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IEEE Recommended Practice for the Investigation of Events at Nuclear Facilities

IEEE Power and Energy Society

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Nuclear Power Engineering Committee

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IEEE Std 1707™-2015

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IEEE Recommended Practice for the Investigation of Events at Nuclear Facilities

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Abstract: Common terminology and recommended practices for initiating and conducting event investigations, analyzing data, producing results, and identifying corrective actions associated with facility personnel, processes, equipment, and systems at nuclear facilities are provided in this document. The scope of event investigation activities addressed includes, but is not limited to, root cause analysis, which is an in depth investigation process used to identify primary causes of an event based on the systematic and consistent use of analysis tools. This recommended practice can be used for the investigation of all events and allows the use of a graduated approach to the depth of the investigation based upon the event significance.

Keywords: event investigation, IEEE 1707™, nuclear, root cause

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Introduction

This introduction is not part of IEEE Std 1707™-2015, IEEE Recommended Practice for the Investigation of Events at Nuclear Facilities.

IEEE Subcommittee 5 on Human Factors, Control Facilities and Human Reliability (SC5), a unit of the IEEE Nuclear Power Engineering Committee (NPEC), has developed and maintained human factors engineering standards for nuclear facilities since the early 1980s. SC5 has structured its standards in a hierarchical fashion. The top-level SC5 guidance document is IEEE Std 1023™, IEEE Recommended Practice for the Application of Human Factors Engineering to Systems, Equipment, and Facilities of Nuclear Power Generating Stations and Other Nuclear Facilities. IEEE Std 1023 promotes the systematic integration of human performance considerations in the life cycle of commercial nuclear power stations and other nuclear facilities. IEEE Std 1023 is supported by additional standards written to address specific technical needs. IEEE Std 1707 is an additional standard that provides a recommended practice to establish the characteristics of an acceptable approach to event investigations. Such investigations can serve as part of the basis for operating experience reviews needed to support IEEE Std 1023. The need for a Corrective Action Program at nuclear facilities is discussed in regulations (e.g., 10 CFR Part 50, Appendix B, criterion XVI). The investigation process in IEEE Std 1707 provides one framework for implementing such programs. In addition, this process aligns with the event investigation section of the voluntary guidance of OSHA Safety and Health Program Management Guidelines (Federal Register 54:3904-3916), which supports 29 CFR 1910 requirements.

This recommended practice provides the nuclear industry a common approach for planning, conducting, and reporting event investigations. It includes definitions and elements for corrective action plans. Staff and management at nuclear facilities who complete event investigations and those evaluating event investigation reports can use the document to fulfill their respective roles. Event investigation reports serve a key role for sharing event information within the facility conducting the investigation, as well as among similar facilities and by the organizations charged with evaluating the event investigations. It is important that reports include sufficient information in a manner that allows for a common understanding of event causation. This recommended practice focuses not only on specific causes, but on the entire organizational infrastructure's role in events. The investigation reports also can be used to focus on needed improvements in personnel, processes, and system and equipment performance.

This recommended practice identifies seven elements of an acceptable event investigation including the following:

a) Establishing roles and responsibilities (see 4.1)

b) Planning (see 4.2)

c) Information gathering and analysis (see 4.3)

d) Cause determination (see 4.4)

e) Corrective action plan (see 4.5)

f) Investigation report (see 4.6)

g) Records (see 4.7)

This document is intended to be used by personnel at nuclear power plants, nuclear fuel processing plants, research and test reactors, and at nuclear materials production reactors to implement an acceptable event investigation process and by regulators whose job it is to assure that a robust event reporting system is being applied.

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1. Overview

1.1 Scope

This document provides common terminology and recommended practices for initiating and conducting event investigations, analyzing data, producing results, and identifying corrective actions associated with facility personnel, processes, equipment, and systems at nuclear facilities.

1.2 Overview of event investigation process

The event investigation process provides a systematic and complete framework for investigating events and their causes consistently. The threshold for a root cause investigation should be based on the level of risk, which is a function of the probability of recurrence (assuming no corrective actions) and consequence of the event (actual and potential). For example, a high consequence event with a high probability of recurrence is a high risk event requiring a root cause analysis.

Figure 1 provides a graphical view of the steps of an event investigation and refers to the applicable clauses of this document where the topic is discussed as follows:

— Planning (4.2): The important aspects of this step are early actions (remedial actions, preservation of evidence), investigation team formation, and charter development.

— Information gathering and analysis (4.3): Success in determining the cause(s) of an event requires obtaining factual information that supports analysis to conclusively explain what occurred and why it occurred. This includes extent of condition and operating experience reviews, as well as use of data analysis to support cause determination.

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— Cause determination (4.4): The gathered information is then systematically analyzed through the use of facility approved methods as a means of determining the cause(s) of the event. The factually-based analysis provides a direct link between the event itself and the cause(s).

— Corrective action plan (4.5): Provides a specific set of the actions targeted to address the adverse conditions associated with the event as well as its causes, extent of condition, and extent of cause.

— Investigation report (4.6): Conveys the results of an investigation in a manner that enables management to make informed decisions. The first phase is for initial review and approval of the completed report, while the second phase is an assessment of corrective action effectiveness.

— Records (4.7): Investigation reports and associated information should be retained in accordance with company requirements and in some cases, reports may be required to be maintained as quality records based upon regulatory and industry requirements (e.g., NRC 10 CFR Part 50 Appendix B [B1][1]).

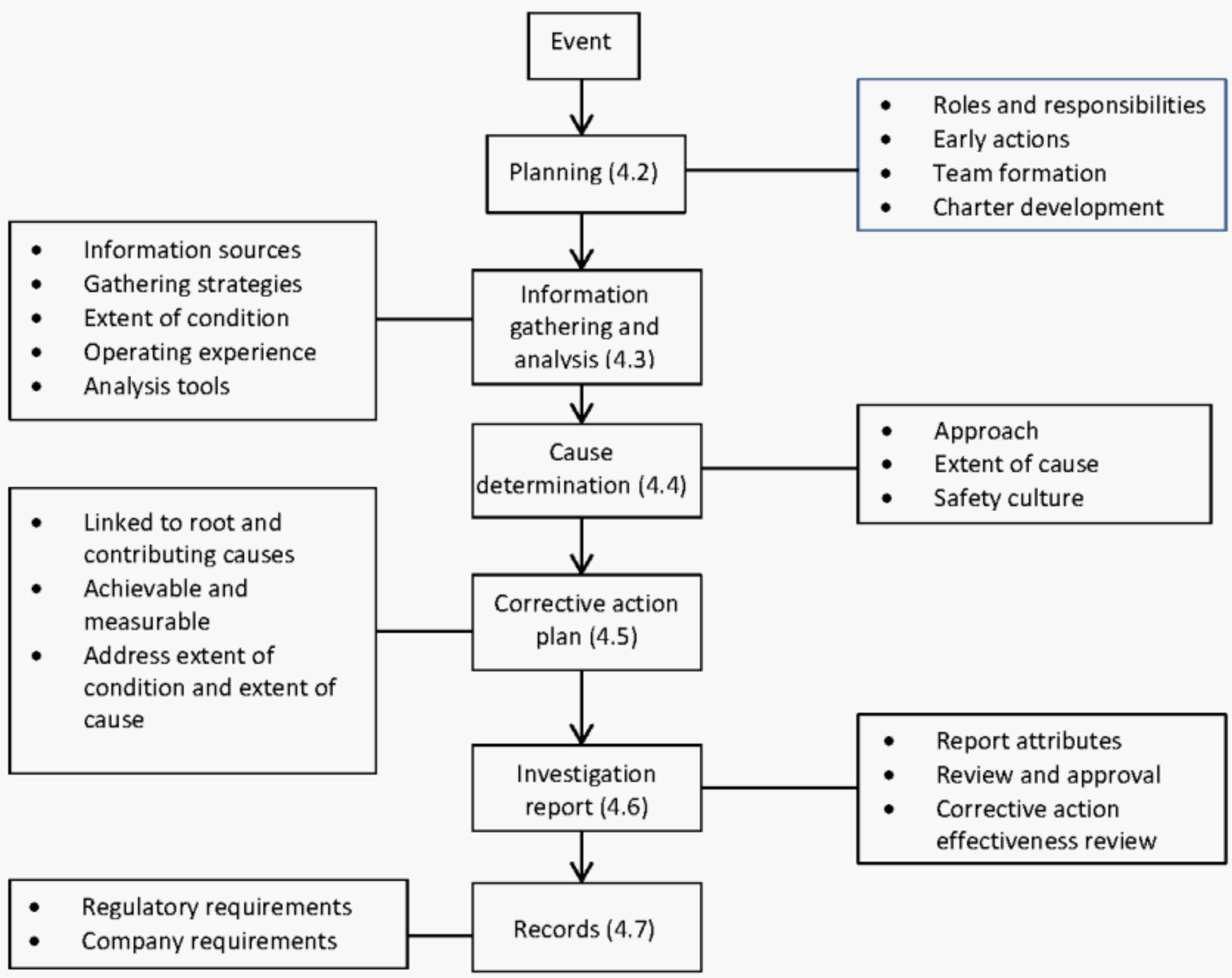

Figure 1—Event investigation process

Figure 1 shows the process for event investigation activities is based on a root cause analysis approach, which is an in-depth investigation process used to identify primary causes of an event based on the systematic and consistent use of analysis tools. This recommended practice can be used as a framework for the investigation of all events, but this document will only focus on events requiring a root cause analysis.

[1]The numbers in brackets correspond to those of the bibliography in Annex A.

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A common cause is a cause that leads to multiple events, either through a recurring problem for one component, system or unit or a cause that leads to events across similar components, systems, or units. Situations or events that may have a common cause should be evaluated using a common cause analysis (CCA) approach. Annex B provides additional guidance on performing CCA. Annex A provides a bibliography of applicable references concerning the event investigation process.

Finally, the investigation process and methods described in this recommended practice should be defined within site policies, procedures, guidelines, and training programs in sufficient detail to achieve a high level of consistency between investigations in terms of strategies, data analysis, and deliverables.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

None.

3. Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.[2]

barrier: A control, either physical or administrative, that functions as a layer of protection between an asset and a hazard. Barriers are established to detect, prevent, or inhibit an adverse condition.

condition report: A document used to record the event investigation activities and the associated results.

contributing cause: A cause that by itself would not create the problem, but did contribute to the event outcome and is important enough to be recognized as needing corrective action.

event: An undesirable change in the state of plant structures, systems, components, or human (organizational) conditions (health, behavior, administrative controls, environment, etc.).

extent of cause: The degree to which the root cause(s) of the event being investigated exists elsewhere and may have created or could create additional events.

extent of condition: The degree to which the actual condition that prompted the investigation exists or may exist in other procedures, processes, organizational aspects, human performance, or equipment (including software); thereby rendering the facility vulnerable to a similar event.

occurrence: Observable actions that culminated in the event.

root cause: The basic reason(s) for a problem that, if corrected, will prevent recurrence of the problem.

[2] *IEEE Standards Dictionary Online* subscription is available at: http://www.ieee.org/publications_standards/publications/subscriptions/prod/standards_dictionary.html.

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4. Event investigation process

4.1 Establishing roles and responsibilities

The key participants of the event investigation process range from senior management to the investigation team members. Management is responsible to provide the necessary resources, communicate standards and expectations, and ensure appropriate management involvement in the process. This subclause lists the responsibilities of key participants in the event investigation process.

4.1.1 Senior management responsibilities

Senior management should take on the following responsibilities:

a) Establish expectations in policies and procedures that promote effectiveness of the event investigation process.

b) Participate in training on event investigation methodology and possess knowledge of this recommended practice.

c) Provide the resources such that a cadre of personnel is trained in the event investigation process and methodology.

d) Provide for evidence preservation as soon as safely possible after the event.

e) Support the gathering of written personnel statements prior to any involved staff leaving the facility.

f) Assign a manager or above, as a management sponsor.

g) Confirm that the employees with the right knowledge and skills are assigned to the event investigation.

h) Provide the internal and external resources required to complete the event investigation.

i) Review and approve event investigation report prior to submittal to management review body for review.

j) Participate in the site management review body, which is responsible for approving the event investigation charter, holding management and the investigation team accountable for event investigation milestones, quality of the investigation, corrective action appropriateness, and due dates.

4.1.2 Management sponsor responsibilities

Management sponsor should take on the following responsibilities:

a) Follow the investigation preparation activities in 4.2.1, Early actions, to completion.

b) Communicate with investigation analysts on a regular basis to monitor team progress, but not directing the cause determination.

c) Eliminate obstacles so that teams are provided with adequate material and personnel resources.

d) Act as a liaison between the team and other members of management, thereby permitting the team to focus on investigation activities.

e) Be the investigation team's primary advocate with the senior management team and provide accurate updates on the investigation's progress and results.

f) Confirm that the investigation is conducted in accordance with the charter.

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g) Challenge the team's findings during the investigation to address questions or concerns, as opposed to waiting for the team's final conclusions.

h) Establish a corrective action plan that addresses the issues and has the concurrence of the department assigned to carry out the action.

i) Review the final report for quality to ensure that procedural requirements have been met and the charter's objectives are covered.

j) Present the investigation report to senior management for review and approval and then to the facility management review body for review.

4.1.3 Line management responsibilities

Line management should take on the following responsibilities:

a) Provide required personnel and resources to support the investigation. This includes implementing plans to reassign the normal responsibilities of personnel supporting the investigation.

b) Assist in the identification and preservation of evidence.

c) Confirm that actions assigned to them in the corrective action plan can be performed as written and are fully implemented.

4.1.4 Investigation analyst responsibilities

The investigation analyst should take on the following responsibilities:

a) Assure the investigation meets the charter objectives, facility procedure requirements, and quality criteria.

b) Provide direction to team members regarding the appropriate use of investigation methodology, tools and techniques to support identification of fact-based causes, which could include root causes and contributing causes.

c) Confirm that the event investigation report is developed in compliance with facility procedures and quality criteria.

d) Communicate with the team leader regarding investigation progress and results.

4.1.5 Team leader responsibilities

The team leader should take on the following responsibilities:

a) Assure investigation meets investigation charter objectives, facility procedure requirements, and quality criteria.

b) Confirm that the event investigation report is developed in compliance with facility procedures and quality criteria.

c) Communicate with the management sponsor and investigation team regarding investigation progress and results.

4.1.6 Team member responsibilities

Team members should take on the following responsibilities:

a) Conduct the investigation in accordance with facility policies, procedures, and training.

b) Communicate with investigation analysis and team leader regarding investigation progress and results.

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4.2 Planning

4.2.1 Early actions

Early actions are those steps that should be taken at the first recognition that the risk significance of an event is such that a root cause investigation should be performed. Early actions include remedial actions and evidence preservation and are discussed in 4.2.1.1 and 4.2.1.2.

4.2.1.1 Remedial actions

Remedial actions should be implemented as deemed necessary by management based on the scope of the immediate problem to place the facility in a safe condition and correct immediate physical damage.

4.2.1.2 Evidence preservation

Preservation of evidence actions should include the following:

a) Senior manager on site immediately initiating evidence preservation activities upon learning of a potentially significant event. In cases where evidence preservation conflicts with safety, senior management ensures safety considerations take precedence.

b) Use of formal guidance that includes the following:

- Highlights that evidence preservation is a priority during the course of an investigation
- Identifies type of evidence to be preserved; photos or videos should be used where appropriate
- Directs that written personnel statements be gathered prior to involved staff leaving the facility
- Provides for evidence preservation as soon as possible (e.g., quarantine equipment, collect physical evidence for equipment failures)
- Preserves evidence that includes both the event site and its surrounding area
- Define protocol for evidence release

4.2.2 Preparation for investigation

Initial preparations should focus on team formation and establishment of a charter for a thorough investigation. Establishing a plan for the investigation promotes resolution of the problem within the defined scope and timeframe.

4.2.2.1 Initial preparation

Initial preparation for the investigation should address the following:

a) Balancing the need to return key equipment to service with the associated risk of data loss and loss or compromise of evidence.

b) Special time requirements or concerns for a required response to a regulatory or external agency. Examples include the following:

- Investigations for USNRC Licensee Event Reports per 10 CFR 50.73 (60 days)
- Investigations to support responses to NRC Inspection findings
- Investigations to support state agencies, OSHA, and EPA requirements

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c) Consider potential legal issues associated with the event and its investigation. Examples include the following:

— Potential lawsuits as a result of an injury

— Supplier contractual agreement disputes

4.2.2.2 Investigation team formation

Management should form the investigation team, which should include the following:

a) Forming and briefing investigation teams in a timely manner based upon the significance of the event. More significant events may require team formation outside of normal work hours.

b) Assigning sufficient personnel, independent of the event, who possess the correct expertise appropriate for the scope and complexity of the event under investigation. Recommended team composition should include a manager sponsor, a team lead, a qualified investigation analyst, and subject matter expert (SME) personnel with an unbiased facility perspective. Legal counsel is involved in the investigation as appropriate.

c) Assigning investigation analysts who are formally trained on investigation strategies and use of facility-approved root cause analysis tools.

d) Avoiding assigning personnel directly involved in the event to the investigation team. It is possible that the personnel may have some bias as to the cause(s).

e) Dedicating team members to the investigation, relieving them to the degree possible of their regular duties until such involvement is no longer needed.

f) Assigning a team leader (typically an experienced analyst or project manager) to oversee team activities and serve as the liaison between the management sponsor and other team members, if assigned.

g) Identifying a management sponsor who has been formally trained in effectively supporting investigation activities.

4.2.2.3 Preparing the investigation charter

Preparation of the investigation charter includes the following:

a) The team, working with the management sponsor, should prepare an overall charter that defines the following:

1) Problem statement

2) Scope of investigation

3) Scope excluded from the investigation

4) Team members and their time commitment

5) Resources that are required to support the investigation

6) Investigation schedule, including milestones such as the following:

— Completion of the data gathering

— Analysis

— Report completion

— Management review

— Report approval

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b) Problem statement development is a critical initial action to ensure that the investigation is focused on evaluating the right problem or condition and should have the following attributes:

1) Be a specific and concise one or two sentence statement worded in the active voice

2) Be a factual statement of the actual undesired condition that includes the following:

— Date and time of the event

— Location of the event (reactor building, control room, etc.)

— Equipment by name

3) Include the difference between the expected result and the actual condition

4) Include the consequences of the actual condition

5) Defined so that everyone involved in the investigation can understand it

6) Does not include opinions, judgments, symptoms or causes

7) Is not a restatement of the initial condition report description

c) The charter should be approved by the management sponsor and if required, agreed to by the management review body.

4.2.2.4 Plan of investigation

The team prepares a plan of investigation activities and assigns actions to team members. The plan is expected to be dynamic and may change during the course of the investigation. The plan should typically include the following:

a) Relevant documents to be gathered
b) Interviews to be conducted
c) Analysis tools to be used
d) Plans for troubleshooting, testing, or external analysis that need to be factored into schedule

4.2.3 Confidentiality, security, and privileges

Investigation reports must be factual and sufficiently transparent to convey what happened, the causes, and the associated corrective action plan.

4.2.3.1 Confidentiality

Confidentiality considerations should include the following:

a) Investigation teams clearly conveying that there is no guarantee of confidentiality between personnel providing information and the investigation team.

b) The team making every effort to keep names out of final report so as not to adversely affect personnel who provide information were involved in the event. “Worker 1’, ‘Manager 2” should be used to describe affected personnel in the final report.

c) Application of the legal department standards for confidentiality, security, and privileges for investigation initiated or controlled by the legal department.

4.2.3.2 Security

Security considerations should include the following:

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a) Keeping information that has not been validated from being disseminated during investigation. Care should be taken to keep preliminary findings and information that was not required for the final report from being released.

b) Ensuring safeguards information is accessible to only those individuals approved by security.

c) Providing the security requirements for each analysis (locked file cabinets, password coded files, etc.) via a security agreement OR provide a facility security standard for all investigations.

4.2.3.3 Privileges

Privilege consideration should include the following:

a) The security agreement or standard should provide names or titles of personnel with privileges to access the information prior to completion of the final report.

b) A provision for external review privileges and controls while still providing a secure environment should be in place.

4.3 Information gathering and analysis

Success in determining the cause(s) of an event requires obtaining factual information that supports analysis to conclusively explain what occurred and why it occurred. The investigation should identify the factors necessary to explain the nature, the magnitude and timing of each important consequence. Failure to do so will prevent identification of corrective actions capable of precluding recurrence.

4.3.1 Information gathering

The process for information gathering is as follows:

a) Start investigation activities, including interviews, in a timely manner to minimize loss and corruption of relevant information.

b) Identify the sequences of occurrences leading up to and including the event as well as post event occurrences up to and including the point where the situation was stabilized. For each occurrence, identify what should have occurred as well as what did occur.

   1) For equipment related occurrences, determine if systems, structures, and components performed as designed.

   2) For organizational and programmatic occurrences, determine if behavior or condition was consistent with management expectations, regulatory expectations, procedures, policies, and the organization's espoused safety culture.

c) Identify the human, situational (e.g., environmental) or organizational factors that potentially influenced personnel behaviors and analyze them for relevance to the outcome.

d) Identify the failure mechanisms involved for equipment failure events.

e) Information gathering should cover a variety of types and sources, such as the following:

   1) People: This information type would include personnel directly involved with or witnessing the event being investigated. Other sources would include subject matter experts and management.

   2) Media: Examples of this information type are electronic data, videos, and computer files.

   3) Documents: The nature of the event being investigated will determine the type of documents to be used as sources of information. Types of documents to be considered as sources could include printouts, logbooks, procedures, work packages, radiological surveys, schematics,

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design change packages, task qualification records, vendor manuals, operating experience reports, pre-job briefs, job hazard analysis, job task analysis, and internal and external reports.

4) Materials: Physical evidence is an important source of investigation information. This type of information could include components, fluid samples, residue, debris, and other physical materials.

5) Area conditions: The environmental and physical conditions of the area in which the event occurred may be a key to identifying the cause(s) of the event. Considerations when looking at the area as a source of investigation information include: area congestion, equipment layout, lighting, noise, temperature, and radiological hazards.

6) Plant operational conditions: The plant mode (e.g., full power operations, refueling) and condition of equipment at the time the event occurs may also provide key information. Information sources of this type include switch and valve positions, labeling, operating parameters, equipment status, and alarms.

f) The team should develop a strategy for information gathering and data management that should include the following:

1) It is recommended to have central files, one for hard copy data sources and one for electronic documents. The data can be numbered for reference in the report. Central files will

— Facilitate sharing data within the team

— Avoid different team members requesting the same information

— Support collaboration

— Ensure the information remains available for referincing in the final report

2) At the start of the investigation the team should create a preliminary list of needed data to be gathered based on initial available information for the event. Assignments can be made to investigation team members to collect the items on the list.

3) The teams should identify any troubleshooting, testing, and external analysis that is needed to determine causes of the event. For example, at times this data gathering can take extra time, work scheduling or require special resources outside of the investigation team to complete.

4) Information that is discovered during the investigation should be preserved. The team should establish and maintain a chain-of-custody for the evidence, as appropriate, such that accountability is maintained.

5) When possible, the team should visit the location of the event to obtain a clear understanding of the situation at the time of the event. This supports factual event analysis, cause determination, and description in the report.

6) The team should perform a walk-through of any human actions in the area they occurred, if safe, or a simulation is also often useful.

7) Interviews should be conducted as part of information gathering.

— Interviews should be conducted by individuals who have been trained on interviewing skills and practices completed as soon after the event as practicable.

— An interview plan should include interviewees, schedule, locations, roles, key topics, specific questions, and methods of documentation.

— Interview information should be shared with team members for a common understanding of the event.

g) Limitations on information disclosure and confidentiality are understood and noted in the report.

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4.3.2 Assure valid and unbiased information

The following help assure valid and unbiased information:

a) Guard against potential team and management influences such as

1) Personal biases (e.g., natural tendency to jump to conclusions)

2) Dismissing information that does not support a preferred hypotheses

3) Following a perceived or actual management agenda

4) Investigating issues outside the scope of the investigation (e.g., research project)

— Avoid scope creep by focusing the investigation on activities that address the management approved problem statement.

— Review gathered information at regular points during the investigation process to determine if any changes are required to the charter, allocated resources, or investigation schedule.

— Interface regularly with the designated management sponsor as a means of communicating investigation progress and continued alignment with management's expectations for the scope of the investigation.

— Obtain management sponsor and management review body approval for any changes to the charter that may be required if the investigation finds that the problem is narrower or broader than known at the time of the event.

— Use data validation methods and corroborating evidence measures to verify that information is factual.

— Show that conclusions are based on facts and evidence obtained from different sources.

— Obtain in-process challenges of team conclusions from subject matter experts, independent investigation analysts, or a designated devil's advocate to detect possible investigative shortcomings.

— Bring any identified deficiencies outside the facility management approved scope of the investigation to management's attention for independent assessment and resolution.

4.3.3 Extent of condition analysis

A summary of the extent of condition analysis is as follows:

a) The extent of condition analysis identifies whether the condition that prompted the investigation exists or may exist in other procedures, processes, organizational aspects, human performance, or equipment. Such a situation may render the facility vulnerable to a similar event prior to the identification of the actual causes. The purpose of the analysis is to put interim actions in place to address the additional areas where the condition is identified.

b) The extent of condition analysis is started as soon as the condition or problem is identified.

c) The extent of condition analysis can be performed in parallel with other investigation activities, provided that interfaces are established so that information is shared between the extent of condition and investigation teams.

d) The extent of condition analysis is a review of current facility vulnerability. Accordingly, its scope is limited to current facility operation and practices. It is not an historical review of previous events, which is included in the operating experience section.

e) The extent of condition analysis should

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1) Identify the specific condition being evaluated (e.g., mis-positioned valve).

2) Determine the scope of the evaluation by deciding if similar situations should be included. For example:

   — For equipment-related conditions, the scope may include equipment with similar design, used in similar applications, present in a similar environment, or manufactured by the same company.

   — For organizational and programmatic conditions, the scope may include other work groups and processes that would include similar tasks.

f) The extent of condition analysis determines whether any portion of the scope can be eliminated based on low or no associated risk.

g) The extent of condition analysis employs database searches to identify other areas where a component or procedure identified in the condition can exist.

h) The extent of condition analysis confirms whether the condition is present in other situations, by testing, document review, interviews, and observations.

i) The extent of condition needs to be documented and communicated and should include the following:

   1) The actual condition for which the extent is being evaluated, the basis for determining the scope of the evaluation and the scope of activities undertaken or needed in order to confirm the extent of condition.

   2) A clear conclusion statement in the investigation report as to whether an extent of condition does or does not exist.

   3) Communication to management of extent of condition findings, so immediate and interim mitigating actions are promptly implemented. If no further actions are required, there is documentation of the logic that was used to form the conclusion.

4.3.4 Operating experience review

The operating experience (OE) review is an important input to the event investigation and should include the following:

a) The OE review should be started at the beginning of the event investigation process. The review may be expanded as the investigation proceeds to incorporate the investigation findings.

b) A review of internal and external operating experience provides an historical review of previous similar events as a means of learning from them. The purpose of an operating experience review is to

   1) Identify possible causes and corrective actions for the event being investigated.

   2) Review internal and external events having previously occurred to understand if the current event could have been prevented with more effective corrective actions.

   3) Understand as a means of continuing learning whether the previous corrective actions were implemented as intended in the investigation.

c) Reviewing previous instances of events involving similar structures, systems, components, processes, etc. both at the facility and elsewhere.

d) Obtaining relevant operating experience through key word or trend code searches within databases available to the facility.

e) Listing events that are related only as a common key word.

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f) Reviewing the resultant list to identify the events that are germane to the event being investigated and possible failure scenarios that could be considered in the investigation of the current event.

g) Evaluating if corrective actions taken in the previous events were effective and if such corrective actions are applicable to the current event investigation.

h) Sources of OE include the following:

   1) Internal databases (corrective action program, equipment and material history, clearance and tagging databases, etc.)

   2) External databases such as the Institute of Nuclear Power Operations (INPO) Consolidated Event System (ICES) and NRC Event Reports (e.g., Part 21 Reports, Event Notification Reports)

   3) Internal and external subject matter experts

   4) Vendor correspondence (technical bulletins, notices, etc.)

   5) Industry working group publications

i) The OE review documentation should include the following:

   1) The sources used for the review and the key words and trend codes used in the search. As a function of demonstrating the depth of the review, a statement of the query results should also be included. Typically, not all results are relevant; in this case provide the rationale for excluding the data in the review.

   2) A synopsis of the events determined to be relevant. The review should also indicate if the selected operating experience events had been previously reviewed by the facility and had been analyzed appropriately per the procedure. It is not recommended to copy the entire OE document into the report.

j) If the review identifies an applicable operating experience event that was not evaluated, a corrective action or separate condition report should be initiated to have the OE item reviewed.

k) The review should also evaluate the relevant operating experience events to determine if the previous actions were effective. If the review finds that they were not effective, consideration should be given to create new corrective actions to resolve the issue.

l) The review should draw a conclusion as to whether the current event could have been prevented if

   1) The external operating experience had been properly evaluated for applicability and any vulnerabilities addressed.

   2) The internal operating experience was investigated thoroughly such that the cause(s) were based on fact and supported with evidence.

   3) The corrective actions for any of the relevant operating experience were implemented as intended or timely enough to have prevented the repeat event.

m) State any further actions that may be required to address any identified weakness through the OE review. Also indicate if no further actions are required.

4.3.5 Analysis tools and techniques

The selection and application of analysis tools and techniques is as follows:

a) Determine which root cause analysis tools and techniques will be applied to facilitate information gathering and analysis based upon consideration of the event. The list that follows is not all inclusive. The team should consider combining tools and techniques for event investigation (e.g., use of barrier analysis with event and causal factor charting) since each tool may provide different information.

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1) Event and causal factor charting: Charting of event over time, factoring in contributing factors.

2) Task analysis: Effective for events involving human processes.

3) Barrier analysis: Used to evaluate where barriers (e.g., people, processes, physical) should have prevented event.

4) Change analysis: Useful where a recent change (e.g., process, equipment replacement) is suspected for event cause.

5) Failure modes and effect analysis: Useful for equipment failure related events.

b) For each occurrence, identify what should have occurred as well as what did occur.

c) For equipment failure events, identify the possible failure modes by evaluating system, structure, and component design, as applicable. Systematically review and validate or refute each mode as a cause of the failure. Failure modes that are validated as being a cause are then further analyzed for the organizational aspects (e.g., design process).

1) Formal test plans should be developed to guide troubleshooting and other testing performed in support of the investigation.

2) An example of a failure mode with potential organizational aspects would be contacts that are not making an electrical connection. The preventive maintenance plan for the component should be reviewed to determine if it was robust enough to have prevented the event.

d) Identify the situational or organizational factors that potentially influenced personnel behaviors and equipment failures and analyze them for relevance to the outcome.

1) Behaviors can be symptoms of a cause but not the cause themselves.

2) For equipment failures, the design process should be reviewed for factors that may have caused or contributed (e.g., inadequate review process for design change).

3) Consider if the design of the human-system interface affected personnel performance.

e) Organize information, assess its relevance to the event outcome, and determine if additional information is needed. The analysis tools are utilized throughout the duration of the event investigation. As information is discovered in the investigation it is added to the analysis tools being used.

f) Focus the analysis on factual information that is directly linked to the problem and scope of the investigation. Care should be given to not deviate from the scope. Any new issues identified during the investigation should be documented in a new condition report.

4.4 Cause determination

Causes of events are determined based on the facts identified in the systematic approach that was used in the investigation.

NOTE—A multi-event investigation or evaluation of multiple events of similar nature would result in the need for a common cause evaluation rather than a root or apparent cause approach. The purpose of the common cause analysis is to determine if there is a commonality among the events. Recommendations for completing a common cause analysis are provided in Annex B.[3]

[3]Notes in text, tables, and figures are given for information only and do not contain requirements needed to implement the standard.

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4.4.1 Cause determination approach

The cause determination approach is as follows:

a) Cause determination is conducted as an extension of the analysis phase after sufficient information has been gathered, analyzed and documented about the initiating actions and physical phenomenon involved in equipment failure.

b) Facility approved systematic methods are used to establish the linkage between the event, how the event occurred, and why the event occurred (refer to 4.3.5).

c) Document the logic that shows the connections between the event, its important consequences, and its cause(s).

d) The number of root and contributing causes is determined by the analysis. Significant events may have more than one root cause along with contributing causes.

e) When determining causes of events, investigation analysts should look beyond the specific human behaviors and equipment issues involved to identify any organizational weaknesses that induced them.

   1) Behaviors are symptoms and further analysis is required to identify why the behavior made sense to the individual at the time, why the individual believed that the decision was appropriate, and if organizational aspects allowed the situation to occur.

   2) Equipment failures are symptoms and further analysis is required to identify the organizational aspects that allowed the failure to occur (e.g., design weakness, installation error, maintenance practices, improper operation, run-to-failure disposition).

f) The factors that resulted in the organizational weaknesses should be evaluated further to identify root causes.

g) The cause statements should be specific to the results of the investigation and not non-descript phrases such as “error prevention tools were not used,”, “procedure non-compliance,” or “management oversight was less than adequate.” It is important to clearly articulate the behaviors behind the phrases so that corrective actions can specifically address the cause.

h) When determining causes of events initiated by factors outside the control of the organization (e.g., weather), investigation teams should assess the organizational aspects. In this case the analysis should consider the following factors to determine if they are root causes or contributing causes according to the cause definitions:

   1) The facility response to the situation

   2) The response of the plant equipment

   3) Preparations made to mitigate the consequences to the facility from the initiating event (e.g., tornado, hurricane, severe storm, or flood)

i) If it is determined that this event can be attributed to ineffective resolution of a previous significant event, the causes for the current event should include the reasons why the prior event was not properly assessed and addressed.

j) Once determined, causes are validated to confirm that

   1) The event could have been prevented if some additional or different barrier had been in place.

   2) The causes had to have been present for the analyzed event to occur.

   3) All causes that directly affected the outcome of the event were identified.

   4) If the causes are corrected, it is likely to preclude the repetition of this and similar events from occurring.

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k) In cases where the investigation is unable to determine a root cause, the basis for not being able to identify a root cause should be documented in the report.

4.4.2 Extent of cause analysis

The extent of cause analysis contains the following attributes:

a) The extent of cause analysis identifies where else in the facility the same cause may exist.

b) The extent of cause analysis to determine how widespread the cause is can only be started after root cause(s) have been identified.

c) Consider if other facility equipment, programs, processes, procedures, documents, or organizations contain the same cause characteristics.

   1) Consider similar equipment that may be susceptible to the same cause of the failure. Are the same maintenance practices used on other system trains? Are there other models of the equipment that could contain the same type of part or mechanism?

   2) If other facility programs and processes utilize the same resources identified in the cause, determine if these resources would be susceptible to the same deficiencies.

   3) If a procedure is involved as a part in the cause, are there similar procedures that contain the same deficiency or error trap? In considering the extent of cause regarding procedures, consider other procedures that were written and approved by the same people, or that use the same test set up, prerequisites, test methodology, or equipment.

   4) In analyzing similar documents, determine if the same cause is found elsewhere. Were other documents reviewed by the same process? Were the same assumptions made that may have been the cause assumed in other documents?

   5) Determine if the cause exists in other facility organizations. As an example, if the cause resided in the electrical maintenance group, does the same cause exist in mechanical maintenance, operations, chemistry, etc.?

   6) Consider it the management cause is found elsewhere at the facility. Was the cause a function of a management decision making model that was faulty and used in other instances?

   7) In the case where a Programmable Digital Device (PDD) is found to be the cause, determine where else the same PDD is used.

      — Determine if a software common cause failure (CCF) exists in other applications of the PDD.

      — Were the same verification and validation practices used elsewhere?

      — Refer to IEEE Std 7-4.3.2™ [B7] for definition of PDD.

d) Consider what other work is performed in the same environment that was found to be the cause. Does the environment that was determined to be the cause exist in another location at the facility? The work environment could be a physical work environment or an organizational norm.

e) The investigation report documents the cause(s) to which the extent of cause is being evaluated, the basis for determining the scope of the evaluation the scope of the activities undertaken or needed in order to confirm the extent of cause.

f) The extent of cause analysis documents a conclusion as to whether an identified cause does exist in other areas beyond the scope of the event investigation.

   1) If an extent of cause is confirmed, corrective actions are created to address the other areas where the cause may exist.

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2) If an extent of cause does not exist, no further actions are required and the rationale is provided to support the conclusion.

4.4.3 Safety culture and root cause review

Safety culture has been identified as an important indicator of the health of an organization. The investigation team should review root causes to determine if the root cause evaluation appropriately considered whether any safety culture aspect caused or significantly contributed to any risk-significant performance issue.

a) Root cause analyses should include an analysis of the safety culture aspects of the event that provides an opportunity to understand the health of the organization.

b) Investigators should evaluate the identified causes of the event against each of the safety culture aspects to determine if an aspect caused or significantly contributed to the event.

c) Each cause should be considered individually against every safety culture aspect.

d) If a safety culture aspect is identified as a cause or significant contributor, the investigation should review larger organizational attributes to determine if cross cutting themes may exist within the organization.

e) The event investigation report should contain detailed documentation of the assessment and include the following:

1) A clear statement of the causes analyzed.

2) The result of the analysis should be documented in the body of the report.

3) Rationale for the determinations made as a result of the analysis. Include the analysis for aspects that were not found to be a factor in the event.

4.5 Corrective action plan

The corrective action plan should provide a specific set of actions needed to address the adverse conditions associated with the event as well as its causes, extent of condition, and extent of cause.

a) Managers should consider investigation team recommendations and input of impacted organizations when formulating corrective action plans and due dates.

b) Corrective actions should be directly linked to root and contributing causes.

c) Corrective actions should be developed that as a minimum are

1) A specific, high level of detail description (step by step) of what needs to be changed in the system or process to obtain the desired outcome

2) Assessed prior to approval to assure no unintended adverse consequences

3) Achievable by the individual and organizations assigned

4) Measurable in both implementation and effectiveness

i) Actions are in place in timely manner based on schedule reviews

ii) Event reoccurrence rate is eliminated or reduced based on trend data of challenges

d) Corrective action plans should include actions capable of resolving the immediate deficiency, addressing the consequences, and providing interim protection until corrective actions to prevent recurrence are implemented.

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e) Root cause(s) should be resolved by corrective actions that demonstrate the capability of long-term recurrence prevention. Short-term actions such as lessons learned sessions and required reading are not robust recurrence prevention measures.

f) Corrective actions should effectively address the identified extent of condition and extent of cause, so that identical or similar events may be prevented.

g) Corrective actions should be included in the investigation report.

h) Actions to address the extent of condition or extent of cause should not be deferred, canceled, or linked to another event investigation report, which could result in an inappropriate deferral or cancellation.

i) Investigation teams should consider use of different types of actions, as follows:

   1) Remedial actions: Should correct existing conditions and restore functions for normal plant operations.

   2) Interim actions: Should be taken as provisional actions until the corrective actions to prevent recurrence can be implemented.

   3) Corrective actions to prevent recurrence: Intended to prevent recurrence or to reduce the probability or severity of a significant event by addressing one of more of its root cause(s).

   4) Corrective actions: Should address the existence of an extent of condition, extent of cause, and other contributors to the event. These actions are not required to prevent recurrence but to mitigate or reduce the probability of additional problems.

k) Actions should be clearly worded, such that they stand alone and do not require interpretation.

l) Actions should be agreed to by the person or organization sufficiently knowledgeable in the area and having the resources available to complete the task, as follows:

   1) Action should be assigned to the person or organization in the facility action tracking database.

   2) When it is unclear who should be responsible for an action or when there are disagreements as to ownership of an action, then the sponsoring manager for the root cause investigation should begin negotiations and escalate the disagreement as required by station protocols.

m) Action due dates should be given a priority based on their safety and risk impact.

n) Actions completed as corrective actions to prevent recurrence should be identified as such in the implementing mechanism (e.g., procedure annotation, modification purpose statements) to prevent inadvertent removal. Proposed changes that will remove a corrective action to prevent recurrence should be approved by the station management.

o) If it is not feasible to preclude recurrence of a root cause then corrective actions taken should

   1) Minimize the potential for recurrence

   2) Minimize the consequences of recurrence

   3) Improve the ability to investigate future events

   4) Include justification for not precluding recurrence and criteria by which its success may be judged (risk acceptance)

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4.6 Investigation report

The primary purpose of an investigation report is to convey results of an investigation in a manner that enables management to make informed decisions. Investigative report reviews should consist of two different phases. The first phase is for initial review and approval of the completed report, while the second phase is an assessment of corrective action effectiveness. These assessments should support consistency in the investigation process and a means of communicating the results of the investigation to support facility improvement.

4.6.1 Attributes

Attributes of an effective investigation report is as follows:

a) Meets facility requirements and standards and is written in a professional and unbiased manner suitable for external agency review and release as a public record.

b) Is fact based and technically accurate. Investigation reports should be clear and concise and differentiate between facts, analysis, deduction, and conclusions.

c) Establishes a logical connection between what occurred (adverse condition), how and why it occurred (causes), how significant (consequences) and widespread it is (extent of condition), and what must be done in response (corrective actions).

d) Provides supporting information such that independent readers can understand how the conclusions were derived from the investigation analyses and come to similar conclusions.

e) Report content should include the following:

1) Executive summary that provides a synopsis of key points of the investigation

2) Body of the report that includes the following:

— Problem statement: Concise description of the event under investigation including actual, expected, and potential consequences.

— Event description: Chronological narrative description describing the organization(s) involved what occurred, when it occurred, where it occurred, and how it affected the consequences.

— Extent of condition: Includes statement of the condition being analyzed, methods of evaluation, conclusions, and bases).

— Operating experience: Related site and industry experience, including any investigations or corrective actions that failed to prevent the current event.

— Safety significance: Description of actual or potential nuclear, industrial, radiological or environmental safety implications of the event, as well as any safety culture aspects of the event.

— Analysis: Narrative describing how and why the event occurred. Includes reference to cause analysis tools used to reach conclusions.

— Causes and contributors.

— Extent of cause(s): Includes a statement of the cause being extended, methods of evaluation, conclusions, and bases.

— Corrective action plan: Includes the bases for concluding that the corrective actions will result in the elimination or control of the causes.

— Effectiveness review: Plan for the review of completed corrective actions to prevent recurrence.

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3) Attachments

4) References

5) Investigation analysis tools tables and charts

6) Diagrams and pictures

7) Any other supporting documents

4.6.2 Review and approval

Investigation report review and approval should adhere to a prescribed process, as follows:

a) Review and approval criteria should be specified in writing as follows:

1) A checklist should be developed for assessing investigation report. The checklist should contain the attributes that will measure the adequacy and quality of the investigation.

2) Facilities define the criteria against which the investigative report quality is assessed based on internal, regulatory, and industry guidance.

3) Direction and guidance for the checklist should be outlined in the facility approved procedure and provide clear and consistent expectations

4) The checklist should be used for the management review body to assess the thoroughness of the investigation.

b) The review and approval phase should occur after technical accuracy reviews are complete, the management sponsor has reviewed the results, applicable revisions have been completed and the investigation team has reached consensus on the report.

c) Final investigative reports should have the following reviews. Additional reviews external to the team based on event significance may be warranted:

1) Peer review: Investigation reports should be thoroughly reviewed by peers and subject matter experts for technical and administrative validity prior to final approval. These reviewers should not be members of the investigation team or directly involved with the event. Comments should be provided to the team for disposition.

2) Management sponsor approval: Management sponsor should review the final report prior to submittal for senior management review.

3) Senior management review and approval, which should verify the following:

— The investigation process produced a quality product that supports the findings

— Each corrective action has an owner and a date for completion

4) A management review body should review the investigation report as an oversight function. In this capacity the management review body reviews the investigation report as a means of understanding the details and causes of the event. The review should establish alignment on why the event occurred and actions to resolve the condition.

— Management review body members, as designated by facility management, are trained in their respective roles, including how to assess the adequacy of an investigation.

— Management sponsors and management review bodies should not change the conclusions of the investigation analyst or team, unless there is a technical inaccuracy. If a change is made, the rationale for the change should be documented.

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4.6.3 Corrective action effectiveness reviews

Corrective action effectiveness reviews should be performed to verify the effectiveness of the corrective actions to prevent recurrence.

a) Effectiveness reviews should be assigned to the person or organization sufficiently knowledgeable in the area evaluated to be a considered subject matter experts (SME).

b) The effectiveness review should confirm that the action was implemented as intended and remains in effect unless modified or deleted in accordance with facility protocols.

c) Effectiveness reviews should include the following:

    1) The attributes that should be evaluated and the associated acceptance criteria.

    2) The method(s) that should be used to evaluate that the identified corrective actions to prevent recurrence had the intended outcome. Examples include interviews, document reviews, field observations, and other means to determine continuing knowledge or use of revised methods, habits, procedures, or processes.

    3) The best time to perform the review (e.g., when will enough time have elapsed to allow corrective action to take effect). The effectiveness review should be completed after the condition has been challenged or had the opportunity to be challenged.

    4) An interim effectiveness review should be conducted if all corrective actions to prevent recurrence will not be implemented in a timely manner (e.g., within 6 months of original event).

    5) Interim effectiveness reviews typically assess the effectiveness of any corrective actions to prevent recurrence that have already been completed, as well as that of interim actions acting as temporary defenses until the remaining corrective actions to prevent recurrence have been completed.

    6) The review should document any identified delays in the implementation of a corrective action to prevent recurrence and the potential risk for not completing the action when originally scheduled.

    7) This review should also identify if further interim or temporary actions are required to be developed or extended.

    8) The effectiveness of the action(s) should be judged based upon the success of the corrective action to prevent or mitigate subsequent events that challenged the plant, system, or component.

4.7 Records

Investigation reports may be required to be maintained as quality records based upon regulatory (e.g., NRC 10 CFR Part 50 Appendix B) and industry requirements.

a) Company requirements for investigation reports and associated information

    1) Individual company requirements may vary on which documents, obtained during the investigation, will be maintained as quality records.

    2) Any information gathered and not included in the final root cause report should be retained for a designated period of time. Site organizations may consider destroying information if no longer required.

b) Final root cause report

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1) The final root cause report represents a concise compilation of the investigation, including the charter, summary of information gathered, and documentation of information analysis process (e.g., Event and Causal Factor Charting) and the identified root cause(s) and corrective actions.
2) In most cases the final root cause report is also electronically attached to the initiating adverse condition report.

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Annex A

(informative)

Bibliography

Bibliographical references are resources that provide additional or helpful material but do not need to be understood or used to implement this standard. Reference to these resources is made for informational use only.

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Annex B

(informative)

Common cause evaluations

B.1 General

A common cause is a cause that leads to multiple events, either through a recurring problem for one component, system, or unit or a cause that leads to events across similar components, systems, or units.

This annex provides a process to conduct an analysis of multiple events to determine if there is a cause that is common to all or to most of the events being considered.

B.2 Common cause analysis approach

Event investigations are prompted by individual events. Where a history or grouping of multiple events exists or facility performance indicators are significantly declining, a common cause analysis should be performed. The purpose of a common cause analysis is to identify and address any cause(s) that are common to related conditions of events.

An extent of condition is not required for a common cause analysis. An extent of condition analysis was completed for each of the individual events in the data set at the time the events occurred. A new condition does not exist in the common cause.

Common cause analyses should be initiated as a result of facility trending or collective knowledge that the potential for continuous improvement exists by looking at similar events in the aggregate. Another initiator for a common cause may be an external agency inspection or findings. The example would be the consideration of a review of all of the Institute of Nuclear Power Operations Areas for Improvement stemming from an evaluation and assessment.

B.3 Common cause analysis methodology

B.3.1 Determination of scope

Determination of scope is as follows:

— Identify the area of interest for the evaluation based on the trend information, collective knowledge or assessment feedback. The scope should encompass all issues that touch on the area of interest. Determine a clear problem statement based on the scope of the area of interest being investigated.

— The problem statement should identify both the nature of the problem and the adverse consequences resulting from the problem.

— Establish the time period to be analyzed.

— The selected data set for the analysis should be sufficient enough to lend itself to the analysis. A data set with too few events may not lead to any insight as to a common cause. A data set that is too large can be unwieldy and extend the analysis time.

— Identify the sources of the data to be used in the common cause analysis.

B.3.2 Sources of data

Sources of data are as follows:

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— Corrective action program database
— Corrective action program trend reports
— Internal and external assessments
— Management observation program
— System performance monitoring and trending

B.3.3 Data analysis

After the data is collected, analyze the data for commonalities. Typical commonalities include the following:

— Initiating actions
— Common failure modes
— Frequency of the events—the occurrence rate of the events
— Outage vs. non-outage
— Common program
— Procedure group
— Work group
— Work task
— Plant location
— Time of day or day of week
— Plant process

Validate the analysis through interviews with subject matter experts, review of data that is similar and/or previous internal and external evaluations, audits, self-assessments, and historical facility documents.

B.3.4 Common cause analysis communication and documentation

Common cause analysis communication and documentation should be as follows:

— Use visual means to assist in displaying the data in the groupings and the various considerations. For example, a graph of the chronology of the events or occurrences may help identify the cause(s).
— Document special considerations that may have impacted the population, such as: inspections and assessments that may skew the data (e.g., an outage, a self-assessment, oversight inspection, or external agency evaluation).
— The results should be documented in a common cause analysis report. Common cause analysis uses an approach that is different than for a root cause such that it does not fit well in a root cause reporting format easily. A common cause analyzes multiple events rather than specific occurrences. The purpose is to find commonality in the data set of events rather than the basic reason(s) for a problem. Therefore, not all of the sections of the root cause process would be applicable to common cause investigation documentation as a function of the purpose, theory, or philosophy of the analysis.

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Consensus

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