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Conduct of Operations for Control Room Personnel

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Conduct of Operations for Control Room Personnel

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EPRI Project Manager
N. Espinoza

ELECTRIC POWER RESEARCH INSTITUTE
3420 Hillview Avenue, Palo Alto, California 94304-1338 ▪ PO Box 10412, Palo Alto, California 94303-0813 ▪ USA
800.313.3774 ▪ 650.855.2121 ▪ askepri@epri.com ▪ www.epri.com

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THE FOLLOWING ORGANIZATION, UNDER CONTRACT TO EPRI, PREPARED THIS REPORT:

The Accuro Group, Inc.

NOTE

For further information about EPRI, call the EPRI Customer Assistance Center at 800.313.3774 or e-mail askepri@epri.com.

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The Accuro Group, Inc.
1330 St. Mary's Street
Suite 150
Raleigh, NC 27605

Principal Investigator
J. P. Gawron

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ABSTRACT

This report provides a guideline against which fossil-fueled electrical generating plants can benchmark their current control room policies and practices against industry best practices or use the information to develop new policies and practices.

This guideline provides information on standards, expectations, roles, and responsibilities typically found in a control room, including control room command and control, human performance tools, training and professionalism, monitoring and alarm response, industry best practices, and operating experiences.

This guideline's dominant themes are to create a culture of safety and professionalism and to provide a framework for consistent standards and expectations. These standards and expectations are in addition to existing policies and procedures that apply to all station personnel. (EPRI report 1024051, *Operating Procedures Guideline*, provides additional information.) Continuous performance improvement and plant operating efficiency are the benefits of a "best practices" culture.

Background

With the increasing impact of electrical power from renewable energy sources, more stringent environmental regulations, an aging workforce turning over to a less experienced workforce, and new and innovative technologies, the fossil power industry is one that continues to experience change from year to year. Through experience and learning over time, the value in identifying standard "ways of doing business" has helped the industry adapt and grow with these changes. With increased attention on plant availability, reliability, and cost-effective performance, prior EPRI publications have documented the need for an Operations-focused organization paving the way to meet a station's performance goal. Although management and supervision help set the organization toward this goal, the day-to-day operation of a station is typically led from the main control room—making the conduct of operations for control room personnel a key to achieving and maintaining a strong Operations-focused organization.

Objective

This project was undertaken to develop a guideline for conduct of operations for control room personnel. Key elements included are roles and responsibilities, professionalism, plant status management, and best practices and lessons learned through industry experience. These key elements may include some of the following topics: operator fundamentals, control room interaction, human performance, ergonomics, alarm response, documentation, turnover guidance, span of control, short-term relief, housekeeping, emergency management, and supervisor engagement.

Keywords
Control room
Conduct of operations
Unit operators

CONTENTS

1
GLOSSARY AND KEY POINTS

This section provides definitions for common terms used throughout this report. Usage varies slightly within the industry. The definitions below will clarify how the terms are to be understood in the report.

Definitions

Command and control: Responsibility for direction of all unit activities and associated plant manipulations to ensure safe plant operation.

Control room supervisor: The individual responsible for unit operation and directing the activities of the personnel on shift.

Critical step: A procedure or order step, series of steps, or action that, if performed improperly, will cause irreversible harm to plant equipment or people or significantly impact plant operation.

Expected alarm: An alarm anticipated by the control room staff due to plant conditions.

Human performance: The sum of what people (management and staff) are doing or what they have done and how that behavior impacts the operation of the plant. (See EPRI report 1012786, *Human Performance: Fossil Operations*, for more information.)

Human performance tools: A set of error-prevention behaviors used by workers to help in performing their duties more accurately. These behaviors have proven to help individuals anticipate, prevent, and/or recognize mistakes before these mistakes can harm people or property.

Operations-focused organization: An organization whose total body supports the common goals and priorities—to operate the plant in the optimum manner to achieve maximum long-term production due to its first-rate material condition while properly balancing safety, cost, and environmental compliance. See EPRI report 1022131, *Guideline for an Operations-Focused Plant Organization.*

Operator aids: Instructions or postings at or on equipment regarding its operation or manipulation. These aids may be procedures, drawings, specific manipulative instructions, and so on. (See EPRI report 1019807, *Guideline for the Control and Use of Operator Aids*, for additional information.)

On-duty: The period of time that a person is in paid status and is performing work within the company service territory.

Oversight: Maintaining a broad overview of unit status and all control room activities to ensure safe conditions:

- Broad perspective oversight: Normal method of oversight in which the individual is maintaining a higher level knowledge of plant status to ensure that the staff is engaged in the correct activities.
- Direct personal oversight: Likely to be used during transient conditions in which the individual may be more engaged with ensuring that the details of an activity are correct.

Peer checking: A human performance tool in which two individuals work together—before and during a specific act—to prevent an error by the person who performed the act.

Performance improvement: Striving to reduce errors, mitigate events, and improve production that involves implementing organizational changes to processes, policies, and procedures and results in desired behavioral changes. (See EPRI report 1022132, Guideline for Improving Organizational Performance, for additional information).

Pre-job brief: A meeting of workers and supervisors conducted before performing a job to discuss the tasks involved, hazards, and related safety precautions.

Post-job review: A self-assessment method conducted after a work activity to solicit feedback from the worker.

Procedural deficiencies: Situations in which errors are found in a procedure, no procedure exists, or plant conditions are different from those assumed in the procedure.

Safety culture: The standards and actions demonstrated by site leadership and adopted by site personnel that serve to make safety the predominant priority.

Situational awareness: The accuracy of a person's current knowledge and understanding of the task at hand and related working conditions/environment compared to actual conditions at a given time.

Task preview: A worker's review of procedures and other related documents prior to attending a pre-job briefing or starting work. The preview is intended to familiarize the worker with the scope of work, task sequences, and critical steps.

Task review: A final check at the job site to ensure that the task is complete, the system or component is in its intended condition, and appropriate notifications have been made.

Unexpected alarm: An alarm that was not anticipated by any member of the control room staff.

Key Points

Throughout this report, key information is summarized in "Key Points." Key Points are bold lettered boxes that succinctly restate information covered in detail in the surrounding text, making the key point easier to locate.

The primary intent of a Key Point is to emphasize information that will allow individuals to take action for the benefit of their plant. The information included in these Key Points was selected by EPRI personnel, consultants, and utility personnel who prepared and reviewed this report.

The Key Points are organized according to four categories: O&M Cost, Technical, Safety, and Human Performance. Each category has an identifying icon, as shown here, to draw attention to it when quickly reviewing the report.

Key O&M Cost Point

Emphasizes information that will result in reduced purchase, operating, or maintenance costs.

Key Technical Point

Targets information that will lead to improved equipment reliability.

Key Safety Point

Identifies information that will lead to improved worker and industrial safety.

Key Human Performance Point

Denotes information that requires personnel action or consideration in order to prevent injury or damage or ease completion of the task.

The Key Points Summary section (Appendix B) of this guide contains a listing of all Key Points in each 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 report can determine if they have taken advantage of key information that the writers of this report believe would benefit their plants.

2
STATION STANDARDS

It is important for individuals to know what is expected of them in order to be accountable for their performance. It is management's responsibility to define the standards and expectations of the station in order to achieve the level of behavior required.

Standards and expectations must clearly define the behavior that is acceptable and that which is not acceptable. A "best practice" is for each station to develop a document that defines the station's own standards and expectations that clearly define *conduct of operations*. The station document needs to state specifically what the station standards and expectations encompass, what behaviors are expected, and define precisely what is acceptable and what is unacceptable.

When management allows behavior that does not meet defined expectations, prevailing actions and behaviors have in essence been redefined. Continued redefinition of standards and expectations eventually leads to a downward spiral in performance and error-likely behavior.

Well-defined expectations are clear, concise, obvious, and easy to hold individuals accountable for achieving. Any deviation from these standards calls for immediate action that can be achieved through coaching. Coaching reinforces correct behavior and is addressed in Section 4 of this report.

Safety Culture

Safety culture can be defined as an assembly of qualities, characteristics, and values in an organization—and internalized by the individuals within that group—that institutes a prevailing priority regarding plant safety issues. Organizations with a positive safety culture are characterized by trustworthy communications, shared opinions of the importance of safety, and confidence in the effectiveness of conservative decision making.

Safe power plant operation is based on the principle that each operator accepts the unique and grave responsibility inherent in operating a power production facility. Safe operation of the facility takes precedence over all other considerations, including economic and competitive pressures.

Key Safety Point

Safe operation of the plant takes precedence over all other considerations, including economic and competitive pressures.

Safe operation employs the principle that each person accepts responsibility for the protection of plant personnel and equipment in the operation of the facility:

- Operations personnel fully participate in and are supportive of the safety program, which has clearly written procedures and well-defined expectations.
- Safety topics are incorporated into shift turnovers and pre-job briefs.
- Industry operating experience (OE) is included in shift turnovers and pre-job briefs. (See EPRI report 1012783, *Guidelines for Obtaining and Using Operating Experience at Fossil Power Plants*, for more information.)

Key Safety Point

Station, fleet, and industry operating experience is provided to operators frequently and includes discussions on how and why the event could or could not happen at the station as well as how to prevent it. Summaries of lessons learned from these events are often discussion topics at tailgate and safety meetings and are sometimes included in safety newsletters.

- Improvements are made to the safety program through the tracking and trending of safety violations and near-misses.
- All station personnel are aware of the expectations regarding the use of personal protection equipment (PPE) and use PPE appropriately for the job at hand. Senior employees are open to receiving feedback from younger employees on the use of PPE.
- Operations personnel regularly review safety performance and station safety goals.

With safety standards and expectations clearly stated by procedure, it is mandatory that adherence to these principles be required at all times. Shift turnover is an appropriate time to relate safety to work being done during the shift and covering "what if" scenarios; discussing general safety topics such as material safety data sheets (MSDS) or trip hazards is also appropriate during shift turnover. Occupational Safety and Health Administration (OSHA) requires specific information be covered in a safety meeting prior to starting work, and shift turnover is an ideal channel of communication for such information.

A combination of adhering to written standards and expectations along with continuous communication will instill the deference to a strong safety culture that signifies an industry best practice.

Leadership Model

It is management's obligation to set, maintain, and implement standards that can result in performance improvement. Management must first determine the standards and expectations measured against industry best practices and continually review these best practices and adapt them for the plant. It is also important to solicit involvement from station personnel.

Once these standards are written or revised, management must explain the standards and communicate the expectations to site personnel. After procedure implementation, regularly performed observations and coaching should be ongoing and include positive feedback and behavioral improvements.

In order to continually seek to achieve industry best practices, it is important for station leaders to foster a work environment in which personnel feel free and are encouraged to raise safety issues without fear of retribution or intimidation.

Additionally, station management needs to self-examine its model and the safety expectations that have been laid out to all station personnel.

Key Safety Point

Personnel feel free and are encouraged to raise safety issues without fear of retribution or intimidation.

Station Standards for Operations Personnel

The control room is the most important area at an operating station and is the coordination site for plant operations. Operations personnel must perceive themselves as owning all activities that involve the operation of the plant. Although it might sound redundant, it is this ownership that impacts overall station performance as the operators involve themselves in the day-to-day activities and take leadership in areas that indirectly affect operations, such as housekeeping and the material condition of the plant.

Operators must do the following:

- Have solid knowledge of plant theory and design.
- Understand system and component purpose and design.
- Monitor plant conditions at a frequency related to their importance.
- Set and maintain high standards for equipment reliability and performance.
- Maintain safety as a priority through the use of conservative decision making, which includes the following characteristics:
  - Always place personnel and plant safety before production, cost, or scheduling.
  - All key decisions should involve more than one person.
  - The personnel involved should be willing to challenge or be challenged while making the decision.
  - Avoid complacency during the decision making.

Act according to his or her judgment whenever time-critical action is necessary to achieve the following:

- Prevent injury to personnel.
- Mitigate a plant transient.

  - Prevent damage to property.
  - Maintain service of critical equipment.
  - As soon as possible following such action, notify his or her immediate supervisor.
- Comply with regulatory requirements and environmental permits.
- Maintain control room oversight/command and control.
- Work effectively as part of a team.
- Have a conservative bias.
- Maintain a questioning attitude.

Another key responsibility of operations personnel is to thoroughly understand other departments such as maintenance and how maintenance activities impact the operation of the plant. If operating conditions become unacceptable, operations communicates these conditions to senior management and appropriate personnel so that the condition is properly resolved.

Operators work closely with site support personnel to resolve deficiencies in both plant equipment and station processes. Pursuing the cause of a problem or deficiency, implementing corrective actions, and holding personnel accountable are also expectations of operations personnel.

Key Technical Point

All personnel work closely to resolve deficiencies in both plant equipment and station processes.

Interaction with the Clearance Center

It is the responsibility of the control room to maintain error-free clearance execution. The clearance and tagging process changes the normal baseline configuration of the plant to support hands-on work on equipment—where personnel would be exposed to hazards if the hazards were not controlled—and then restores the configuration back to the normal operating condition when the work is complete and it is safe to do so (OSHA 1910.269, Occupational Safety and Health Standards: Electrical Power Generation, Transmission, and Distribution).

The control room interacts with the clearance center to ensure that clearance boundaries and energy sources are clearly understood and to assess the impact on plant equipment outside the clearance boundary; these tasks support work schedules and optimize the availability of the equipment. Clearance and tagging activities are performed in a manner that protects personnel and equipment. (See EPRI report 1014916, *Clearance and Tagging Guideline for Fossil Electric Generating Stations*, for more information.)

In preparing clearances, personnel use controlled and up-to-date drawings and documents to verify isolation points. If these documents are not available, personnel will then walk down the clearance to maintain accuracy of the isolation points. To not accurately maintain and verify all elements of clearance activities jeopardizes both personnel and the plant. For additional information pertaining to the clearance process, see EPRI report 3002001127, *Lockout/Tag-Out Self-Assessment Guideline*.

Operations Alignment with Other Station Work Groups

It is important that all work groups cooperate to form a cohesive team with everyone trained on the effects of their actions on safe plant operation:

- Operations, engineering, maintenance, and other groups interface in equipment testing and procedure revisions.
- As previously noted, operations, maintenance, and the clearance center work together to clearly define and control boundaries in the lockout/tag-out process.
- Many station workers perform actions that can change plant components, making it vital that all groups communicate and work together to maintain consistent, high standards.
- All plant personnel are responsible for the condition of the plant so that any off-normal circumstances, such as leaks and spills, are readily identified.
- Operations and training personnel work together to keep skills and knowledge optimal, especially in the case of emergency and off-normal procedures and processes. (See EPRI report 1014199, *Emergency Management Guideline for Fossil Generating Stations*, for more information.)

In an operations-focused organization, the specific requests made by individual operators on other plant organizations are always production driven, not personality driven. Other organizations respond to operations' needs with the same motivation.

The level of tolerance for deviation from best practices is maintained low in areas such as material condition and housekeeping; the level of communication is maintained high with all areas of the plant. The attention to OE and lessons learned from other industry facilities is a part of the daily communication with personnel. (See EPRI report 1021808, *Guideline for Communication at Generating Stations*, for additional information.)

3
ROLES AND RESPONSIBILITIES

The responsibilities of operations personnel are wide-ranging and diverse. The operation of a plant depends on each individual's acceptance of the crucial responsibilities of his or her role. Among these responsibilities is the safe and efficient operation of the plant—always in compliance with the station's technical and administrative procedures.

In an operations-focused organization, the role of the operations department is to set the standards for performance and professionalism for the rest of the station by establishing and demonstrating the behaviors to be followed by others in the plant. Operations personnel retain the "big picture": to maximize megawatt generation over the long term—but not production at any cost.

Manager

The manager of operations is responsible for the following:

- Establishing, interpreting, and maintaining standards and expectations
- Conforming with all operating instructions, procedures, and regulations
- Ensuring that all operations personnel are qualified and trained appropriately for their position and working closely with the training department to be sure that proper skills and knowledge are imparted to trainees
- Overseeing the continuation of appropriate behavior of the operations staff in maintaining the integrity of the plant and ensuring that the control room staff conduct themselves in a professional manner
- Staffing and scheduling the control room personnel and always emphasizing operator fundamentals and continuous performance improvement

Control Room Supervisor

The control room supervisor (CRS) reports to the manager of Operations and, depending on station staffing, may also act as the shift manager. The CRS is the senior person on watch in the control room. Although this position is ultimately responsible for all activities in the control room, it is important that the person in this position maintains "the big picture," providing direction to the unit operators (UOs) and assistant unit operators (AUOs) and not becoming directly involved. This person is responsible for the following:

- Supervising and overseeing all of the unit shift activities
- Ensuring that the unit operates safely and efficiently
- Adhering to applicable regulations and station standards

- Does not usually involve himself or herself in routine manipulations
- Maintaining direct supervision and communication with on-duty personnel
- Acting as site manager when other senior management is off-site

Unit Operator

The UO is responsible for the following:

- All of the equipment controlled from the main control room board
- The activities of all of the AUOs and any other on-shift personnel assigned to the unit
- Monitoring the control panels regularly and frequently in order to detect the first signs of any off-normal conditions or trends that would warrant notification to the control room supervisor or shift supervisor that plant parameters were out of specification
- Walking down the main panels and reviewing distributed control system (DCS) screens at a frequency based on their importance to ensure that the plant is operating within its specified boundaries
- Taking the immediate necessary action to return the unit to its boundaries if the unit is found to be outside of its operating parameters
- Having the necessary skills and knowledge from both training and confidence from experience to promptly and accurately respond to emergent situations and return conditions back to the operating norm
- Identifying and documenting deficiencies in main control board indications and controls
- Checking equipment against the procedures that direct operator rounds
- Ensuring that equipment used to monitor the plant is functioning properly
- Maintaining high standards for equipment performance
- Manning the control room unless the shift supervisor or another UO is present and aware of the unit's status
- Overseeing trainees in the control room, especially if the trainee is performing any control panel activity or manipulations
- Complying with all station policies, processes, and procedures governing the operation of the plant, including alarms and emergent conditions
- Using human performance tools as an integral part of operating the unit
- Expecting and reinforcing the use of human performance tools by all departments and individuals on the plant site

Key Human Performance Point

It is the expectation that all station personnel use human performance tools. Workers shall apply these tools during all work activities to help them maintain positive control, regardless of their perception of the risk.

Assistant Unit Operator

The AUOs are the eyes and ears of Operations in the field. The following are the responsibilities of the AUOs:

- Monitoring plant equipment and being mindful of any potential problems that develop, such as leaks in boiler casings and piping, spills, tripping hazards, and other safety and environmental conditions

Key Technical Point

The AUO monitors plant equipment for potential problems and immediately reports issues to the unit operator on shift.

- Immediately reporting issues to the unit operator on shift in the control room
- Acting as the hands of the CROs when they manipulate equipment, as directed
- Performing routine tasks and tests always with safety in mind
- Performing lockout/tag-out duties if they are qualified to do so
- Having the skills and knowledge to identify and report any off-normal conditions when in the field
- Using all of their senses to listen, touch, smell, and feel when things are not operating properly
- Being observant of safety issues that may be found while performing duties in the field
- Helping maintain housekeeping in plant and operations office spaces
- Performing in a professional manner and observing strict procedure use and adherence
- Using human performance tools to accurately and safely perform assignments

On-Shift Personnel

All personnel in the control room are to act as follows:

- Maintain a professional attitude, which in turn contributes to the safe, reliable operation of the plant.
- Always be cognizant of plant status (see EPRI report 1008257, *Plant Status Management Guideline*, for more information).
- Keep the control room free of distractions and situations while monitoring station controls.
- Remain mindful of the level of activity in the control room, and notify supervision when the work reaches a level at which there are distractions from monitoring the basic condition of the plant and its systems.
- Coordinate off-normal activities or multiple concurrent activities to avoid loss of concentration on monitoring basic plant functions.
- Have no other issues to distract him or her in the case of off-normal evolutions that would detract from the successful performance of the task at hand.
- Limit access to the control room in the case of off-normal evolutions so as not to distract the operator conducting the activity.
- Keep non-work related activities and conversations to a minimum as they can become distractions.
- See that communications are not hindered.
- Keep phone calls and requests for information not related to the operation of the plant directed to other locations to avoid distracting the control room operators from their primary function.
- In the event of an abnormal condition not covered by an approved procedure, operations personnel shall take action to:
  - Minimize personnel injury.
  - Protect the health and safety of the public.
  - Minimize damage to the facility and to the environment.

4
REQUIREMENTS OF CONTROL ROOM PERSONNEL

Operations personnel must perceive themselves as owning all activities that involve the operation of the plant. Sound operator fundamentals enumerated in Section 1 are the essential knowledge, skills, behaviors, and practices that operating crews need to apply to operate the plant effectively.

Although it might sound redundant, it is this ownership that impacts overall station performance as the operators involve themselves in the day-to-day activities and take leadership in areas that indirectly affect operations, such as housekeeping and the material condition of the plant.

Command and Control

The on-shift operations supervisor/designee or the on-shift unit operator is responsible for command and control of plant activities that occur during the shift and for seeking answers to changes that occur. The on-shift operators must constantly be aware and knowledgeable of plant equipment status and its ability to meet safety and risk mitigation functions.

Industry Best Practices for Command and Control

Industry best practices for command and control include the following:

- Frequent monitoring of the control board
- Taking prompt action to determine the cause of and correction of off-normal situations
- Identifying and correcting inappropriate actions
- Operator training to include knowledge of backup instrumentation
- Limiting the number of concurrent evolutions affecting control board indications to prevent compromising the operators' abilities to detect and respond to abnormal conditions
- Limiting control room distractions for control room operators
- Implementing and using a corrective action program for review and trending of control room deficiencies
- Establishing effective observation and self-assessment programs of specific areas such as operator workarounds

Control Room Decorum

Access to the control room should be limited, and any necessary technical or administrative work needs to be conducted at a location that does not compromise control room activities or operator focus. The shift supervisor determines who enters the control room and who manipulates controls. This is especially true in emergency situations when operators are expected to act promptly to mitigate the event, including restricting access to the control room. Signs should be posted on the control room access doors to indicate that access will not be granted without approval/permission.

Key Safety Point

Non-operations activities such as administrative functions are conducted outside the operational area in order to avoid distracting operators.

Control Room Professionalism

Although each station establishes its own rules for control room maintenance and behavior, it is important for personnel and their work stations to be professional in appearance. The condition of the control room is the responsibility of on-shift personnel and needs to be clean and organized, with procedures and operations-related material easily accessible. There are stations that are not restrictive about the use of personal reading material and electronic devices such as laptop computers and cell phones, but reasonable use would be necessary to avoid distractions during critical evolutions. This would include eating or cooking and other such activities that would require someone else to monitor the board. Safe operation of the plant takes precedence over all other activities in the control room.

The control room crew needs to remain aware of the intensity of activity in the control room and notify supervision when the work reaches a point at which there are distractions from monitoring the basic condition of the plant and its systems. Off-normal activities or multiple concurrent activities must be well-coordinated to prevent loss of concentration on monitoring basic plant functions. In the case of off-normal evolutions, it is important that the operator conducting the activity have no other issues to distract him or her from the successful performance of the task at hand and that access to the control room is limited.

Non-operations-related activities should never be a distraction to the diligent monitoring and safe operation of the plant. Phone calls and requests for information not related to the operation of the plant are directed to other locations to prevent distracting the control room operators from their primary function.

The professionalism also extends to interaction and communication with other work groups. The control room coordinates all plant activities to ensure the safe operation of the plant and, in the absence of direct supervision, assigns job priorities to all departments and ensures that adequate resources are available to allow planned and emergent activities. Field radios are intended for communication with the control room and should not be used for circumstances other than professional. This behavior extends to control room telephone use for business purposes only, not for personal or phone forwarding purposes. Threatening, abusive, or offensive language or discussion is not tolerated in a professional environment, and all employees shall be treated with

respect. In an operations-focused organization, the specific requests made by individual operators of other plant organizations are always production driven, not personality driven. Other organizations respond to operations' needs with the same motivation.

The professional control room maintains and advocates station safety—including identification and correction of unsafe conditions—holding themselves and others accountable to safety rules and safe work practices. In addition, the professional control room is mindful of environmental impacts from pollution control (baghouses, precipitators, selective catalytic reductions [SCRs], and scrubbers) and chemical treatment equipment that can occur from improper or degraded operating condition.

Key Safety Point

Environmentally sound practices lead to safer conditions for the general public.

Control Room Attire

It is human nature that a professional appearance commands respect—a trait necessary in the operation of an electric generation facility. Although it is up to each station to set its own rules on standard attire, OSHA has set the standards for fire-retardant clothing in the following situations:

- The employee is working on or near exposed energized parts of electric circuits
- It is possible for an electric arc from the exposed energized circuit or a flame to pose a hazard to the employee

Training in the Control Room

The shift operations supervisor (SOS) has the responsibility to see that training is conducted in accordance with company policy and procedures to include safe, reliable operation of the plant and equipment at all times.

Training for New Operators

- Training can take place in the control room as informal on-the-job (OJT) training or using job shadowing and mentoring for operators working on becoming qualified. It is also important that while training is in progress, appropriate actions need to be taken to mitigate distractions such as having someone designated to answer phones and to post signs noting that training is taking place.
- Trainees are provided with and taught the use of human performance tools and are expected to use these tools consistently.
- Trainees are expected to read and follow all pertinent procedures.
- Trainees are taught to discuss activities prior to performance and to stop when they are unsure of the outcome of the activity they are performing.

- The SOS regularly observes the trainee and is always present when a trainee is operating equipment unless the trainee has been temporarily assigned to another qualified operator.
- Trainees are often assigned to crews and are assigned a mentor from whom they can learn valuable personal experience, which may not be captured in procedures or lesson material. (See EPRI report 1014200, *Mentoring OJT Assessment Guideline*.)
- Although mentoring can be more valuable than a textbook, it is necessary for the trainee to have both.

Continuing and Ongoing Training for Qualified Operators

- Operations and training personnel work together to keep skills and knowledge optimal, especially in the case of emergency and off-normal procedures and processes.
- Ongoing training includes knowledge of new and modified equipment as well as backup instrumentation.

Common Training for All Operators

- Training scenarios are used for individual and crew training. Operators are provided scenarios and have to figure out, both individually and as a crew, the proper course of action, including the use of procedures—which keeps the student up to date on procedure knowledge.
- All operators attend human performance training, which includes extensive use of industry experience.
- All operators continually refresh their knowledge base with up-to-date reading material.

The success of a training program is evident in the number of human performance errors that occur and the repetition of non-material-caused equipment failures. Its success can also be measured by the timely fulfillment of training requests and the frequency of review and revision of the materials.

Key Human Performance Point

Operators attend human performance training, which includes the use of human performance tools, error traps, and latent organizational weaknesses and extensive use of industry examples. The training uses skits and other dynamic learning activities rather than just discussion to demonstrate the concepts.

Plant Status Management

Annunciators and Alarms

Changes in alarm functions call for increased monitoring, and changes in board light status must be verified because a loss of power can render the board components inoperable. For this reason, indicator lights must be kept lit, and burned-out lights must be identified and replaced. It is prudent for operations personnel to develop a system of identifying, tracking, and dealing with both lit and disabled annunciators. When an alarm or annunciator malfunctions, it is prudent to immediately investigate and correct the situation. Any "out-of-service" alarms must be corrected as quickly as possible. Likewise, if an action in the plant might actuate a control room alarm, the person performing the task must first inform the control room of the intended work activity and obtain permission from the control room before proceeding. Operators assume that every alarm is valid—whether from a DCS or from any other site. (See EPRI report 1014316, *EPRI Alarm Management and Annunciator Applications Guidelines*, for more information.)

Categories of Annunciators

Annunciators can be classified into three categories: expected, unexpected, and nuisance.

Expected Annunciators

Expected annunciators are those that were previously identified in a pre-job brief and approved by the unit operator. Discussions were held to determine any action that may be necessary due to field work. Expected annunciators were communicated from the field to the operations personnel before the alarm was actuated or anticipated because of control room activity. Testing or maintenance of equipment can also activate an alarm, but this expected alarm is flagged on the board prior to the activity. Sticky notes are not acceptable means of flagging the board.

Unexpected Annunciators

Unexpected annunciators are those that were not expected as part of planned activities. They need to be communicated to the shift supervisor and reference the annunciator response instruction (ARI). In addition, the source of the alarm needs to be determined. If the alarm is due to equipment deficiency or abnormal operations, it becomes necessary to generate the appropriate maintenance or service request. However, if the alarm continues and was not resolved by the requested action, it must be tagged according to procedure.

Nuisance Annunciators

Nuisance annunciators are those that have been identified as malfunctioning and must be investigated as any other alarm—however, upon determination as a nuisance, they need to be identified and requested to be repaired. Another category of nuisance alarm is those that are expected but are repeated frequently so as to become a distraction to the staff.

In the case of a valid alarm, the unit operator immediately assigns a priority to the condition measured against other unit conditions or activities and works with engineering or emergency preparedness personnel to make sure that all necessary actions are taken to correct the situation.

It is important that limits be set on the availability of control board instrumentation and control so that repairs can be made and the number of unavailable instruments kept to a minimum. Station management needs to be informed of control board status, especially with regard to unavailable instrumentation.

Key O&M Cost Point

Detailed shift and daily reports of equipment that is out of service and other equipment issues, along with 24-hour trend data, help keep management informed of plant status.

Computer-Generated Graphics

Computer-generated graphics can be used effectively to provide monitoring capability to the control room operators. However, the use of computer screen monitoring needs to be balanced with monitoring by skilled and knowledgeable operators of the installed main control board meters, instruments, and charts. Additionally, controls and equipment that are designed to operate automatically are not usually operated manually. The exception would be if special testing or manipulations for repair work would need to be performed. Any inoperable equipment meant to be automatic needs to be identified and prioritized for maintenance.

Equipment Restrictions

Control room staff must be knowledgeable at all times of plant equipment status and operational ability. Equipment controlled from the main control board that is defective or has temporary limits that restrict its operation must be clearly identified so that control room personnel are aware of such deficiencies or restrictions.

When equipment is compromised, processes and procedures need to be in place to ensure that the risk to the plant is minimized and that valid solutions are available in a timely manner. An effective corrective action program (CAP) enables the communication, tracking, and trending of equipment deficiencies.

Documentation and Log Keeping

Logs are a chronological record of plant activities, equipment function, and events. They may be electronic or handwritten. (See EPRI report 1019807, *Shift Turnover and Log Keeping for Fossil Generating Stations*, for additional information.) The functions of log keeping are as follows:

- To document the details of any changes to plant and equipment and the reasons for those changes
- To provide an account of plant and equipment activities that assists in maintaining plant status
- To track the performance of plant equipment
- To convey information at shift turnover as a means of communication

- To provide information and review in reconstructing events to prevent recurrence
- To relay details for root-cause investigations following an event
- To share information from previous operators of the plant

Operator logbooks are the easiest and best way to document certain actions related to the North American Electric Reliability Corporation (NERC) Reliability Standards. Refer to EPRI report 1024050, *Internal Compliance Program for Approved North American Electric Reliability Corporation and Regional Reliability Standards: A Guide to Compliance for Fossil Generators*, for additional information.

Log entries can be used for communication with the balancing authority or transmission operator and to document changes in automatic voltage regulation (AVR) and automatic generator control (AGC). Instances such as responding to a directive, communicating a forced outage, or documenting a change in equipment status are also common. Successful logbook entries should note who called, at what time, what the issue was, and how it was resolved.

Because logs are legal documents and could be called into account in the reconstruction of an event or other matter, they should meet high standards for accuracy and consistency.

Announcements

The station's public address (PA) system is for business use in announcing emergency situations, major equipment starts, and other potentially impactful events. Misuse of such a system could result in distractions during activities, possibly leading to less-than-adequate oversight.

Administrative Controls

Communication

The control room provides coordination of all plant activities to ensure the safe operation of the plant and, in the absence of direct supervision, assigns job priorities to all departments and ensures that adequate resources are available to allow planned and emergent activities. Regardless of whether the communication is verbal or written, it is important that the exchange of information be clear, concise, and timely for the safety of the staff and for the reliability of the plant equipment.

A combination of adhering to written standards and expectations along with continuous communication will instill the deference to a strong safety culture that signifies an industry best practice.

Operator Turnover Guidance

Shift turnover is an appropriate time for the following:

- Performing detailed turnovers to include any changes to systems and components of which oncoming personnel need to be aware and to discuss current plant status and particular conditions of individual watch stations
- The crew to discuss and plan work for the upcoming shift

- Supervision to update the crew on administrative items
- Allowing groups to interface with operations to update the crew on activities that may impact the shift
- Observing oncoming shift personnel for signs of fatigue or other physical impairments such as fitness for duty
- Verifying that oncoming personnel are qualified to relieve control room staff
- Log turnover brief, as required

Oncoming personnel are obligated to review logs, rounds sheets, and other related documents that were revised or generated during the previous shift. Shift brief discussions should include activities that impact the following:

- Plant safety and reliability
- Personnel safety
- Human performance

The shift brief should be attended by all crew members; watch standers may attend via speaker phone with SOS authorization. Shift briefs should not be used as a forum to resolve complex issues.

End-of-Shift Brief

An end-of-shift brief should be held at the discretion of the shift manager (or delegate) prior to the completion of each shift to accomplish the following:

- Communicate any issues or problems that occurred during the shift
- Ensure that consistent turnover is provided to the oncoming shift
- Communicate administrative topics or items of general interest

Operator Rounds

Operator rounds are the systematic monitoring and inspection of equipment by personnel during system walkdowns of assigned areas while on shift. Rounds are a specific operations activity for operators to take ownership of equipment and plant condition and ensure the early detection and correction of equipment problems. Operators identify actual and potential equipment problems, as well as conditions that could impact the function of the equipment, at a point early enough for supporting organizations to correct the problems. (See EPRI report 1015834, *Operator Rounds Guideline*, for additional information.)

Operator Aids

Operator aids are instructions or postings at or on equipment regarding its operation or manipulation. These aids may be procedures, drawings, specific manipulative instructions, and so on. However, it is not acceptable to use informal or uncontrolled aids such as yellow sticky notes as operator aids or labels.

Procedures

Procedures are the guiding documents that address specific processes, programs, or tasks and are intended to be followed in the performance of that particular element—step-by-step until the job is complete. Station procedures need to be in place to provide adequate guidance for all activities or evolutions that could cause personal injury or damage to plant equipment. *Procedure adherence* means clearly understanding the purpose of the document and following its guidance as written.

Some stations will acknowledge a less-than-strict observance of procedure use and adherence. When a document cannot be used as intended, workarounds should not be acceptable. The work should stop and the procedure corrected before proceeding with the task.

Non-Controlled Documents

A mention should be made here regarding the use of non-controlled documents in lieu of procedures. The use of non-controlled training materials or checklists to replace procedures is not prudent. When equipment is compromised, processes and procedures need to be in place to ensure that the risk to the plant is minimized and that valid solutions are available in a timely manner. Facilities should routinely review their controlled documents to ensure that they are current with any equipment monitoring upgrades, data gathering capabilities, or operational changes that might have been implemented.

Plant components shall be operated according to written guidance that maintains status control, examples include the following:

- Procedures
- Clearances
- Rounds sheets
- Formal communications
- Operations and orders

Operations personnel may be allowed to manipulate components according to the watch station rounds sheets using the rounds sheet basis document as guidance.

Briefings

Pre-Job Briefs

After receiving a job assignment, the work crew that holds a comprehensive pre-job brief is likely to accomplish the work safely and error free. The *brief* is a meeting of the workers assigned to the task along with the pertinent supervisors. The group covers all elements of the task involved, including the guiding documents, as well as any hazards that may be encountered that would affect personnel or equipment. The purposes of the brief are 1) to create a focus and clarification of the objectives of the work and the environment in which it is to be performed and 2) to accomplish the task as safely as possible. The safety discussion included in the pre-job brief can be used to meet the OSHA requirement for a safety brief prior to starting work.

The details of the work are covered in the pre-job brief, including each person's role and experience performing the task, critical steps involved that may need rehearsing, resources to be used, lessons learned from previous experience, and any precautions that need to be taken as well as any contingencies that need to be planned.

Pre-job briefs are held not only for complex tasks, but also in more simplified form for tasks that would be considered lower level. Complacency with routine or familiarity with a task does not negate the need for a pre-job brief. Often the simplest action may be the one that creates the most disastrous outcome.

Post-Job Briefs

Post-job briefs or reviews are conducted at the completion of a task or activity and include lessons learned that can be entered into a database and used the next time the task is performed. Management and relief operators often attend to ensure continuity and maximum learning. Post-job briefs can be valuable tools for performance improvement.

Key Human Performance Point

Pre- and post-job briefs for infrequently performed activities are used as a tool for continuous improvement. Pre-job briefs include discussions of the specific task, lessons learned from previous similar work, job hazard analysis, and safety walkdowns. Post-job reviews are conducted at the completion of the task or activity and include lessons learned that are entered into a database and used the next time the task is performed. Management and relief operators often attend to ensure continuity and maximum learning.

Temporary Relief

Occasionally, it may be necessary for an operator to be temporarily relieved from shift for any number of reasons that may be personal or work related. It is prudent for the station to have a relief designee for each watch. Relief turnover should be in accordance with the amount of time the watch is relieved, and the responsible individual should ensure that the new watch stander is fully informed of plant and position status. Notation of relief should be made in the log book.

Environmental Compliance

It is important to personnel, the plant, and the public that the station complies with regulatory requirements and environmental permits. However, operators should ensure that their actions are based on sound operational principles—not solely on compliance with rules.

Environmental stewardship means being mindful of environmental impacts from pollution control (baghouses, precipitators, SCRs, and scrubbers) and chemical treatment equipment that can occur from improper or degraded operating conditions as well as potential problems that develop such as leaks in boiler casings and piping, spills, tripping hazards, and other safety and environmental conditions.

Problem Identification

Whether problems concern personnel or plant equipment, it is everyone's responsibility to try to identify potential problems and error precursors before they become issues.

Personnel performance gaps, habits, and behaviors may be identified by observation or by using human performance tools.

Plant equipment issues may be identified by 1) local instrumentation, indicators, and controls and 2) physical aspects that are picked up by an operator using his or her primary senses of sight, touch, smell, and hearing.

Human Performance

Humans make mistakes that can be compounded by the failings of equipment, flawed processes and programs, and uninformed decisions. However, there are human performance tools to help identify and mitigate hidden conditions and situations that could cause injury to people and damage to the plant. Human performance tools allow the individual to focus on the task at hand and retain positive control of that task. The individual using the right human performance tool at the right time is conscious of how his or her actions impact the plant. A listing of the most frequently used human performance tools include the following:

Self-Checking

Self-checking is what its name implies. The conscientious worker is aware of the consequences of his or her actions before, during, and after performance of the task. The workers should ask before each task, "Am I taking the correct action?"

Stop, Think, Act, Review (STAR)

STAR stands for *stop*, *think*, *act*, *review*. The knowledgeable, trained worker approaches a component, takes the time to validate that it is the correct one, thinks through the action to be performed, anticipates the expected results, performs the task, and then reviews and verifies the action and its results.

When a problematic condition is recognized, work should be stopped to eliminate it. Examples include distractions, an uncomfortable feeling, or a confusing situation.

Peer Checking

Peer checking usually occurs when one person requests a "check behind me" review by a coworker. Sometimes the "check" occurs while the initiating person performs the task. Peer checking is a way to have another set of eyes looking at the situation as an additional method of verifying that the work has been or is in the process of being correctly performed. The peer who is familiar with the task may see a potential hazard that the performer may not see.

An obstacle to peer checking may be that the checker is using the same standards as the performer, possibly as a coworker on the same crew with the same training and knowledge. Additionally, the initiating worker may depend on the peer checker to catch problems and may be less focused than he or she should be.

Independent Verification

Independent verification involves two or more individuals, working independently and separated by time and distance, checking the results after the initial work has been completed. Unlike self-checking and peer checking, independent verification occurs after performance of the work not during or after the job is complete. It is also separated by time and distance.

Pre-Job Briefs

As previously mentioned, the pre-job brief is a meeting of the workers assigned to the task along with the pertinent supervisors. The group covers all of the elements involved in the task—including the guiding documents—and any hazards that may be encountered that would affect personnel or equipment. The purposes of the brief are 1) to create a focus and clarification of the objectives of the work and the environment in which it is to be performed and 2) to accomplish the task as safely as possible.

Pre-job briefs should encompass the following:

- Have a clear start and end
- Be conducted such that they do not interfere with evolutions or transient response requiring the attention of all participants
- Be placed on hold as appropriate for interruptions and resumed by gaining all participants' attention prior to restarting
- Be tailored using a graded approach, considering the frequency, complexity, and risk of the task and the knowledge levels of those involved

Procedure Use and Adherence

Procedures are the guiding documents that address specific processes, programs, or tasks. They are intended to be followed in the performance of that particular element, step-by-step until the job is complete. *Procedure adherence* means clearly understanding the purpose of the document and following its guidance as written.

Three-Way Communication

During activities in the plant, there is often a need for work assignments or changes in the task or the environment that in turn make it necessary for workers to communicate with one another clearly and precisely. This can take place in person, by phone, or by radio. Three-way communication is a NERC requirement when giving and receiving directions from the system operator or dispatcher.

Three-way communication has three verbal exchanges between a speaker and a respondent. The speaker initiates the exchange and must be sure that the receiver understands the information being transmitted:

- The speaker gets the receiver's attention and states the information clearly and precisely.
- The receiver repeats the message in his or her own words, which indicates to the speaker that the information is clearly understood.
- The speaker lets the receiver know whether the message was received as intended and, if not, corrects the receiver's perception and rewords the message.

It is important that the speaker never assume that the receiver understands all aspects of the message. It is the speaker's responsibility to verify the transmission of the message; in return, it is the receiver's responsibility to ask for clarification if there is any doubt about what was said.

Phonetic Alphabet

The phonetic alphabet is a list of words used to identify letters in a spoken message. It is much easier to understand "bravo" and "victor" than trying to discern the difference in the sounds of "b" and "v." When the only difference between two valve labels may be a single letter, the use of the phonetic alphabet eliminates any confusion in identifying the correct component.

Questioning Attitude

To have a *questioning attitude* means to look at a situation and train oneself to see things that are out of place or are not as they should be.

A questioning attitude encourages situational awareness on the job, especially regarding safety issues prior to starting the work. Being aware of working conditions and the situations that could arise avoids being blindsided by hazards in the environment as well as errors or omissions on a work order.

Members of an organization may share assumptions and flawed beliefs. The individual with a questioning attitude is attentive to circumstances and activities that may have an adverse outcome on work performance.

There are a number of ways to promote a questioning attitude. Among these are a pre-job brief in the work area where situational attentiveness can be used. The pre-job brief creates an atmosphere for personnel to discern what the situation is and what it should not be. The person conducting the brief can ask about potential hazards in the area, any critical steps to the job, and any error precursors that could create unwanted consequences. Job situational awareness arms the crew with knowledge and helps dissolve complacency.

Another method to heighten a questioning attitude is to stage a scene with built-in flaws. This laboratory training exercise could be as simple as a display of PPE, requiring the staff to choose which to use in given situations, or the lab could be a long-term setup with several scenarios involving flawed working conditions.

Two-Minute Rule

Sometimes referred to as *situational awareness*, the *two-minute rule* is a "stop and look" tool that offers more detailed components of self-checking with questions such as the following:

- What are the hazards in the work area?
- What personal protective equipment do I need?
- Are energy sources secured?
- Am I at the right component?
- Do I understand the procedure and the consequences of improperly performed actions?
- Am I qualified to do this job?
- What could go wrong during the performance of this task?
- What defenses are available to prevent or manage unintended consequences?

Coaching

Coaching is the act of providing guidance and direction to personnel in order to elevate their ability to achieve specific organizational goals as well as guiding the individual in achieving personal career development. The objective of coaching is to achieve an employee's commitment to changing behavior.

5
MONITORING PRACTICES

Managers, superintendents, and supervisors monitor plant operations on a day-to-day basis and perform periodic assessments to identify areas for improvement. Their monitoring activities include the following:

- Starting and stopping major equipment
- Operators making their designated rounds
- Observing control room operations
- Implementing the clearance process
- Ensuring compliance with regulatory requirements
- Using procedures and other support documents that provide direction for plant operations
- Ensuring that equipment used to monitor the plant is functioning properly
- Knowing the status of the plant, key activities, and current risks at times such as the starting and stopping of equipment
- Maintaining direct oversight of plant and crew response during transient and emergency conditions
- Frequently monitoring crew response and performance to ensure the highest standards of excellence in performance through broad perspective oversight
- Supervising individual turnovers and shift briefs (beginning-of-shift meetings)

Unloading Chemicals

Because of safety concerns, chemical unloading needs to be monitored from the time of the container's arrival on-site to the completion of the unloading activities. See Appendix A, "Industry Experience." The safe handling of chemical unloading includes the following tasks:

- Security gate personnel verify with operations that a shipment is expected, and the paperwork and container placards clearly identify the chemical.
- Operator gives instructions to the driver as to the location/storage tank for the unloading.
- A member of the operations team is on location to verify the shipment, the correct storage location, and the storage tank's capacity for the load. The operator also checks the shipping container for leaks and other unsafe conditions that may interfere with unloading. The operator also verifies that the compatibility of the material to be transferred is appropriate, authorized, and consistent with applicable procedures.
- Necessary PPE is being used.

- Other precautions are staged as appropriate for the chemical being unloaded.
- Inspection and securing of transport unit fittings and closures at the completion of the transfer of chemicals.

High Safety Risk Activities

Daily operation of the facility includes the understanding and managing of risk. Operators must understand the current material condition of each system, the work being performed each shift, temporary alterations to the design, and any operator workarounds that may exist. This understanding is critical to grasp the aggregate risk of each system and its impact on the total operation of the facility. Risk is acceptable as long as it is fully understood and thought out. Accepting risk—when the risk is not fully understood in terms of an event or degrading condition—is not acceptable. These cases call for conservative decision making.

In the worst-case scenario, it is necessary to notify the applicable station management (by phone/voice mail or as specified by station management) as soon as plant conditions permit, if any of the following occurs:

- Any unplanned unit shutdown
- A fire
- An environmental release not requiring activation of the emergency response plan
- Equipment upset requiring load reduction
- A failure to meet scheduled on-time delivery of a unit's return to service
- Any personnel injury requiring off-site treatment

Observation Program

The purpose of an observation program is to identify declining trends in safety and human performance. An observation program uses the collection of data to close performance gaps in order to prevent injury and improve performance.

An observation program allows supervisors to systematically observe and monitor plant activities in order to identify both good and declining practices. Observations reinforce station standards and expectations and determine whether those standards are being implemented. They are usually conducted during actual plant evolutions but can be done during training. Observations are positive activities that can add value to performance and support the ability to trend, track, and correct low-level or emerging issues. The activities to be observed might include shift turnover, pre-job briefings, post-job reviews, daily work routines, training, or work environment observations. The observer usually has a specific focus area, such as performance improvement tools, including condition reporting, human performance, use of OE, and procedure adherence. For more information, see EPRI report 3002001131, *Developing an Observation Program for Fossil Electric Generating Stations*.

Identification and Reporting of Problems and Follow-Up of Issues

Supervisors create an atmosphere that encourages the worker to identify problems, report them, and consciously search for opportunities for improvement. Workers are rewarded—not punished—for being self- critical. Active participation in a corrective action program is consistently encouraged and positively reinforced.

Supervisors set the example for self-critiquing and for initiating corrective actions. Supervisors are also involved in benchmarking other stations for good ideas and selecting self-assessment topics to be sure that activities are in sync with the station's business goals. The resulting actions are captured in the corrective action program for the purpose of identifying trends and for follow-up and resolution of issues.

6
CONTROL ROOM ARCHITECTURE

A control room is the place where the actual control of the plant occurs. A control room is composed of monitors, gauges, dials, and other instrumentation—called *operator stations*—based on usability. There are system cabinets, printers, networking switches, consoles, and interconnecting cables as well as collections of procedures and other administrative material. The configuration, from field or in-plant equipment to junction boxes and computers for accessing the controller, is a part of overall architecture in the control room.

Key Human Performance Point

The control room should be designed and arranged for efficiency, low ambient noise, and ergonomically correct furnishings.

The conduct of shift operations and the decorum in the control room should be professional. Control room distractions should be managed and kept low, including overlapping or simultaneous evolutions. Access to the control room should be limited, and any necessary technical or administrative work needs to be conducted at a location that does not compromise control room activities or operator focus. The shift supervisor determines who enters the control room and who manipulates controls.

Access to control rooms is gaining attention as a security issue.

North American Electric Reliability Corporation

The North American Electric Reliability Corporation (NERC) and its Critical Infrastructure Protection (CIP) program are requiring bulk electricity producers to draft and implement security policies for their facilities that comply with its NERC-CIP standards. For example, future plans call for control rooms and NERC-compliant stations to implement access restrictions. Mechanical maintenance staff will no longer be allowed into the control room but will instead have to go to a clearance office to have clearances issued.

The requirements in the NERC standards are performance based. In other words, they are designed to encourage certain actions on the part of the registered entity (member). The requirements fall into two broad categories:

- A procedure that informs personnel about actions to be taken
- An action that is to take place in the event of certain triggering events

Put simply, the evidence of compliance with reliability standards is either a procedure for doing something or evidence that something was done.

Emergency Response

During a plant transient or emergency situation (for example, boiler leak, equipment tripping, fire, or injury), operators are expected to take prompt actions to eliminate or reduce the seriousness of the event—which may not allow time to use a procedure. However, when the emergent condition is rectified, the appropriate procedure should be procured to make sure that all steps are complete.

Operators should implement the following practices when responding to a plant transient OR emergency:

- It is understood that operators have the required knowledge from job- related training and experience to respond to an emergency situation to the point of stabilizing the condition without the need for step-by-step procedural guidance.
- When time and conditions allow during the situation, applicable procedures will be consulted while performing actions.
- Before deviating from any procedural requirements, the situation should be assessed with the SOS determining the appropriate action.
- Action may include restricting access to the control room.
- Should the emergency be in the control room itself, such as a fire, personnel will know what to do based on training, procedures, and drills.

Control of Noise

It is important for operations to maintain a quiet and orderly control rooms free from external distraction.

During emergency or abnormal conditions, scan and acknowledge alarms as soon as practical to reduce noise level and to ensure critical alarms are not overlooked, but this should not interfere with abnormal operating instruction task performance. Someone other than the operator at the controls would be tasked with answering the telephone, making announcements and posting any necessary signage.

Emergency Management

The true test of control room personnel is how they manage emergency situations such as fires, personnel injury, and mechanical failures such as boiler leaks or equipment trips. It is the expectation that operators act promptly to mitigate the event including restricting access to the control room.

Key O&M Cost Point

It is necessary to ensure that instrumentation is working properly. Results can be affected by actions beyond the operator's control, such as equipment failure.

If it is possible to reference applicable procedures during the event, personnel refer to the document and follow the steps when performing manipulations. If there is no time to reference the procedures, once the situation is under control, personnel will check the procedure to be sure that all steps were completed.

The shift operations supervisor will make any final decisions if actions must vary from those designated by procedure. Once the emergent situation is eliminated, the control room returns to normal operations.

7
INDUSTRY BEST PRACTICES

The following is a list of best practices identified at plants in the industry for control room conduct for optimal and event-free operation:

- The control room was located, designed, and arranged for efficiency, low ambient noise, and ergonomically correct furnishings. Entrances to the plant, break rooms, kitchen, restrooms, and operations management offices were all in close proximity.
- Non-operating activities such as administrative functions were conducted outside the operational area.
- The station established clear expectations for plant personnel regarding attire, use of non-work-related reading materials, personal laptop computers, cell phones, personal phone calls, and so on that also apply to the control room.
- Distractions in the control room were managed and kept low, including overlapping or simultaneous evolutions.
- Operators demonstrate a high degree of professionalism and ownership as well as a strong drive for good station performance. Operators often ask one another for help, and peer-to-peer coaching occurs frequently.
- Use of industry operating experience and lessons learned through a process called *Learning Through Sharing*—a weekly review of station, fleet, and available industry OE performed by each crew, with requirements for a summary of discussion on how and why the event could or could not happen at their station and how to prevent it. Results for each crew are summarized, compiled, and shared with the station and the fleet.
- Some plants include human performance events from their fleet and the industry in monthly safety packets.
- Training scenarios are developed and given to crews for discussion of the expected indications leading up to the event and the proper responses. Some scenarios are based on actual events at their station or in the industry.
- Scenarios focused on NERC requirements are provided to each crew at least quarterly for discussion of the proper actions and responses.
- Having simulators near the control room enables more frequent use of the simulator for training.
- Detailed shift and daily reports of equipment that is out of service and other equipment issues along with 24-hour trend data help keep management informed of plant status.
- Each category of alarm has a different audible tone to help operators establish alarm priorities; critical alarms are on different screens.

- Observation programs are used to identify worker performance gaps, weaknesses in written instructions or station policies, and safety deficiencies to improve worker and station performance.
- Operators are required to attend 8 hours of training on human performance. The training includes the use of human performance tools, error traps, and latent organizational weaknesses and extensive use of industry examples. The training uses skits and other dynamic learning activities rather than just discussion to demonstrate the concepts.
- Operators at a station with a self-directed work force and minimal station management demonstrated a high degree of ownership and drive to maintain good performance.
- High standards for housekeeping are established and maintained by assigning specific areas of the plant, office spaces, and the control room to each shift.
- A continuous improvement suggestion program is used as a means of capturing employees' suggestions for improving plant processes and safety. The potential for monetary rewards exists.
- Operators are required to take an annual refresher course for emergency response.
- Pre- and post-job critiques for infrequently performed activities are used as a tool for continuous improvement. Pre-job briefs include discussions of the specific task, lessons learned from previous similar work, job hazard analysis, and safety walkdowns. Post-job reviews are conducted at the completion of the task or activity and include lessons learned that are entered into a database and used the next time that task is performed. Management and relief operators often attend to ensure continuity and maximum learning.
- An "Operations Top 10" list is used as a constant reminder of important focus items.
- One station has its own fire simulator and is able to conduct training more frequently for operators at a lower cost than using other sources.

8
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A
INDUSTRY EXPERIENCE

The material in this appendix comes from the U.S. Department of Energy.

Chemical Delivery Incident

On 12/4/12, a load of 3,500 gallons of sulfuric acid arrived at a fossil fuel power plant. Operations personnel were misinformed by Security that the chemical was sulfur. The sulfuric acid was inadvertently loaded into a tank containing emulsified sulfur, requiring the tank to be drained, cleaned, and inspected for compromise.

Sequence of Events

When the Driver arrived at the security checkpoint, the Driver informed the Security Guard that he had a delivery of sulfuric acid. The Security Guard called Purchasing to verify the purchase order for the shipment. Though the Security Guard stated that the load was sulfur, the Buyer overheard the Driver correcting the Security Guard and heard the Driver emphasizing sulfuric acid, not sulfur. The Buyer confirmed the purchase order for sulfuric acid and instructed the Security Guard to contact Operations. The Security Guard stated that the Driver was correcting him while he was on the phone but that he did not correct himself because he did not know the difference between sulfuric acid and sulfur. The Security Guard stated he thought sulfur was an abbreviation for sulfuric acid.

The Security Guard contacted a Control Operator and informed Operations of a sulfur delivery. The Security Guard was told by the Control Operator that someone would be standing by to receive the load. The Security Guard directed the Driver, who had never been on plant site, to the sulfur tank area.

After the call from Security, the Control Operator directed an Auxiliary Operator to receive the load. The Auxiliary Operator had no experience unloading sulfur. However, the Auxiliary Operator did note a memo that indicated a sulfur delivery expected on 12/6 and thought that this was part of a split load. The Auxiliary Operator met the Driver to receive the load, directed the Driver to the sulfur tank, and assisted with supplied air. At that time, the Auxiliary Operator asked for the paperwork and the Driver informed her that he would get the paperwork when the unloading was complete. No pre-job brief was performed. The signage for the sulfur tank was on a temporary post and was not present at the unloading site at the time of the event.

The Auxiliary Operator noted that the Driver had more than adequate PPE and thought that the Driver was being extra cautious. Once the unloading was complete, the Driver unhooked the hose. At this point, the Auxiliary Operator noted that the clear liquid dripping on the ground was not consistent with the color of sulfur. The Auxiliary Operator asked the Driver what he unloaded and the Driver stated that it was sulfuric acid. At that point, the control room was contacted along with Operations and Environmental personnel. The area was red barrier taped, Plant Management notified, and mitigation action began.

Analysis Summary and Conclusions

Operations did not have a procedure in place for the offloading of elemental sulfur at the time of this event. A procedure for sulfuric acid did exist, but it was not pulled by Operations personnel because the understanding by Operations personnel was that the delivery was elemental sulfur.

The error occurred because no procedure existed at the time of the event. Regardless of the communications and/or miscommunications leading up to the event, general requirements for chemical unloading that included a verification of the chemical being unloaded would have prevented this event.

While procedures for specific chemical loading and unloading are valuable, a generic chemical unloading procedure requiring verification of chemical prior to unloading would have prevented this type of event. This will also prevent similar events from reoccurring because a generic procedure would apply to all chemicals delivered.

The absence of the use of human performance tools is also a strong contributing factor. Three-way communication may not have worked at the Security checkpoint because the Security Guard had already convinced him/herself that the chemical was referred to as *sulfur*. However, if three-way communication between the Auxiliary Operator and the Driver had occurred, the error would have likely been discovered. Additionally, the absence of a pre-job brief contributed to this event. The pre-job brief form contains a section that requires chemical review and reference of the material safety data sheet (MSDS) prior to beginning the task. The Driver would have provided the MSDS, the job would have been reviewed, and the Auxiliary Operator would have likely discovered that the delivery was sulfuric acid and not sulfur.

Contributing Causes

- No pre-job brief was performed with the Driver prior to the chemical being unloaded.
- There was a lack of three-way communication.
- No procedure was in place for Security to verify the chemical being delivered.
- The sulfur tank was not permanently labeled.
- Other Operations personnel stated that close calls had occurred in past years that were similar to this event, but those events went unreported.

The Grounding of the Costa Concordia and Resulting Industry Changes

In June 2013, Italian maritime officials released a 176-page report documenting the events of the January 2012 grounding of the Costa Concordia. The event resulted in the death of 32 individuals.

The report blames Captain Francesco Schettino with causing the accident and delaying the evacuation of passengers and verifies that he was in command of the ship when it hit rocks and went aground off the coast of Tuscany. The Captain is charged with manslaughter and abandoning the vessel while 4,200 passengers and crew members remained on board. The trial of the Captain of the Costa Concordia is ongoing as of this writing.

The report points out a grave lack of communication by the Captain for his failure to advise the Italian Coast Guard of the event. The Coast Guard learned of the incident from a passenger's mother.

Other findings indicated a number of factors leading to the event, all of which are directly credited to Schettino:

- The speed of the ship and its proximity to the shoreline
- A delay in sounding the ship's alarm
- Distractions by unauthorized individuals on the bridge
- Failure to check landmarks
- Failure to immediately notify the Coast Guard
- Making misleading announcements to the passengers

As a result of the Costa Concordia incident, cruise lines around the world began to assess their safety standards and procedures. The industry performed an Operational Safety Review in 2012 and is conducting a Preparedness Risk Assessment in 2013 to review and address redundancies related to power systems that provide essential services in the event of a loss of main power.

The Cruise Lines International Association, with input from member lines, is establishing new standards and procedures that are being implemented by the major cruise lines. This effort communicates the industry's high standards and provides a clear level of accountability. A Cruise Industry Passenger Bill of Rights was published in May 2013. This 10-item list specifically addresses issues that might arise if a ship suffers an emergency or mechanical failure as well as passenger comfort, safety, and care.

Additionally, the U.S. Coast Guard led a multiday emergency drill involving authorities from the U.S. and the Bahamian governments in April 2013.

B
KEY POINTS SUMMARY

Key O&M Cost Point

Emphasizes information that will result in reduced purchase, operating, or maintenance costs.

Page Number	Key Point
4-6	Detailed shift and daily reports of equipment that is out of service and other equipment issues, along with 24-hour trend data, help keep management informed of plant status.
6-2	It is necessary to ensure that instrumentation is working properly. Results can be affected by actions beyond the operator's control, such as equipment failure.

Key Technical Point

Targets information that will lead to improved equipment reliability.

Page Number	Key Point
2-4	All personnel work closely to resolve deficiencies in both plant equipment and station processes.
3-3	The AUO monitors plant equipment for potential problems and immediately reports issues to the unit operator on shift.

Key Human Performance Point

Denotes information that requires personnel action or consideration in order to prevent injury or damage or ease completion of the task.

Page Number	Key Point
3-3	It is the expectation that all station personnel use human performance tools. Workers shall apply these tools during all work activities to help them maintain positive control, regardless of their perception of the risk.
4-4	Operators attend human performance training, which includes the use of human performance tools, error traps, and latent organizational weaknesses and extensive use of industry examples. The training uses skits and other dynamic learning activities rather than just discussion to demonstrate the concepts.
4-10	Pre- and post-job briefs for infrequently performed activities are used as a tool for continuous improvement. Pre-job briefs include discussions of the specific task, lessons learned from previous similar work, job hazard analysis, and safety walkdowns. Post-job reviews are conducted at the completion of the task or activity and include lessons learned that are entered into a database and used the next time the task is performed. Management and relief operators often attend to ensure continuity and maximum learning.
6-1	The control room should be designed and arranged for efficiency, low ambient noise and ergonomically correct furnishings

Key Safety Point

Identifies information that will lead to improved worker and industrial safety.

Page Number	Key Point
2-1	Safe operation of the plant takes precedence over all other considerations, including economic and competitive pressures.
2-2	Station, fleet, and industry operating experience is provided to operators frequently and includes discussions on how and why the event could or could not happen at the station as well as how to prevent it. Summaries of lessons learned from these events are often discussion topics at tailgate and safety meetings and are sometimes included in safety newsletters.
2-3	Personnel feel free and are encouraged to raise safety issues without fear of retribution or intimidation.
4-2	Non-operations activities such as administrative functions are conducted outside the operational area in order to avoid distracting operators.
4-3	Environmentally sound practices lead to safer living conditions for the general public.

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Electric Power Research Institute
3420 Hillview Avenue, Palo Alto, California 94304-1338 • PO Box 10412, Palo Alto, California 94303-0813 USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com