seem right." A questioning attitude is a healthy technique that enhances several other human performance tools, including pre-job briefs, decision making, and problem solving.
Tool: QV&V	QV&V is a process that is used to ensure that raw information is fact. Effective use of this technique prevents rule-based performance errors. In many situations, the available information is inaccurate or lacks sufficient detail. It is gathered by individuals through observation and filtered through their experience, knowledge, training, skills, and assumptions. If gathered during periods of stress, the information may be even more suspect. "Qualifying" the source of information is a test for reliability and relevance. "Validating" the information is a "gut-feel" test of its accuracy and reliability. If the information fails these tests, it should be verified. "Verifying" the information is a test of the information against a second external source.
When to use	When information does not appear consistent with knowledge and training. When an operator has a "gut feeling" that things just "don't seem right." In unfamiliar situations. When faced with unexpected results. During uncertainty regarding compliance with expectations or procedures.
Reasons to use	To provide a systematic process (QV&V) for making good decisions prior to the performance of the task or activity. To challenge assumptions and preconceived ideas. To provide a method for challenging assumptions before considering action.

Table 4-11 (continued)
Supervisor/Manager Toolbox: Questioning Attitude (QV&V)

Application	Description, Use, and Anticipated Outcomes
Behavior standard	1. **Qualify**: The operator should ensure that the information received is from a qualified source and determine whether the source is accurate, reliable, and relevant to the situation. 2. **Validate**: The operator should ensure that the information is consistent with experience, knowledge, training, and expectations. The operator should determine whether the information is relevant to the task or activity and whether it makes sense based on the knowledge of and experience with the task. **Caution: If the answer to either Qualify or Validate is "No," the operator should verify the information with facts.** 3. **Verify**: The operator should use an independent and qualified source of information to support and confirm the information, for example: – Redundant instrumentation. – Plant documentation (such as drawings and set-point documents). 4. Task performance can continue if all questions and assumptions have been resolved. 5. If questions and assumptions cannot be resolved, the operator should call a time out.
Activities to avoid	Cook-booking procedures. Overly relying on "thumb rules." Using "unthinking" responses to what are perceived to be simple problems. Failing to use "what-if" logic when uncertain. Not being open and receptive to being questioned by others.
How to evaluate	Supervisor observation. If monitored, a reduction in rule-based errors. Standards reinforcement.

4.2.4 Problem Solving: Decision Making

Table 4-12 explains the problem-solving tool in the supervisor/manager human performance toolbox.

Table 4-12
Supervisor/Manager Toolbox: Problem Solving

Application	Description, Use, and Anticipated Outcomes
Technique: problem solving	Error mode: uncertainty about a new or unidentified situation.
	Problem solving is a systematic process that begins with defining the problem and ends with implementing a solution. Embedded in the problem-solving process is decision making: the process of selecting a course of action or alternative from several alternatives in order to solve a problem. Although many problem-solving and decision-making techniques exist, each providing a unique approach to the process, the tool described here is generic and captures all elements of the problem-solving and decision-making processes.
Tool: problem solving	The following are the steps in the problem-solving process: 1. Define the problem. 2. Develop alternatives. 3. Analyze and compare alternatives. 4. Decide which alternative to implement. 5. Develop and implement a plan. 6. Conduct feedback and evaluation.
When to use	During troubleshooting. In an unfamiliar situation. When no readily known solution exists for the problem. When time constraints do not exist, allowing a formalized problem-solving process to be used.
Reasons to use	To minimize the potential for error when operating in the knowledge-based performance mode. To implement the most effective solution to a problem. To provide a common framework for resolving problems: problem-solving improves with practice. To improve team-building skills.
Behavior standard	Note: A devil's advocate should be used throughout the process to monitor and challenge the problem-solving and decision-making processes. 1. Define the problem. If the problem is not properly defined, a solution will likely be implemented for a symptom of the problem, not the problem itself: a. What is the problem? b. What is causing the problem?

Table 4-12 (continued)
Supervisor/Manager Toolbox: Problem Solving

Application	Description, Use, and Anticipated Outcomes
Behavior standard (continued)	c. Is there enough information to properly define the problem, or should more information be gathered? d. State the problem and discuss it with the team. 2. Develop alternatives: a. Gather additional information if required. b. Brainstorm: do not eliminate any alternative as being too "wild." 3. Analyze and compare alternatives: a. Gather information about each alternative. b. Rank alternatives in terms of cost, level of complexity, timeframe for implementation, and perceived effectiveness. c. Compare the alternatives. 4. Decide which alternative to implement by achieving a consensus among the team, even though some team members may believe that another alternative would be more effective. 5. Develop and implement a plan: a. Confirm the chosen solution. b. Communicate the plan: communication of the plan is more effective when it precedes action. c. Implement the plan for the chosen solution. 6. Conduct feedback and evaluation: a. Was the plan implemented as designed? b. Were the desired results achieved? c. Was the problem resolved? d. Were any new problems created as a result of the chosen solution?
Activities to avoid	Failing to properly define the problem (that is, solving for a symptom of the problem and not the cause). Eliminating proposed alternatives during the brainstorming process. Failing to gather all necessary information on alternatives in order to make a fair assessment. Failing to achieve consensus on the proposed solution (that is, team members giving in just to reach agreement). Failing to communicate the plan before implementation. Failing to monitor the effectiveness of the implemented solution. Ignoring the role of the devil's advocate.
How to evaluate	The problem was resolved. No new problems were created as a result of the implemented solution. Feedback from the devil's advocate.

4.2.5 Coaching

Table 4-13 explains the coaching tool in the supervisor/manager human performance toolbox.

Table 4-13
Supervisor/Manager Toolbox: Coaching

Application	Description, Use, and Anticipated Outcomes
Technique: coaching	Coaching is a behavior control technique used by supervisors or peers to follow progress and to provide informal guidance, instruction, and constructive feedback.
Tool: coaching	There is no better way for supervisors or managers to monitor their staff than through direct observation. One method of accomplishing this is through coaching. Coaching gives a supervisor a firsthand opportunity to reinforce expected behaviors, resolve emergent human performance problems, clarify expectations, assist an individual in achieving those expectations, improve performance, provide constructive feedback, and recognize good performance. It also serves as an excellent team-building opportunity, developing a healthy rapport and respect for everyone involved. In team building, the opportunity for peer-to-peer coaching should not be overlooked.
When to use	When teaching new skills in the field. When assessing the implementation of acquired training in the field.
Reasons to use	To clarify and reinforce expectations. To improve job performance. To reinforce good human performance techniques. To provide constructive feedback. To observe firsthand a person's skills and knowledge. To promote team building.
Behavior standard	The coach: 1. Should prepare the participant for the coaching opportunity, for example, set and explain realistic expectations, establish rapport , offer encouragement, and empower the participant. 2. Should establish a proper atmosphere for coaching, that is, attempt to relieve tension and anxiety, provide proper reinforcement, and be empathetic and approachable. 3. Should demonstrate the proper performance of the task or activity, for example, demonstrate the task, explain the task during performance, emphasize the expectations, and provide opportunities for questions. 4. Should observe the participant performing the task or activity by, for example, using good observation techniques, empowering the participant to achieve independently but assisting during difficulties, and so on. 5. Should provide constructive feedback that is directed at the action and not at the participant.

Table 4-13 (continued)
Supervisor/Manager Toolbox: Coaching

Application	Description, Use, and Anticipated Outcomes
Behavior standard (continued)	The participant: 1. Should be motivated and show interest in the coaching opportunity. 2. Should have taken the initiative to be prepared for the task or activity to be demonstrated. 3. Should assist in keeping the lines of communication open (that is, listen nondefensively). 4. Must be coachable (that is, receptive to instruction and feedback).
Activities to avoid	Communicating in a way that places the participant on the defensive. Instead, use “could” versus “should,” “we” versus “you,” “sometimes” versus “always/never,” “learning” versus “mistake,” and so on. Offering feedback directed at the participant rather than the action. Blaming or criticizing. Communicating vaguely. Acting impatiently. Criticizing issues irrelevant to the situation.
How to evaluate	Coaching of operators in the field. Observation of operators in the field. Monitoring of overall operations human performance indicators.

4.2.6 Observation

Table 4-14 explains the observation tool in the supervisor/manager human performance toolbox.

Table 4-14
Supervisor/Manager Toolbox: Observation

Application	Description, Use, and Anticipated Outcomes
Technique: observation	Observation: the act or practice of noting and recording facts and events.
Tool: observation	The observation process provides an opportunity for supervisors to acquire firsthand knowledge of personal performance. The supervisor can assess whether standards are understood and are being followed. Knowledge can be obtained from the following areas: 1) human performance techniques, 2) industrial safety practices, 3) procedural adequacy, 4) communication standards and use, 5) personal skills, and 6) housekeeping standards.
When to use	When the task or activity is important to plant reliability. When observing operator work performance. When following up on a known plant problem area. When following up on corrective actions. When observing for understanding and compliance with programs and processes.
Reasons to use	To ensure that standards are understood and are being followed. To ensure an understanding of and the use of human performance tools. To observe understanding and compliance with industrial safety practices. To assess personal skills (such as training adequacy and worker practices). To verify that housekeeping is properly maintained.
Behavior standard	1. The observer should properly prepare for the observation by doing the following: a. Determine an appropriate task to be observed. b. Gather all material related to the task, activity, or process to be observed. c. Review the material for the observation (for example, prepare a checklist). 2. The observer should conduct the observation with the following in mind: a. Place the observed personnel at ease. b. Do not be distracted by “blinders.” c. Take good notes (just the facts). d. Use good observation skills.

Table 4-14 (continued)
Supervisor/Manager Toolbox: Observation

Application	Description, Use, and Anticipated Outcomes
Behavior standard (continued)	3. The observer should conduct follow-up and feedback as follows: a. Follow up as required to determine whether problems or areas for improvement are identified. b. Provide constructive feedback. c. When appropriate, provide positive feedback and recognition. d. Remember that feedback is a two-way communication. 4. The observer should prepare an observation report as follows: a. Base the report on observed facts. b. Draw conclusions and recommendations.
Activities to avoid	Treating the observation as a secret. Be open to observation. Criticizing or blaming. Failing to provide feedback or recognition when appropriate.
How to evaluate	Reviewing of observation reports periodically for effective resolution to problems or areas for improvement. Reviewing of observation performance indicators (number of observations performed with negative outcomes).

5
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A
LISTING OF KEY INFORMATION

This appendix provides the location of the Key Points information in this report.

A.1 Key Human Performance Points

Key Human Performance Point

Denotes information that requires personnel action or consideration in order to prevent personal injury, equipment damage, and/or improve the efficiency and effectiveness of the task.

Section	Page	Key Point
2.7.7	2-31	Coaching provides an opportunity for training, feedback, and recognition. It is an effective method of personnel development that focuses on the core skills necessary for a person to perform his or her job. If properly implemented, coaching can improve overall job performance.
2.7.7	2-33	Never underestimate the power of recognition. It can be a powerful motivator if it is appropriate, honest, and timely.
2.7.8	2-35	An effective observation program benefits everyone: the operator, the observer, and the organization.
3.1	3-1	Leadership also plays a key role in effective implementation. Plant and operations leadership must be the first to not just “buy in” but “own” the human performance program.
3.5	3-13	Sometimes it is not as necessary for an organization to measure the “goodness” of its safety culture as it is to recognize signs that indicate a poor or failing safety culture. Some key indicators of a poor or failing safety culture are easily observable.
3.7	3-16	Effective communication is essential to the successful implementation of a human performance program. No single item is more important to the change. It is so important to the overall outcome that it is not possible to over-communicate.
3.10.2	3-24	For the human performance initiative to be self-sustaining, it is essential that successes and desired behaviors, no matter how small, are recognized, communicated, and reinforced.

Section	Page	Key Point
4	4-1	Human performance tools are specific defenses that are optimized to prevent or mitigate errors when specific tasks are performed. The human performance tool used for a task or activity must be adapted for that specific task or activity.
L	L-1	Because the human performance improvement program should be viewed as a long-term process, it lends itself to being implemented in stages.

A.2 Key O&M Cost Points

Key O&M Cost Point

Emphasizes information that will result in overall reduced costs and/or increase in revenue through additional or restored energy production.

Section	Page	Key Point
2.1.2	2-3	The effective implementation of a human performance improvement program works. The number of errors is reduced. Day-to-day success can be difficult to measure and realize, but long-term benefits can be achieved.
2.8.3	2-45	There are definitely costs associated with long working hours. Facilities that reported severe fatigue-related problems had average workers' compensation claims of $4037 compared to moderate fatigue-related problems ($2240), minor fatigue-related problems ($981), and no fatigue-related problems ($276).
3.1	3-3	Parts of a human performance program can be implemented quickly—with minimal impact on resources—yet still provide effective and noticeable results.

B
ANATOMY OF AN EVENT

The processes described in this appendix are not intended to replace any organization's existing corrective action program (CAP) processes. However, their attributes may provide additional insight into human performance errors during the conduct of investigations. In the absence of a formal CAP, these documents can provide an organization with valuable guidance for reviewing events containing issues related to human performance. The following are provided in this appendix:

- Checklist: Anatomy of an Event (see Figure B-1 for a graphical illustration)
- The 5 Whys ("The Why Staircase")
- Error precursors
- Commonly encountered error precursors

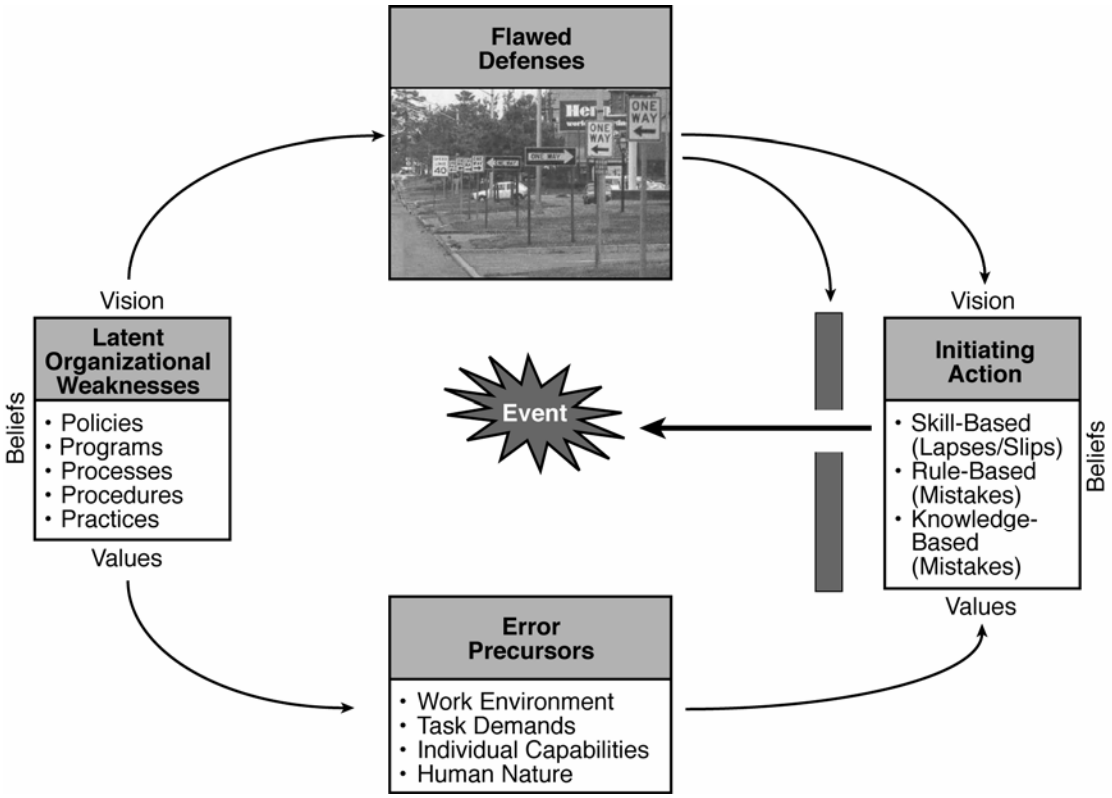


Figure B-1
Anatomy of an Event

B.1 Checklist: Anatomy of an Event

Table B-1 provides a checklist for the anatomy of an event.

Table B-1
Checklist: Anatomy of an Event

1. Activity (What activity was being performed?)
o Task or activity _____ _____ o Procedures in use _____ _____ o Other resources in use (for example, drawings, operator aids, and test equipment) _____ _____
2. Work group (functional organization)
_____
3. Location
• Physical location _____ _____ • System, structure, or component affected _____ _____ • Work environment conditions (for example, lighting, noise, and temperature) _____ _____

4. Event

- Initiating action (What happened?)

_____

_____

- Work situation
  - Immediate goal (What was the goal when the event occurred?)

_____

_____

  - Focus of attention (What was the person's specific attention level when the event occurred?)

_____

_____

  - Mind-set (What was person's mind-set when the event occurred?)

_____

_____

- Detection of the event (If detected, describe how.)

☐ Individual ☐ Coworker

☐ Equipment ☐ No one

- Outcome (What was the impact? [for example, plant generation, industrial safety, hazardous material, or environmental])

_____

_____

5. Error precursors (See the list of error precursors in Section B.3, and check all that are applicable. Some error precursor definitions are provided to assist in the determination.)

_____

6. Error mode ☐ Skill-based ☐ Rule-based ☐ Knowledge-based

7. Defenses/barriers (What defenses existed that could have prevented the event from occurring?)

_____

_____

_____

8. Latent organizational weaknesses (What process or program weaknesses contributed to the event?)

_____

_____

_____

9. Additional relevant information	
_____	
_____	
_____	
_____	
_____	
_____	
10. Reviewed by: _____	Date: _____

B.2 The 5 Whys ("The Why Staircase")

The 5 Whys is a simple technique that is commonly used to assist in developing causal factors or a root cause to a problem or an event. The technique is a cause-and-effect analysis and has been a useful tool in identifying causes associated with human factors or interactions. Developed in the 1930s by Sakichi Toyoda, the technique did not become popular until the 1970s when Toyota implemented it to help analyze production problems. Repeatedly asking "why" makes it possible to "peel away" layers of symptoms and identify the causal factor of an event.

Although the technique has been proven useful, it does have limitations, which can be reduced by combining it with another technique or making the questioning more robust. The following sections explore the use of the technique and its limitations along with how those limitations can be addressed.

B.2.1 How to Use the 5 Whys

The process is implemented in a team setting. The team should first be knowledgeable in both the use of the technique and the facts of the event being reviewed. The second step is to develop a written event statement for the team. This formalizes the event by describing it completely, and it ensures that the entire team is focused on the same event. When the event statement is formalized, the team is ready to ask the first "why" question.

The 5 Whys concept is based on the premise that it could take a series of five "why" questions to arrive at the root cause of an event. The number of "whys" varies based on the complexity of the problem. The 5 Whys is also based on the idea that it takes five "why" questions to get through the symptoms and look at typical defensive layers for causal factors. For illustrative purposes, the 5 Whys may explore the following:

1. Symptoms: Identify the symptoms surrounding the event.
2. Problems: Identify problems, possibly in a variety of programs, processes, or workers' skill and knowledge.

3. Program: Focus on specific program and process deficiencies that contributed to the event (for example, in the areas of human performance, industrial safety, training, and clearance/tag-out process).
4. Cause: Identify specific causal factors in programs, processes, and procedures.
5. Culture: Identify causal factors in the organization's culture that have either 1) allowed error precursors or flawed defenses to continue without correction or 2) been unable to identify the existence of these error precursors or flawed defenses.

As the "whys" are asked, each member of the team has the opportunity to identify possible causes that led to the event. As this brainstorming unfolds, for each "why" question asked, there should be a word of caution. Proposed causal factors must be based on direct observation and not speculation or deduction. If it was not observed, it is just guessing—and falling back on guesswork is a brainstorming trap of which the team should be aware and should avoid.

The most difficult part of the 5 Whys technique is asking the right "why" questions. The variability of the questions is a limitation in the process. The results of one team are not necessarily reproducible or consistent with the results of a second team reviewing the same event. The teams will arrive at different conclusions because they possess different cause-and-effect frameworks and causal knowledge bases. Brainstorming is difficult, if not impossible, to duplicate.

The "why" questioning continues until the final causal factor (that is, root cause) is identified.

B.2.2 Limitations of the 5 Whys

The process appears straightforward and simple to implement; however, there are limitations in the technique. If the team is aware of these limitations, it can reduce their effect by supplementing the technique with additional tools. Recognized limitations of the 5 Whys include the following:

- Brainstorming. As stated previously, brainstorming is not likely to achieve reproducible and consistent results. In addition, it is a time-consuming process. Team members may find the process tedious and also have difficulty in reaching consensus on causal factors. (Each member possesses his or her own causal knowledge set and works it into his or her own simple solution to the event.)
- The "straight-line" causation trap. The technique lends itself to focusing on a single cause for an event, thereby missing additional causal factors related to the event.
- The difficulty in asking the right "why" questions. Asking the correct questions is important to the success of this technique because the more extensive the causal knowledge base possessed by the team, the better the possibility that the right questions will be asked. The causal knowledge base will draw on the collective training and experience possessed by the

team, which is why it is so important to assemble a knowledgeable team to review events. Teams should not be composed of new or inexperienced personnel and should be aware of any team shortcomings. Consider the following:

  - Everyone has limited knowledge (in other words, some causal factors may be overlooked).
  - People tend to rely on "favorite" causes.
  - It is human nature for people to focus on information that proves their hypotheses. This is referred to as the "I've seen this before" trap.

- Just as asking the right question is important, the right answer to the "why" question is equally important. If an answer to a "why" question is incorrect, the causal factors that follow will also be incorrect. Moreover, the earlier in the process this incorrect answer occurs, the further away the final causal factor will be from identifying the root cause of the event.
- Because the 5 Whys is a cause-and-effect analysis, it is subject to the same limitations as that analysis:
  - Because of its structure, the technique will not lead the team beyond the knowledge level it possesses. It does not promote new ways of thinking.
  - The cause-and-effect relationship is not reproducible. (It is not very likely that, if a cause produces an effect, a second person will see the effect and assume that the same cause produced it.)
  - The cause-and-effect analysis is perfect only if there is one cause for each effect.
  - Regardless of the causal factors identified, they should be validated using qualification, validation, and verification (QV&V).
- In most cases, the 5 Whys are implemented without a team being trained. Because the technique appears to be so simple, few see the need for formal training on it, which is a grave mistake. In addition to asking the "whys," team members must know the limitations of this technique and how these limitations can be mitigated in order to deliver a sound and reliable product.
- This technique may create an atmosphere of blame and suspicion. During an interview, the question "why?" tends to place people on the defensive. If interviews are conducted while this technique is being used, the "why" questions must be phrased in a less defensive posture.

B.2.3 Overcoming the Limitations of the 5 Whys

The limitations of the 5 Whys can be reduced or eliminated by using one or more simple additional tools. The first is to enhance the "why" level questioning. This can be performed at each level of the "why" or with the final identified causal factors. Each level (or each causal factor) should be validated with the following questions. If the causal factor(s) cannot be supported by these questions, it is likely that the cause of the event has not yet been identified.

- Is there proof that this cause exists? (It must be observable and measurable.)
- Is there proof that this cause could lead to the stated event?
- Is there proof that this cause actually contributed to the stated event?
- Is anything else required along with this cause in order for the stated event to occur? (Is the cause self-sufficient, or is anything else needed to manifest and sustain it?)
- Is there anything else in addition to this cause that could lead to the stated event? (Does any other cause "fit better"? Are there other risks that should be considered?)

Asking—and answering—these questions will validate the causal factor(s) identified during the 5 Whys process.

B.2.3.1 The Fishbone Technique

The second enhancement that can be used is another cause-and-effect technique: the "fishbone," so named because of its shape. Kaoru Ishikawa developed this technique in the 1960s. When used in conjunction with the 5 Whys, the fishbone technique prevents the team from falling into the "straight-line" causation trap. It also assists the team in exploring a variety of potential or real causal factors in several areas by accomplishing the following:

- Helps the team to determine causal factors
- Helps the team to understand why a process is not functioning as expected
- Aids in identifying further areas for data collection

The fishbone technique provides a graphical relationship of inputs (causes and reasons) and the output (the event). If difficulties are encountered when placing the "bones" (causal factors) on the "backbone" (the event), using the "3 Ps" or the "4 Ms" provides a basic framework for the source of the causal factors. Table B-2 defines the 3 Ps and the 4 Ms.

Table B-2
The 3 Ps and the 4 Ms

3 Ps	4 Ms
People	Man
Process	Method
Products	Materials
	Machine

The 3 Ps or the 4 Ms can be used directly with the 5 Whys to start "why" questions in each of the chosen categories to eliminate the straight-line causation trap.

The fishbone technique uses brainstorming to place the bones on the diagram. Figure B-2 illustrates a fishbone diagram.

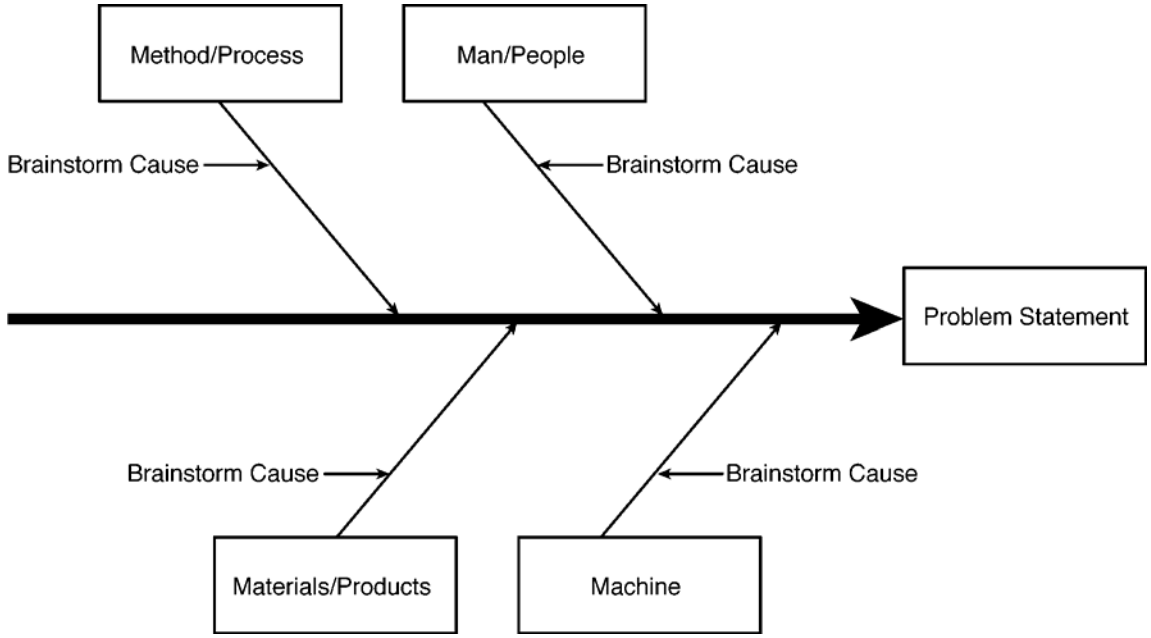


Figure B-2
Generic Fishbone Diagram

B.2.3.2 How to Create a Fishbone Diagram

The following are the steps in creating a fishbone diagram:

1. Establish a team to investigate the event.
2. Draw a horizontal line as the "backbone" and a box to the right of the backbone as the "head" on a presentation board or flip chart.
3. Have the group develop a clear and concise problem description. Write the problem description in the box at the head of the diagram.
4. Have the team agree on the major cause groups (in other words, the initial "ribs"). If the group cannot agree on the major causes, just use the 3 Ps (people, process, and products) or the 4 Ms (man, method, materials, and machine).
5. Use brainstorming techniques to fill in possible reasons for the ribs as follows:
   a. One by one, each person gives a possible cause (perhaps in the form of a question) for each rib. Each cause should be clear, concise, and measurable.
   b. If a participant cannot think of a possible cause, he or she can pass.
   c. Draw the cause on a line connected to the appropriate rib and label it with the cause. If the proposed cause is a factor in an existing cause (rib), draw another backbone off the rib, add another rib, and label it.
   d. Repeat the process until everyone says "pass" and there are both no more possible causes for existing ribs and no new ribs to add.
6. With the fishbone complete, review and discuss the diagram, looking for common or repeated causes. Try to determine the root cause of the problem.
7. The fastest and easiest way to interpret the diagram results is to select and rank the top five causes.
8. The 5 Whys are useful in determining the most likely root cause when the diagram is completed.

B.2.4 Benefits of the 5 Whys

Even with its limitations, the 5 Whys is a widely used analysis tool that has proven to be beneficial. Benefits of the 5 Whys include the following:

- It is simple to implement, easy to learn, and does not require statistical analysis.
- It assists in identifying causal factors through brainstorming.
- It determines relationships among different causal factors.
- It probes more deeply than conventional problem solving.
- If performed properly, it can produce deep underlying causes embedded in the culture of the organization.

To achieve the greatest benefit from the 5 Whys technique, it is recommended that it be used along with a validation of causal factors as well as the fishbone diagram or the 3 Ps or 4 Ms.

B.3 Error Precursors

Table B-3 lists error precursors to an event. In reviewing the anatomy of an event, check all that apply.

Table B-3
Error Precursors

Note: Items in *italics* are more prevalent.

Task Demands	Individual Capabilities
☐ *Time pressure (rushed or in a hurry)*	☐ *First-time task or unfamiliar with task*
☐ *High workload*	☐ *Lack of knowledge (poor mental model)*
☐ *Simultaneous or multiple tasks*	☐ *Techniques never before used*
☐ *Monotonous or repetitive actions*	☐ *Poor communication habits*
☐ *Irreversible acts*	☐ *Inexperienced or lack of proficiency*
☐ *Interpretation requirements*	☐ *Poor problem-solving skills*
☐ *Unclear goals, roles, or responsibilities*	☐ *"Unsafe" attitude or poor awareness of criticality of task*
☐ *Unclear standards*	☐ *Fatigue, illness, or stress*
☐ Vague or confusing procedure or guidance	☐ Unawareness of critical parameters
☐ Excessive communication requirements	☐ *Inappropriate values*
☐ Delays, idle time, or interruptions	☐ *Poor manual dexterity*
☐ Complex or high information flow	☐ Moody
☐ Excessive length of task	☐ Questionable ethics
☐ Long-term monitoring	☐ Sense of control or feeling of helplessness
	☐ *Personality type*
Work Environment	**Human Nature**
☐ *Distractions or interruptions*	☐ *Stress (limits attention)*
☐ *Changes in or departure from routine*	☐ *Habit patterns*
☐ *Confusing controls or displays*	☐ *Assumptions (inaccurate mental picture)*
☐ *Workarounds or out-of-service (OOS) equipment*	☐ *Complacency or overconfidence*
☐ *Hidden system response*	☐ *Mind-set*
☐ *Unexpected equipment conditions*	☐ *Inaccurate risk perception*
☐ *Lack of alternative indications*	☐ *Mental shortcuts*
☐ *Personality conflicts*	☐ *Limited short-term memory*
☐ *Backshift operations or recent shift change*	☐ *Pollyanna effect*
☐ Excessive degree of group cohesiveness (groupthink)	☐ Avoidance of mental strain
☐Adverse physical climate (habitability)	☐ *Fatigue (lack of sleep or overworked)*
☐ Conflicting conventions or stereotypes	☐ *Tunnel vision (failure to see the big picture)*
☐ Poor equipment layout	☐ *Gut feeling (something is not right)*
☐ Fear of consequences of error	☐ *Easily bored*
☐ Meaningless rules	☐ *Difficulty seeing own errors*
☐ Unavailable tools or parts	☐ Imprecise physical actions
☐ Mindlessly following procedure	☐ *Spatial disorientation*
☐ Lack of clear vision or goals	☐ *Physical reflex*
☐ OOS warning systems	☐ *First day back from vacation or days off*
☐ Nuisance alarms	☐ Limited attention span
	☐ Anxiety (usually involves uncertainty)

B.4 Commonly Encountered Error Precursors

Precursors from Table B-3 that are more commonly encountered are described next. The error precursors for each category are arranged in order of influence.

B.4.1 Task Demands

Time pressure (in a hurry): Characterized by urgency or excessive pace required to perform an action or task. This is exhibited by the use of shortcuts, being in a hurry, and an unwillingness to accept additional work or to help others (that is, no spare time).

High workload (high memory requirements): Characterized by mental demands on an individual to maintain high levels of concentration, for example, interpreting and decision making, which require recall of excessive amounts of information (typically information is from training or acquired earlier in the task).

Simultaneous or multiple tasks: Characterized by the performance of two or more activities, either mentally or physically. This can result in divided attention, mental overload, or reduced vigilance on one or the other task.

Repetitive actions or monotony: Characterized by an inadequate level of mental activity resulting from the performance of repeated or boring actions. It can also result from insufficient exchange of information at the task or activity performance location to assist an individual in attaining and sustaining an acceptable level of alertness.

Irreversible acts: Actions that, once taken, cannot be recovered without some significant delay—regardless of recovery efforts.

Interpretation requirements: Characterized by situations or conditions that require "in-field" diagnosis. This can lead to a misunderstanding or the application of incorrect rules or procedures.

Unclear goals, roles, and responsibilities: May be characterized by unclear work objectives or expectations. It may also involve uncertainty about the task, situational awareness for which an individual is responsible in a task that involves other individuals, or task demands that are incompatible with other individuals.

Lack of or unclear standards: Typically results from ambiguity or misunderstanding about acceptable behaviors. If standards are unspecified, the tendency is to default to the standards of the worker in the field (which may be good or bad).

B.4.2 Work Environment

Distractions or interruptions: Characterized by either the task or work environment conditions that require an individual to stop and restart a task sequence; anything that diverts an individual's attention from a task or activity.

Changes or departure from routine: Characterized by the departure from a well-established routine and includes unfamiliar or unforeseen tasks or task-site conditions that could disturb an individual's understanding of a task.

Confusing displays or controls: Characterized by installed displays and controls that could confuse or exceed the working memory capability of an individual, for example:

- Missing or vague content (that is, insufficient or irrelevant content)
- Lack of indication of specific process parameters
- Illogical organization or layout of controls or both
- Insufficient identification of displayed process information
- Controls in close proximity without obvious ways to discriminate conflicts between indications

Workarounds or OOS instrumentation: Characterized by uncorrected equipment deficiencies or programmatic defects that require compensatory or nonstandard action by an operator in order to comply with a requirement or condition. This includes long-term material conditions that place a burden on an operator.

Hidden system response: Characterized by a system response that is invisible to an operator after manipulation of plant controls (for example, lack of process indications or equipment controls); a lack of information conveyed to the operator about previous action(s) that had any influence on the equipment or system.

Unexpected equipment condition: Characterized by a system or equipment status not normally encountered during manipulations that creates an unfamiliar situation for the operator.

Lack of alternative indication: Characterized by 1) the inability to compare or confirm information about system or equipment state or 2) the absence of redundant and other instrumentation.

Personality conflict: Characterized by the incompatibility between two or more operators working together on a common task, resulting in a distraction from the task because of preoccupation with personal differences.

B.4.3 Individual Capabilities

Unfamiliarity with task/first-time performance: Characterized by an unawareness of task expectations or performance standards or first-time performance of a task (including tasks not performed previously or tasks performed after major procedural changes).

Lack of knowledge (mental model): Characterized by an unawareness of factual information necessary for successful completion of a task or a lack of practical knowledge about the performance of a task.

New technique(s) not used before: Characterized by a lack of knowledge of or skill with a specific work method required to perform a task.

Poor communication habits: Verbal communication habits that do not enhance or support accurate understanding by all individuals involved in the exchange of information.

Lack of proficiency/inexperience: Characterized by the degradation of knowledge of or skill with a task or activity as a result of infrequent performance of the task or activity.

Indistinct problem-solving skills: Characterized by an unsystematic response to unfamiliar situations, including the inability to develop strategies to resolve problem scenarios without excessive use of trial-and-error or reliance on previously successful solutions. Also included is the inability to cope with and respond to changing plant conditions.

"Unsafe" attitude for critical tasks: Characterized by personal beliefs about the importance of accomplishing a task or activity without consciously considering the associated hazards, and is associated with a perception of invulnerability while performing a particular task or activity. These human nature flaws can be characterized as pride, heroic, fatalistic, summit fever, the "Pollyanna effect," or bald tire.

Illness/fatigue: A degradation of a person's physical or mental abilities because of sickness, disease, or debilitating injury; it may be brought on by a lack of adequate physical rest to support acceptable mental alertness and function.

B.4.4 Human Nature

Stress: Characterized by the mind's response to the perception of a threat to one's health, safety, self-esteem, or livelihood if a task or activity is not performed to acceptable standards. This manifests itself in an individual as anxiety, degradation in attention, reduction in working memory, poor decision making, and transition from accurate performance to careless performance. The degree of stress reaction depends on an individual's experience with a task or activity.

Habit patterns: Ingrained or automated patterns of action attributable to the repetitive nature of a well-practiced task. This inclination occurs because of similarities to past situations or recent work experience.

Assumptions: Suppositions made without verification of facts, usually based on perceptions of recent experience and provoked by an inaccurate mental model. In many cases, assumptions are believed to be fact. They are stimulated by the inability of the human mind to perceive all facts pertinent to a decision.

Complacency/overconfidence: Sometimes referred to as the "Pollyanna effect," leading to a presumption that "all is well in the world" and that everything is as expected. It is characterized by self-satisfaction or overconfidence with a situation in which there is an unawareness of actual hazards or dangers. In many cases, the operator underestimates the difficulty or complexity of a task or activity based on past experiences with it.

Mind-set: A tendency to "see" only what the mind is "tuned in" to see (in other words, inattention). The individual has a preconceived idea of what is to be. In this condition, information that does not fit a mind-set may not be noticed. It is also possible to miss information that is not expected or to see something that is not really there. A mind-set inhibits an operator's ability to detect his or her own error(s).

Inaccurate risk perception: Occurs when an individual's personal appraisal of hazards and uncertainty is based on incomplete information or assumptions. In this condition, an unrecognized or inaccurate understanding of a potential consequence or danger may occur. The degree of risk-taking behavior is typically based on the individual's perception of the possibility of an error and the understanding of consequences.

Mental shortcuts: The tendency to look for or see patterns in unfamiliar situations based on previous experiences and situations. The operator may apply thumb rules or "habits of mind" (that is, heuristics) to explain unfamiliar situations.

Limited short-term memory: Characterized by forgetfulness or the inability to accurately respond to more than two or three pieces of information simultaneously.

C
COMMON ERROR PRECURSORS AND THEIR EFFECTS ON PERFORMANCE AND HUMAN PERFORMANCE TOOLS USED TO ADDRESS THEM

Table C-1 lists common error precursors and their effects on performance as well as human performance tools that can be used to address them.

Table C-1
Common Error Precursors and Their Effects on Performance and Human Performance Tools Used to Address Them

Error Precursor	Effect on Skill-Based Performance	Effect on Rule-Based Performance	Effect on Skill-Based Performance	Human Performance Tool
Time pressure	Hurried or rushed Performing multiple tasks Slips or lapses	Procedure noncompliance Poor qualification, validation, and verification (QV&V)	Failing to consider all options Poor QV&V Tunnel vision	Stop, think, act, review (STAR) Peer checking
Distractions	Forgetting as-left condition Forgetting to return to task Slips or lapses	Poor concentration	Poor concentration	Eliminating distractions Performing a single action Peer checking
First-time evolution			Source of knowledge-based performance errors	QV&V Problem solving Observation Knowledge of skill fundamentals
Vague or incorrect guidance		Incorrect rule or procedure Rule or procedure misapplication	Incorrect information Wrong assumptions	QV&V “Time out”

Table C-1 (continued)
Common Error Precursors and Their Effects on Performance and Human Performance Tools Used to Address Them

Error Precursor	Effect on Skill-Based Performance	Effect on Rule-Based Performance	Effect on Skill-Based Performance	Human Performance Tool
Improper communication		Incorrect rule or procedure Rule or procedure misapplication	Incorrect information Wrong assumptions	QV&V Three-way communication
Stress	Inattention to detail Preoccupied Slips or lapses	Rule noncompliance Poor QV&V	Tunnel vision Poor QV&V Poor concentration	Relaxation Meditation Communication
Heavy workload	Distractions Time pressure Stress	Rule noncompliance Poor QV&V	Failing to consider all options Poor QV&V Tunnel vision	STAR Pre-job briefs

D
MANAGING THE FATIGUE OF SHIFT WORK

Actions can be taken at both the organizational and individual levels to help shift workers better cope with the demands of shift work. Because shift work affects everyone in different ways, not all suggestions provided in this appendix will work for everyone. In fact, debate continues with regard to how beneficial some of the techniques are in helping a person adjust to the rigors of shift work.

D.1 Organizational Factors to Manage Shift Work Fatigue

The following actions may be taken by management to manage the fatigue that results from shift work:

- Each shift should be designed to be forward rotating (for example, first days, then afternoons, then nights). This minimizes the impact on the circadian rhythm more effectively than backward rotation does, and it takes advantage of the circadian rhythm's 25-hour cycle.
- Quick changes from one shift to another should be avoided.
- The number of consecutive working days on shift should be controlled.
- Breaks of two days between shift changes should be worked into the schedule, if possible. Providing some of those two-day periods during the weekend should also be worked into the schedule.
- Some staffs are fortunate enough to have an extra shift that can cover absences, vacations, and illnesses. Although this minimizes the effect of potential extended hours for personnel on shift, the extra shift does have the same fatigue issues because personnel move to afternoon and night shifts to cover vacancies.
- If possible, shift hours should be adjusted so that night-shift personnel drive home before the sun rises to minimize the effect that daylight has on the body.
- Installation of bright lights in work areas (for example, the control room) helps to alleviate fatigue. Some installations with sophisticated lighting systems are available that adjust to the circadian cycle. For example, they are brighter during the 3:00 a.m. to 5:00 a.m. period and start to dim prior to the end of the shift when workers travel home in order to minimize light's impacts on the body.

- Some proponents suggest a three-week rotation on a given shift. This is based on estimates that the body takes at least a week to adjust to an 8-hour shift change.
- Many occupations have several weeks of night shifts in a row. This reduces the number of circadian disruptions required over the course of a year. If shifts are composed of several weeks of night shifts in a row, personnel should maintain the shift rotation through the days-off period.

D.2 Individual Techniques to Help Manage Shift Work Fatigue

There are no guarantees that the suggestions presented in this appendix will work for all shift operators. However, these suggestions are recommended by professionals who study shift operations in various industries. It is at the discretion of the individual to determine which of these may suit his or her individual needs. The suggestions are provided in three categories: sleep, diet, and fitness.

D.2.1 Sleep

It is important for shift workers to obtain as close to the average amount of required sleep as possible. The quality of the sleep is not the same as that of night sleep: because day sleep is generally lighter than night sleep, the possibility of being disturbed by noise is higher. Considering these factors, workers must plan the conditions of their sleep to obtain the best possible results. Some suggestions are the following:

- Avoid bright lights during the period prior to sleeping. During the drive home, dark sunglasses are recommended if the drive is during daylight hours.
- Use blinds, curtains, or both to reduce light levels. A finished basement can be an excellent place to sleep—not only for light, but for noise considerations as well.
- Remember that cool conditions assist in getting to sleep more quickly.
- Find a sleep pattern that works for you. Some people prefer to obtain their sleep during a single sleep period. If this is the preference, it should be done immediately after the shift. Some prefer to break the sleep into two periods of 3–4 hours each, with one after the shift and the other just prior to the shift. This pattern has the benefit of obtaining a majority of the sleep during periods of normal sleep activity.
- Turn off ringers on phones and answering machines.
- Develop ways to briefly unwind and relax after a shift prior to attempting to go to sleep. For example, take a shower, read, or listen to music.
- Try to follow normal routines that are used as if going to sleep at night.
- Educate friends and relatives that you are working on shift and need to avoid unwanted disruptions.

D.2.2 Diet (Eating and Drinking)

Food and drink consumed prior to sleep affects the quality of sleep. The digestive system is controlled by circadian rhythms and has its own regular rhythm of activity and rest. Digestive activity slows down during the night, regardless of the amount of activity in which the body may be engaged. The timing of meals and the quality of food and drink ingested affect sleep quality. Shift workers should be aware of the following with respect to diet:

- Avoid heavy and fatty foods at night because these are difficult to digest at night.
- Whenever possible, attempt to keep daytime eating patterns. This may involve having two meals at regular times and a lighter meal during the night shift.
- Consider having the largest meal during the day.
- Eat lighter, healthy foods that are easy to digest on the night shift.
- Consume the night-shift meal during the first half of the shift. The process of digesting a meal during the second half of the shift can decrease alertness. Eating lightly throughout the shift is another alternative.
- Consume the night-shift meal before becoming fatigued.
- Do not eat a big meal or ingest too much liquid before sleeping.
- Avoid drinks that contain caffeine in the last few hours prior to sleeping.

D.2.3 Fitness

Everyone is different, and shift work affects people in different ways. Fatigue and sleep are affected by age, gender, stress, fitness, and diet. Because health and fitness are contributing factors to fatigue, it is important for shift workers to maintain a good level of fitness. Some effort should be made to include some physical activity during leisure periods. Shift workers should consider the following:

- Be aware of possible different responses if you are on regular medications, especially those that are associated with causing drowsiness.
- If chronic medical conditions exist, heighten your awareness of your conditions if on shift.
- Be aware of longer recovery times for colds and other similar ailments because of the body's slower recovery caused by fatigue.

E
SAMPLE QUESTIONNAIRE: MANAGING FATIGUE CAUSED BY SHIFT WORK

This appendix consists of a questionnaire to help an organization and its workers manage the fatigue caused by shift work. This questionnaire is only a sample and should be modified to suit each facility's needs.

Questionnaire to Evaluate Existing Shift Schedule

Shift: _____ Time: _____ Date: _____

The following information is optional: Name: _____ Job title: _____ Gender: Male____ Female____ Age: ____

General schedule and shift preferences:

1. How long have you worked on this schedule? _____ (weeks, months, years)
2. During this rotation, how long have you worked on this shift? _____ (days, weeks)
3. Have you ever worked on other shift schedules? ____ Yes ____ No
4. Have you ever worked on other shifts? ____ Yes ____ No
5. Do you prefer rotating shifts or staying on one shift? ____ Rotating ____ One shift
6. On the shifts you have worked, which do you prefer? _____
7. On the shifts you have worked, which do you least prefer? _____
8. Which shift change do you find the most difficult (for example, days to nights)? _____

Present shift:

On the following scale, place an "X" at the point that best describes how frequently you feel sleepy while working on this shift. You can place the "X" anywhere on the line.

9. Do you ever feel sleepy while working on this shift? ____ Yes ____ No

|·····|

Never | A few times a year | A few times a month | Once a week | Several times a week | Every day | Several times a day

10. Have you ever been so sleepy that you have actually fallen asleep on shift? ____ Yes ___ No

|·····|

Never | A few times a year | A few times a month | Once a week | Several times a week | Every day | Several times a day

11. How often do you fall asleep on shift?

|·····|

Never | A few times a year | A few times a month | Once a week | Several times a week | Every day | Several times a day

12. How sleepy do you get?

|·····|

Often ready to fall asleep | Sometimes sleepy | Rarely sleepy | Not sleepy | Often tired | Occasionally tired | Always wide awake

13. How easy do you find it to adjust to working on this shift? This should reflect sleeping, eating, and social patterns as well as your ability to perform your job.

|·····|

No adjustment required | Very easy | Fairly easy | Neither easy nor difficult | Fairly difficult | Very difficult | Impossible

14. Which features in your life figure most prominently in adjusting to working on this shift? Place a check by all that apply.

_____Sleeping
_____Spouse's schedule
_____Children (including child care, school, activities)
_____Television
_____Other_____

_____Eating
_____Commuting
_____Socializing
_____Recreational activities

15. To what extent do you feel you are an integral part of the company and that your needs are considered by management?

I am part of the company	My needs are usually met	My needs are often met	About average	My needs are sometimes met	My needs are rarely met	Never

16. To what extent are you included in company social functions?

Always	Usually	Often	Sometimes	Not often	Rarely	Never

17. Have you ever seen an incident, near incident, or injury that you feel was mostly caused by fatigue or sleepiness? ____ Yes ____ No

18. Have you ever been involved in an incident, near incident, or injury that you feel was mostly caused by fatigue or sleepiness? ____ Yes ____ No

19. Optional:
    If you answered "Yes" to either question 17 or 18, please describe the situation.
    Do not use names.

    _____

    _____

    _____

    _____

20. If you have any suggestions or recommendations regarding the present shift schedule or proposals for any shift schedule, please describe them here.

    _____

    _____

    _____

    _____

F
SAMPLE VISION AND MISSION STATEMENTS

F.1 Sample Vision Statements

Avis

Our business is renting cars. Our mission is total customer satisfaction.

Eastman Kodak

To be the world's best in chemicals and electronic imaging.

American Red Cross

To improve the quality of life; to enhance self-reliance and concern for others; and to help people avoid, prepare for, and cope with emergencies.

F.2 Sample Mission Statements

Otis Elevator

Who: To provide any customer

What: a means of moving people and things up, down, and sideways over short distances

How: with higher reliability than any similar enterprise in the world.

TVA – Nuclear Human Performance

Who: Protect people and the plant

What: from human error

How: through aggressive control of defense-in-depth and the vigorous use of error-prevention techniques.

Delux Checks

Who: To provide all banks, S&Ls, and investment firms

What: with error-free financial instruments delivered in a timely manner

How: error-free means absolutely no errors; timely means a 48-hour turnaround.

G
COMMUNICATION PLAN

G.1 Example Communication Plan: Initial Communication

Table G-1 provides a template that can be used for a communication plan.

Table G-1
Communication Plan Template

Project Title	Human Performance Improvement Plan: #1
Why: Why are you communicating and for what purpose?	The Operations Department will be implementing a human performance improvement program. The program will be designed to take our operating skills to the next level. It will provide all of us with simple human performance tools that each operator will use to enhance his or her skills in order to achieve reliable, error-free operations.
Who: Know the audience. Design the communication to address their needs.	The two major departments involved will be Operations and Training. An outside consultant may be used to assist in the development of the tools and training.
What: Communication content.	This is the initial communication with the Operations Department: Operations Department manager: 1. Provides a brief synopsis for making the case for change. 2. Emphasizes the reason and why it is good for each operator. Operations Department supervisor: 1. Provides an overview of human performance. 2. Forms the human performance team. 3. Discusses the need for support and feedback. 4. Keeps communication about the change open. Plant general manager: 1. Reiterates management support and commitment. 2. Reemphasizes the need for personal involvement.
How/tools: What method will be used for communication? What tools and techniques will aid in communicating the ideas?	Face-to-face meetings with each operating crew during a crew brief in the control room will be conducted. Off-shift crew, training crew operations support, and training personnel will receive a briefing in the operations support area. Briefs will be conducted over a two-day period to convey information to all personnel.

Table G-1 (continued)
Communication Plan Template

Project Title	Human Performance Improvement Plan: #1
When/schedule: Timing is everything. Communicate often, especially on milestones. Be specific.	Conducted on Tuesday and Wednesday. Crews 1, 4, 5, and 6 will receive the briefing at the beginning of their shifts. Crews 2 and 3, Operations Support, and Training will receive the briefing at 12:30 on Tuesday afternoon.
Responsible: Who is responsible for delivering communication? Partnerships are an effective tool.	1. The Operations Department manager (program mentor) will provide a brief introduction to the initiative. 2. The Operations Department supervisor will provide the current details of what is planned. 3. The plant general manager will make closing remarks and reinforce management's support of the human performance initiative.

G.2 Considerations for the First Meeting with Management

Explain the need for change:

- Describe the current situation. Use facts, including a recent emotional event for the plant.
- Provide industry examples of improvements seen in plants that have implemented a human performance program. Use the improvements seen in the nuclear industry.
- Explain the cost benefits. What is saved if a unit trip is prevented? Past unit trips caused by human error are excellent examples.

Explain how the change will be implemented:

- Explain the human performance initiative.
- Explain some of the tools that are available.
- Explain that management's support is crucial for success.

Explain how the change will be accomplished:

- Explain the role of the human performance team.
- Explain that the program will be introduced in phases.
- Explain that training will be provided at all levels of the Operations and management organizations.
- Delineate resource needs for time, posters, incentive rewards, and so on.

Clarify the need for reinforcement:

- Explain that this is a long-term project.
- Remind management that successes will come slowly at first, and so recognition of small gains is vital.
- Explain that communication must be frequent and come from all levels of management.
- Communicate using as many methods as are available.

Each meeting will be different, based on the individual management team. Although these are ideas to assist in the first meeting, they should not limit the imagination of the presenters in “selling” the program.

H
HUMAN ERROR REDUCTION EXPECTATIONS FOR CONTROL ROOM OPERATORS

H.1 Examples of Human Error Reduction Expectations for Control Room Operators

H.1.1 Behavior

Ensure that you fully understand your responsibility, accountability, and authority for your job and each task you perform.

H.1.2 Communication

Clarify any vague or imprecise communication or instruction immediately.

Use the three-way communication technique to ensure communication quality.

When communicating information during task performance with multiple work groups, ensure that all necessary personnel receive the correct information at the right time.

H.1.3 Unexpected Conditions or Test Acceptance Criteria

When an unexpected condition occurs or test acceptance criteria are not met, notify the control room supervisor immediately. Ensure that the proper personnel are notified of the condition.

When an unexpected condition occurs, notify the control room supervisor, and do not proceed until the condition is fully understood and resolved. Never proceed in the face of uncertainty.

H.1.4 Error Reduction

Use stop, think, act, review (STAR) when manipulating plant equipment.

Qualify, validate, and verify (QV&V) any information received and any document or data used in the decision-making process.

Perform verification tasks with total independence in thought and action.

Identify and correct human error traps.

H.1.5 Activities

While monitoring control boards, stay alert and resolve any changes in instrument readings, alarms, or other abnormal conditions.

Perform technical reviews of documents (such as clearances/tag-outs, procedures, and test packages) thoroughly. Heightened attention should be placed on high-risk, generation-sensitive, or personal-safety-related documents.

Participate in shift meetings, pre-job briefs, and other information-related activities to ensure proper situational awareness of the task or activities. Ensure that human error aspects of the job are known and that contingencies are in place.

I
EXAMPLES OF CULTURAL SURVEY SUBJECT AREAS

I.1 Examples of Cultural Survey Subject Areas

I.1.1 Teamwork

In this company, people ask for help with safety when they need it.

Around here, you'd be better off if you hide your problems and avoid your supervisor.

People do go out of their way to help each other work safely.

I.1.2 Safety Awareness

Around here, people don't think much about safety.

In our company, the employees are aware of their part in safety.

I.1.3 Communication

In our company, safety hazards are rarely discussed openly.

People who raise safety concerns are seen as troublemakers.

Around here, employees' ideas and opinions on safety are solicited and used.

I.1.4 Leadership and Supervision

Little special recognition is given to safe employees.

My manager/supervisor discussed safety and health issues in my last employee evaluation.

It's a tradition: safety matters are given a low priority.

I.1.5 Procedure Compliance

In this company, following safety procedures is consistently expected.

There are so many procedures that they interfere with doing a job safely.

In this company, procedures are too detailed, making compliance a mindless activity.

I.1.6 Training

In this company, safety training is compromised in favor of more pressing demands.

People mostly give “lip service” to safety training; they do little to actively support it.

I.1.7 Plant Facilities

In this company, the physical conditions of work locations inhibit safe work.

In this company, fire and electrical hazards are accepted in some of our facilities.

Concern and attention are being given to maintaining good safety conditions in our facilities.

J
EXAMPLE TRAINING SCHEDULE FOR HUMAN PERFORMANCE TRAINING

In the following example training schedule, times are approximate. It is recommended that two days be set aside for training. If both styles—instructional and facilitative—of training are used, a period of two days is typically required.

Day one: background information

- Hour 1: The "whats" and "whys" of human performance, errors, and violations
- Hour 2: Anatomy of an event; error-likely situations
- Hour 3: The Generic Error Modeling System
- Hour 4: The Swiss cheese model
- Hour 5: Error prevention
- Hour 6: Error prevention (continued)
- Hour 7: Human nature and its limitations
- Hour 8: Team errors

Day two: training for all personnel

- Hour 1: Observation training: techniques
- Hour 2: Observation training: techniques (continued) and practical scenarios
- Hour 3: Observation training: practical scenarios (continued)
- Hour 4: Operators: self-checking
- Hour 5: Operators: procedure use and adherence

K
FACILITATIVE TRAINING EXAMPLES

K.1 Example #1

Human performance subject: Generic Error Modeling System (GEMS).

Objective: To enable students to recognize the different types of skill-based, rule-based, and knowledge-based errors that exist in their organization.

Actions:

1. Divide the class into groups of four to five people.
2. Each group designates a spokesperson.
3. Each group selects an example of each classification of error type.
4. Each group chooses one error type identified by the group and provides a brief case study. The group describes the event (inappropriate action), the human error type, what it believes was the cause (apparent cause), and which corrective actions are appropriate.
5. Events are presented on flip charts.

Time: Allow 10–15 minutes for the groups to identify each of the three error type events. Allow 5 minutes for each group to present its error types and case study. Additional time is required for any additional discussion that may follow.

Notes:

1. The instructor (facilitator) should assist in the analysis, if required, and keep the discussion focused.
2. If error-likely situations and event precursors have previously been taught, the teams should use these concepts in identifying possible causes.
3. The flip charts should be maintained. They can be used during subsequent lectures about tools and techniques.

K.2 Example #2

Human performance subject: Skill-based, rule-based, and knowledge-based error types and human performance tools.

Objective: To enable students to first assign the appropriate error type to given scenarios and then assign the appropriate human performance tool that could have been used to prevent the error from occurring.

Actions:

1. Each student works alone.
2. The instructor (facilitator) provides a handout of predetermined scenarios.
3. Students identify the error type and tool that should have been applied.

Time: Allow 15 minutes for students to complete the exercise. Allow an additional 15–20 minutes for presentation and discussion of the scenarios.

Typical scenarios:

1. During the performance of a test, an operator determined that the acceptance criterion was exceeded. Later in the shift, the operator brought this to the attention of the shift supervisor. The shift supervisor informed the operator that, according to procedure, the operator was supposed to notify him of the test failure when it occurred. The operator responded that he was not aware of that procedural requirement.
2. An engineer was performing a calculation for a plant design. During the calculation, he referred to the wrong table to obtain some data. The calculation error was caught during the review process. The engineer stated that he thought he was using the correct table, based on his memory of this type of calculation. He also stated that he had not performed one of these calculations in a long time.
3. An operator slipped while going down the stairs and broke a bone in his wrist. At the time of the accident, he was thinking about having to clean up the oil around the feedpump later in the shift and how messy that was going to be.

K.3 Example #3

Human performance subject: Human performance commitment.

Objective: To determine some of the barriers to implementing a human performance program.

Actions:

1. Break the class into small groups of four or five people.
2. Inform the groups that they are to identify barriers they see as preventing the effective implementation of the human performance program and the human performance tools.
3. Ask the groups to identify ways to mitigate the barriers so that the human performance program will be successful.

Time: Allow 15 minutes for the groups to identify barriers and mitigating solutions to the barriers. Allow 15–20 minutes for presentation and discussion of the barriers.

Notes:

1. Any managers or supervisors present in the class should be segregated into their own group(s) to prevent possible silencing of workers in the groups. The segregated groups also provide an interesting comparison of what the two groups see as barriers to the successful implementation of the human performance program.
2. The information from this exercise should be fed back to the human performance implementation team for resolution of identified issues.

L
HUMAN PERFORMANCE IMPROVEMENT IMPLEMENTATION STRATEGY

An attempt to implement all of the tools and techniques that may be used in a human performance program in one large change would not only be impractical, but would almost certainly lead to its failure. The change that exists in the implementation of the fundamental concepts and a few basic tools will challenge the organization to implement the program effectively. Because the human performance improvement program should be viewed as a long-term process, it lends itself to being implemented in stages. The tools and techniques can also be implemented in a manner such that they continue to build on and reinforce one another as they are introduced throughout the process.

To assist in the implementation process, the following implementation strategy is offered. The implementation takes place over four years. This is not an uncommon timeframe to implement the fundamentals and the tools and techniques described in this report. Time can be shortened if certain tools or techniques are used in the overall process change. It is recognized that because each organization has different needs, some of the tools and techniques may be implemented in an order other than that provided here. Some concepts do, however, have a logical progression for implementation (for example, self-checking followed by peer checking).

Key Human Performance Point

Because the human performance improvement program should be viewed as a long-term process, it lends itself to being implemented in stages.

L.1 Human Performance Improvement Program Implementation: Year 1

Human performance fundamentals: All managers, supervisors, operators, and Operations training personnel should receive a minimum 8 hours of instruction in the basic human performance concepts. It is typical that the fundamentals cover a day and a half with the remainder of the second day used to roll out tools and techniques. (Two days is recommended.)

Tools and techniques:

Operators:

- Self-checking (stop, think, act, review [STAR])
- Procedure use and adherence

Supervisors and managers:

- Observation

Notes:

1. All personnel (that is, operators, supervisors, managers, and Operations trainers) should attend the sessions on self-checking (STAR) and three-way communication.
2. Self-checking and procedure use and adherence are chosen as initial tools because they are easy to understand, easy to implement, and their accompanying behaviors are relatively easy to observe and monitor. They also tend to show results earlier than other techniques.
3. Observation training should be attended by supervisors and managers and Operations training personnel.
4. Prepared lecture programs for observation training should include a video presentation.
5. STAR simulators have been built to teach self-checking techniques.
6. Supervisors and managers should receive basic leadership skills training if it has not already been provided in the organization.

L.2 Human Performance Improvement Program Implementation: Year 2

Human performance refresher: human performance fundamentals refresher.

Tools and techniques:

Operators:

- Peer checking
- Communication: three-way
- Communication: phonetic alphabet

Supervisors and managers:

- Coaching

Notes:

1. Peer checking is a logical follow-on to self-checking because it is considered by many to be self-checking in parallel.
2. Because communication is a tool that is easily monitored and observed, it should be corrected on the spot whenever the correct behavior is not observed.
3. Supervisors and managers who do not “walk the talk” regarding proper communication cause the behavior to die quickly.
4. Coaching is a logical follow-on and builds on the observation skills previously learned.

5. Human performance refresher training should always seek new and innovative ways to convey a message.
6. A STAR simulator (if developed) is an excellent tool for teaching and reinforcing self-checking, peer checking, and communication tools.

L.3 Human Performance Improvement Program Implementation: Year 3

Human performance refresher: human performance fundamentals refresher.

Tools and techniques:

Operators:

- Questioning attitude (qualify, validate, and verify [QV&V])
- "Take two"

Supervisors and managers:

- Pre-job briefs
- Post-job reviews
- QV&V

Notes:

1. A questioning attitude is a difficult concept for most operators to grasp and implement during the course of their work. Supervisors should take advantage of coaching skills developed over the past year to coach and reinforce this behavior.
2. The various forms of pre-job briefs should be well understood. Formal, documented pre-job briefs should not be as common as the generic or summarize, anticipate, foresee, evaluate, review (SAFER) concept.

L.4 Human Performance Improvement Program Implementation: Year 4

Human performance refresher: human performance fundamentals refresher.

Tools and techniques:

Operators:

- "Time out"
- Flagging

Supervisors and managers:

- Problem solving/decision making

Note:

Participating on root cause analysis teams and eventually leading a team provide excellent on-the-job training for supervisors and managers (if they have not previously done so).

M
EXAMPLES OF COMMONLY USED PERFORMANCE INDICATORS

M.1 The Event-Free Clock

The event-free clock performance indicator is a relatively easy indicator for which to gather data. It is easy to understand and can be readily communicated to the organization. The variability that exists in this performance indicator lies in the consistent classification of human performance events. Best results are obtained if the classification is done in a team format, composed of a stable group of members. If the organization has a corrective action program and its documents are reviewed by the management team (five to seven people), this team may be able to classify the events. The management team must have received training in human performance fundamentals to successfully perform the event-free clock performance indicator. The indicator is presented in one or more of the following formats:

- In chart format, tracking the number of human-performance-related events per specified time period (usually one month). Some organizations also provide a rolling six-month average of events per month.
- As a numeric value, providing the number of days since the last human performance event.
- As a numeric value, providing the average number of days between human-performance-related events. The average is performed for a specified time period.

The organization must define the type of events that constitute a human-performance-related event for the purposes of classifying an event and resetting the error-free clock. Typical event-free clock events and resets are the following:

- A significant industrial safety event (for example, a first aid or an Occupational Safety and Health Administration [OSHA] recordable safety event)
- An equipment malfunction resulting from an inappropriate human action
- Events involving inappropriate actions that required a reduction in power
- A procedure non-adherence that placed personnel, equipment, or the plant at risk
- Events in which personnel operated the wrong equipment (commission) or failed to operate equipment (omission)
- Events of personnel operating equipment on the wrong train or wrong unit
- Inappropriate actions taken as a result of a misdiagnosed event

M.1.1 The Event-Free Clock Performance Indicator

Definition: Human-performance-related events that are directly related to the operation of the facility. These do not include administrative errors or training errors.

Rating criteria:

Green: No event-free clock resets during the month

White: ≤1 event-free clock reset during the month

Yellow: >1 event-free clock reset during the month

Red: >2 event-free clock resets during the month

Objective/goal: This goal can be set as either a total number of resets in a year or a rolling 12-month period, as determined by the organization.

Analysis: In this section of the chart, the latest events and their classification types should be provided. The list can be for the past month or the latest three or four events. "Classification" refers to the error committed (for example, improper communication or procedure non-adherence).

Data responsibility: This is a designated person who ensures that all of the data pertinent to this indicator are collected and that the indicator is maintained.

Performance indicator responsibility: This is the person who has the authority to interpret the performance indicator and the control or significant influence over making adjustments to correct any abnormal gaps that appear.

A plan of day (POD) to communicate daily activities can be an excellent communication tool for human performance. If the message is to be communicated only to the Operations Department, the POD can be attached to the Operations night orders.

Information communicated includes current number of event-free days and average number of days between events. Placing this information in view of the organization on a regular basis (for example, twice a week) raises awareness of human performance. No person or shift wants to make the error that causes the clock to reset. As the number of event-free days approaches the average number of days between events, awareness is heightened.

When this information is communicated is also an excellent time to pass along human performance information (for example, a human performance factoid). This information can consist of a human performance concept or describe the latest causal factors that have been resetting the event-free clock. Figure M-1 provides an example of an event-free clock report.

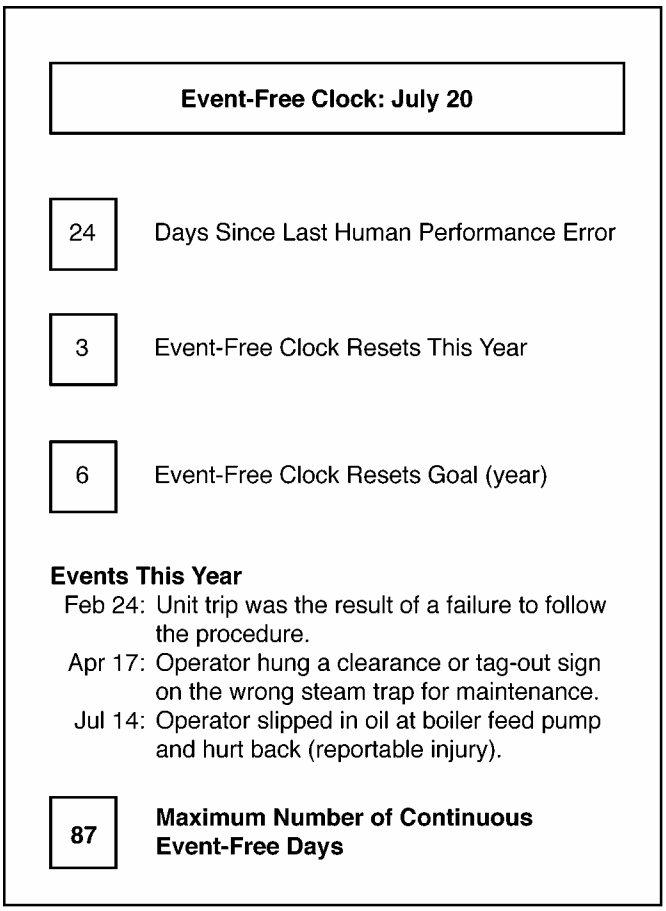


Figure M-1
Example of an Event-Free Clock Report

M.2 Operations Error-Free Rate

The Operations error-free rate is a performance indicator based on the number of errors that occur per work-hours worked. Typically the same types of errors that would be counted in the event-free clock events or resets are used in this indicator as well. In addition, this indicator is typically normalized on 10,000 work-hours worked and is based on a six-month rolling average to prevent a single event from skewing the curve a large degree.

M.2.1 Operations Error Rate Performance Indicator

Definition: Number of events recorded per 10,000 work-hours worked plotted monthly. Points are plotted based on a six-month rolling average.

Rating criteria: The rating criteria provided are based on meeting the event-free clock targets of Green 50% of the time (that is, six events per year). Targets should be revised when actual data are acquired and should be set to meet the department's needs.

The following is an example event-free clock:

A 10-person shift at three shifts per day for a 30-day month is 21,600 work-hours (or 129,600 work-hours per six-month period).

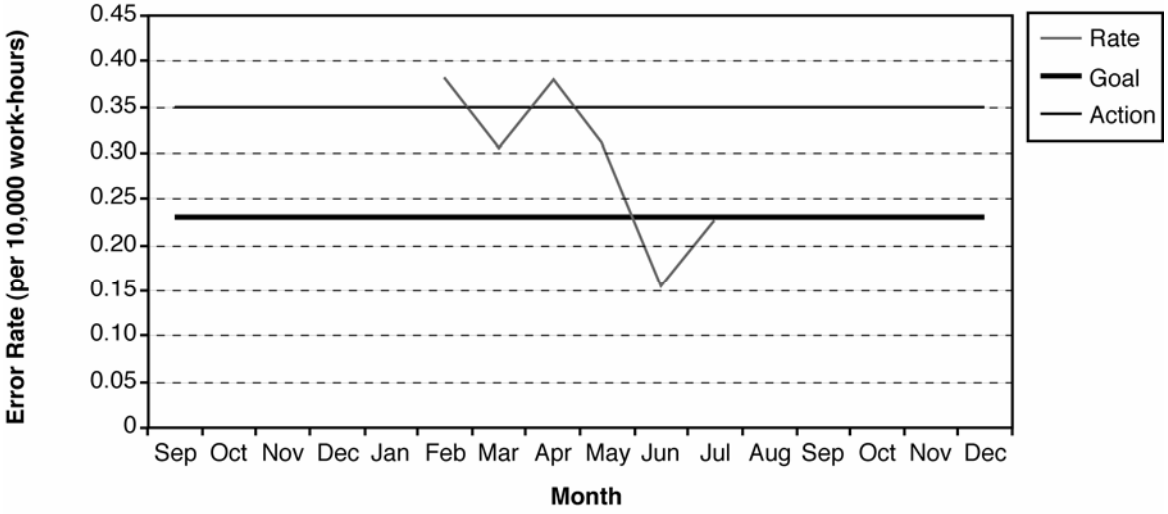
Target: (10,000/129,600) * 3 = 0.23

is the event goal for a six-month period.

An action limit can be set at 150% of the target of the event-free clock:

9 events in one year = 0.35 (150% of limit)

An example indicator for these data, when plotted, is shown in Figure M-2.



Note: Error rate is plotted for six-month rolling average.

Events	1	0	1	2	0	1	0	1	0	0	1			
Hours	22,321	20,907	21,936	22,227	21,880	21,727	22,040	21,984	21,702	22,111	22,100			
Month	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Rate						0.38	0.31	0.38	0.30	0.15	0.23			
Goal	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Action	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35

Figure M-2
Operations Error Rate

Objective/goal: Three event-free clock events in a six-month period.

Analysis: In this section of the chart, the latest events and their classification types should be provided. The list can be for the past month or the latest three or four events. “Classification” refers to the error committed (for example, improper communication or procedure non-adherence).

Data responsibility: This is a designated person who ensures that all of the data pertinent to this indicator are collected and that the indicator is maintained.

Performance indicator responsibility: This is the person who has the authority to interpret the performance indicator and the control or significant influence over making adjustments to correct any abnormal gaps that appear.

N
PRE-JOB BRIEFINGS

N.1 Pre-Job Briefing Checklist

Table N-1 presents a detailed checklist that can be used for pre-job briefing.

Table N-1
Pre-Job Briefing Checklist (Long Form)

☐ Briefly describe the task or activity. • Is the nature of the task understood? • Is the procedure understood? • Are roles and responsibilities clearly understood? _____ _____ _____ _____ _____ _____
☐ Summarize critical steps. • Identify steps or actions that could impact generation if they are not performed properly. • Ensure that all personnel are familiar with the critical steps they are to perform. _____ _____ _____ _____ _____ _____ _____

☐ Anticipate error-likely situations.

- Identify distractions and how they will be minimized.
- Are all personnel familiar with the task or activity?
- Identify safety concerns (such as clearances/ tag-outs, personal protective equipment, scaffolds, rigging, fire watches, and high temperatures).
- Have procedures been revised since the last performance?
- Is this a first-time performance of the task?
- Identify other error-likely situations (such as task demands, individual capabilities, work environment, and human nature). Review the short list.

_____

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☐ Foresee consequences.

- What is the worst thing that could happen?
- Could generation be affected during the task?
- Are there any potential environmental concerns?
- Are there any fire protection concerns?
- Are there any personal safety concerns?

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☐ Evaluate defenses.

- Use self-checking and peer checking.
- Ensure that criteria for stopping the task are identified.
- Ensure that lines of communication are understood.
- Discuss contingency plans for the worst-case scenario.
- Ensure that three-way communication is used.
- Ensure that procedure adherence is followed or revised.
- Ensure that directions for backing out of the task are understood.
- Discuss the use of “time out” if there is uncertainty.

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☐ Review operating experience.

- Discuss site-specific operating experience.
- Discuss industry operating experience.
- Discuss specific experience from performance of the task or activity.

_____

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☐ Review general task performance considerations.

- Has the procedure level of use been discussed?
- Are there any special requirements necessary for the task?
- Is all test equipment that is available and checked out functional?
- Have walkdowns been performed?
- Have task prerequisites or initial conditions been established?
- Have general work environmental conditions been assessed?

_____

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Pre-job briefing attendance:

1. _____ 6. _____
2. _____ 7. _____
3. _____ 8. _____
4. _____ 9. _____
5. _____ 10. _____

Date of pre-job briefing: _____

Person conducting pre-job briefing: _____

N.2 Generic Pre-Job Brief Checklist

Table N-2 presents a basic checklist that can be used for pre-job briefing.

Table N-2
Generic Pre-Job Brief Checklist (Short Form)

Task:	**Date:**
☐ Briefly describe the task or activity. _____ _____ _____ _____	
☐ Summarize critical steps. _____ _____ _____ _____	
☐ Anticipate error-likely situations. _____ _____ _____ _____	
☐ Foresee consequences. _____ _____ _____ _____	
☐ Evaluate defenses. _____ _____ _____ _____	

☐ Review operating experience.

_____

_____

_____

_____

☐ Review general task performance considerations.

_____

_____

_____

_____

Pre-job briefing attendance:

1. _____ 6. _____
2. _____ 7. _____
3. _____ 8. _____
4. _____ 9. _____
5. _____ 10. _____

Date of pre-job briefing: _____

Person conducting pre-job briefing: _____

O
GENERIC POST-JOB BRIEF CHECKLIST

Table O-1 presents a checklist that can be used for post-job briefing.

Table O-1
Generic Post-Job Brief Checklist

Task:	**Date:**	
1. Was the pre-job brief effective in communicating human performance tools related to the task?	Yes ☐	No ☐
2. Was planning/scheduling of the task accomplished with error reduction and human performance in mind?	Yes ☐	No ☐
3. Were task preparations (for example, of participants, test equipment, and communication equipment) adequate?	Yes ☐	No ☐
4. Are there recommended changes that could have improved safety, work environment, or error-likely situations?	Yes ☐	No ☐
5. Were there any unanticipated situations that resulted in errors or near misses?	Yes ☐	No ☐
6. Were there any "good catches" that identified new defenses or prevented an error from occurring?	Yes ☐	No ☐
7. Was the task completed with the expected result(s) or outcome(s)?	Yes ☐	No ☐
8. Were any procedural issues (for example, sequence or accuracy) identified?	Yes ☐	No ☐
9. Were task area environmental conditions (for example, housekeeping, lighting, and noise) suitable for error-free operations?	Yes ☐	No ☐
10. Was supervision support adequate for the successful performance of the task?	Yes ☐	No ☐
11. Were any human factor issues (for example, labeling, operator aids, or physical limitations) identified?	Yes ☐	No ☐
12. Were any potential training issues identified?	Yes ☐	No ☐
13. Were all participants adequately prepared?	Yes ☐	No ☐
Any adverse conditions identified on this checklist should be tracked to their resolution.		
Is additional follow-up required for issues identified in this post-job review?	Yes ☐	No ☐

Participants:	
1. _____	6. _____
2. _____	7. _____
3. _____	8. _____
4. _____	9. _____
5. _____	10. _____
Date of post-job review: _____	Supervisor signature: _____

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