NUCLEAR ADMINISTRATIVE AND TECHNICAL MANUAL

70DP-0EE01

EQUIPMENT ROOT CAUSE OF FAILURE ANALYSIS

Revision 6

This procedure describes the program and activities associated with performance of Equipment Root Cause of Failures.

Provides direction required to perform a complete and accurate Equipment Root Cause Failure Analysis (ERCFA) according to the safety and economic significance of the failure.

Provides controls for proper prioritization of equipment failures to ensure their recurrence will be prevented commensurate with the safety and economic significance of the failure. (OER 052755 Action 01, 052540 Action 01 & 050297 Action 01)

EFFECTIVE DATE 05-31-96

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1.0 PURPOSE AND SCOPE

1.1 Purpose

1.1.1 Provides direction required to perform a complete and accurate Equipment Root Cause Failure Analysis (ERCFA).

1.1.2 Provides definition for the determination of the appropriate level of rigor applied to cause determination of equipment failures to ensure their recurrence will be prevented or reduced commensurate with the safety and economic significance of the failure.

1.2 Scope

1.2.1 Applies to all PVNGS personnel qualified per Section 3.5 who perform Equipment Root Cause of Failure Analyses and shall be utilized to investigate and document all investigated equipment failures.

1.2.2 ERCFA reports in progress for CRDRs initiated prior to the effective date of this procedure need not comply with changes made in this revision.

1.2.3 This procedure implements the requirements for cause determination as required by the Maintenance Rule.

2.0 RESPONSIBILITIES

2.1 Responsible System Engineering Department Leader (RSEDL)

2.1.1 Provides oversight & guidance for the ERCFA Program.

2.1.2 Designates an ERCFA Program Manager in writing.

2.2 Responsible System Engineering Section Leader (RSESL)

NOTE

Maintenance Engineering Section Leaders may also perform this function with the present organization.

2.2.1 Coordinates assignment of engineers and other personnel to perform ERCFA under the ERCFA Team Leader.

2.2.2 Determines if an Equipment Failure Investigation Team (EFIT) is required.

2.2.3 Assigns a Team Leader for investigations where an EFIT is formed. Defines the investigation methods for CRDR Evaluations of ERCFA using guidance in Appendix D - Failure Analysis Guideline.

2.2.4 Ensures that corrective actions required by the investigations are tracked by the Commitment Action Tracking System (CATS).

2.2.5 Approves the ERCFA report to ensure completeness, technical accuracy, and cost effectiveness through compliance with the procedure.

2.2.6 Ensures that appropriate cross-discipline review of ERCFA reports has been considered by the investigator.

2.3 ERCFA Program Manager (PM)

2.3.1 Manages and implements the ERCFA Program.

2.3.2 Participates on the CRDR Review Committee to determine the category of a particular equipment failure and recommends category changes in accordance with 90AC-0IP04, Condition Reporting, if required.

2.3.3 Provides technical and administrative guidance to individual engineers performing the root cause investigation.

2.3.4 Assists the ERCFA laboratory custodians in the areas of budget authorization for the labs.

2.3.5 Assures copies of investigation reports and all necessary supporting documentation are maintained.

2.3.6 Periodically provides an ERCFA status/assessment report and makes recommendations for program improvements to the RSEDL.

2.3.7 Approves alternate ERCFA investigation report formats.

2.4 ERCFA Team Leader

2.4.1 Selects appropriate engineers and other personnel needed for the failure investigation, when a team is deemed appropriate by the RSEL.

NOTE

It is not necessary that each member on the investigation team be Level I or Level II qualified in accordance with section 3.5 of this procedure. However, it is required that the team leader be Level II qualified. See Section 3.5 for qualification requirements.

2.4.2 Organizes the team for investigative tasks.

2.4.3 Interacts with other departments and groups to obtain information and collect evidence.

2.4.4 Determines necessary analyses to support the investigation.

2.4.5 Prepares the ERCFA Report.

2.4.6 Obtains final report concurrence from the PM and approval from the RSESL, as appropriate.

2.4.7 Identifies which affected and/or involved persons should provide Personnel Statements.

2.5 ERCFA Investigator

2.5.1 Produces ERCFA report for SIGNIFICANT failures as identified by the CRDR program.

2.5.2 For ADVERSE failures the investigator is responsible to identify the apparent cause(s) of the failure.

2.5.3 Obtains personnel statements from identified affected and/or involved persons.

2.5.4 Ensures Quarantine Guidelines are properly implemented in order to preserve evidence.

2.6 Shift Technical Advisor (STA)

2.6.1 Provides assistance to the EFIT in the areas of equipment/evidence preservation, potential reportability, initiation of CRDR for ERCFA, etc.

2.6.2 Obtains personnel statements from identified affected and/or involved persons.

2.6.3 Implements the Quarantine Guidelines as identified in Appendix C - Quarantine Guidelines.

3.0 PROCEDURE

3.1 General (RCTS 036851 Action 01) (QATS 392034 Action 03)

Equipment Root Cause Failure Analysis is a process used to identify, analyze, correct, and prevent recurrence of equipment performance problems. Refer to the **Investigation Flow Diagram** (Appendix B - Investigation Flow Diagram) for graphic representation of the ERCFA process flow.

3.1.1 All equipment failures requiring root cause analysis will be identified and dispositioned in accordance with 90AC-0IP04, Condition Reporting. Currently, the need to perform investigations of equipment failures are identified by Condition Report/Disposition Requests (CRDR), and this ERCFA procedure will be utilized to perform and document the analysis.

3.1.2 If the investigation results in corrective actions, the Commitment Action Tracking System (CATS) shall be utilized to ensure completion of the required actions.
(EXECMGT 050009 Action 02) (QATS 290027 Action 05 & 08)

3.1.3 The Maintenance rule requires that a cause determination be made for all system failures. This has been interpreted to mean that whenever a system incurs a Functional Failure, upon demand, the cause must be determined to prevent recurrence. The question becomes - To what degree should the root cause be determined? For those failures which result in SIGNIFICANT CRDRs the current ERCFA process would be employed. And for an indeterminate type failure, an ADVERSE CRDR should be written and the Responsible Engineer should review the failure for significance. This may result in determination of an Apparent Cause or the CRDR may be upgraded to SIGNIFICANT. For normal work processes the maintenance personnel would perform a summary of the observed problem on the WO close out screen. Of course the RSEDL may exercise an option of performing for any failure, a ERCFA level investigation.

3.2 ERCFA Level Determination

CRDRs are categorized by the CRDR committee according to the safety and economic significance of the problem being evaluated. Factors to be considered in the categorization are procedurally detailed in CRDR screening procedure 90DP-0IP03 Appendix G.

3.3 Evidence Preservation

3.3.1 The Duty STA or responsible investigator should initiate a request (preferably, face-to-face) to the responsible department to preserve the evidence necessary for the investigation (i.e., failed parts, as-found conditions, etc.).

3.3.1.1 Equipment Quarantine Guidelines

Guidelines for the control and documentation of quarantined or isolated equipment for the purposes of performing an ERCFA or other similar evaluations are included in Appendix C - Quarantine Guidelines.

3.3.2 Investigators are responsible to preserve evidence and/or data during the course of the investigation. The following general guidelines should be used during an investigation and documented with field notes, as appropriate:

3.3.2.1 Initial Conditions

Describe the initial conditions; What is broken? How is it broken? What is abnormal? Provide a physical description if possible. If possible, describe the conditions that lead up to the failure and conditions that followed the failure. When did it happen? Attempt to record actual time of failure. If estimates are used, indicate method. Was the component being worked on, in operation, or in standby? Who found the failed equipment? Request involved individuals to submit personnel statements regarding the event.

3.3.2.2 Maintenance Scene

Observe the environment for any conditions such as spray, heat, direct sunlight, or unusual odors. Look for out of ordinary conditions. Describe equipment condition when found. Identify unusual conditions or part conditions. Try to control the area (isolate/quarantine area, if possible). Do not remove parts from area until location, orientation, and condition are noted. Videotape or photograph the scene as appropriate.

3.3.2.3 Root Cause Troubleshooting Plan

The RE, STA, ERCFA Team Leader, Maintenance Leader and/or Maintenance Team Member on the job, should work together to develop a detailed troubleshooting and disassembly plan to include the expected failure mode, expected disassembly steps and further processing. The detailed plan should be documented on the Work Order and agreed to by all concerned/involved parties prior to the start of any disassembly. Care should be taken during each disassembly step to preserve all evidence.

- Provide frame of reference for photographic evidence (ruler, etc.). Include identifying labels in photographic evidence whenever possible. Log all pictures and items shown. Record all information (initial and final condition, location/state of all items found). Record any deviation from the detailed action plan. Provide sketches including scale when possible. Indicate camera angles when appropriate. Label and save components for future analysis and reference.
- If necessary, isolate/quarantine the area by placing a "QUARANTINE" sign or "CAUTION TAG" on the appropriate equipment or area, with appropriate instructions on back. Refer to Appendix C - Quarantine Guidelines for quarantine guidelines. This will help prevent the migration of parts and components, and it will preserve any fragile components.
- Control the damaged or failed component, do not dispose of them. Try to identify the components. Do not exercise components without an approved troubleshooting plan.

3.4 Equipment Failure Investigation Team

3.4.1 ERCFA of Significant Failures may require establishment of an Equipment Failure Investigation Team (EFIT) depending on the severity and complexity of the failure. The EFIT is required for complex, inter-discipline, or accelerated schedule failure analysis. The PM, the RSESL (or the designee) normally designate the Team Leader for the investigation effort.

3.4.2 The Root Cause Investigator or EFIT Team Leader, as appropriate, report major milestones and significant findings to the PM and provide information for Condition Report/Disposition Request (CRDR) Evaluations/Responses, as required.

3.4.3 Investigators shall immediately notify the Nuclear Regulatory Affairs Department and the PM if the investigations reveal:

- Design deficiencies in "basic components" that may cause "substantial safety hazards" as defined in 10CFR21.
- Conditions which may be reportable to the Nuclear Regulatory Commission (NRC) under 10CFR50.72 or 10CFR50.73.
- Other conditions which may be potentially reportable under 94AC-0LC01, Non-Routine Reporting.

3.4.4 The investigator should consider the need for cross-discipline and cross-organization review of the ERCFA report. The EFIT may use a checklist similar to Appendix D - Failure Analysis Guideline.

3.4.5 The investigator should notify the Maintenance Rule Expert Panel when a goal setting review is warranted due to:

- exceeding an established performance trigger on a system, structure or component (see Section 3.7.13) or
- when 50% of the established trigger has been reached.

3.5 ERCFA Investigator Qualification

3.5.1 **Level I Investigator** - a Responsible Engineer who may perform independent equipment root cause investigations.

3.5.1.1 Ideally, a Level I Investigator should have completed some formal training in investigative techniques (e.g., EG&G Management Oversight and Risk Tree (MORT), Kepner-Tregoe Change Analysis, Failure Prevention Inc. Equipment Root Cause Analysis), or proven experience in the area of root cause analysis. In addition, the individual should have two years experience as an engineer or equivalent.

3.5.2 **Level II Investigator** - a Responsible Engineer who may function as an Equipment Failure Investigation Team (EFIT) Leader for significant investigations.

3.5.2.1 A Level II Investigator should meet the Level I requirements and have additional training and/or proven experience in the area of root cause investigations. In addition, leadership experience or training is required to ensure the direction of the team is focused on developing a root cause.

3.5.3 The list of personnel authorized to perform the duties of ERCFA Investigator (Level I) and/or Team Leader (Level II) is maintained on TRMS by the use of the Qualification Card process.

3.6 Investigation Methods

3.6.1 The investigator should follow the investigation approach documented below. References 5.2.4 and 5.2.6 provide additional guidance for the investigator. These methods call for the following investigatory steps:

- COLLECT DATA

  Result: Data is collected and reviewed. Failure Symptom Description is generated. Sequence of Events is generated. Facts and Information Lists are generated.

- ASSESS

  Result: Failure Mode Investigation is completed. Troubleshooting/ Disassembly Action Plan is generated. Failure Scenario is constructed. Root Causes are identified. Appendices D &E provide guidance on investigation conduct.

NOTE

If the assessment identifies human performance as contributing to the root cause of failure, contact SAD (Strategic Analysis Department) for possible initiation of HPES report. In some cases, a HPES investigation will be required as part of the ERCFA investigation report. The determination is made by the PM and RSESL.

- CORRECT

  Result: Other Susceptible Equipment is identified. Corrective actions are determined and implemented.

- INFORM

  Result: Internal distribution of findings are made. External notifications are performed (e.g., LER, 10CFR21, etc.). It should be noted that "inform" may take place at any time during an investigation.

- FOLLOWUP

  Result: Effectiveness Review performed (e.g., trend reports, semiannual ERCFA Program reporting, etc.).

3.6.2 Data Qualification, Validation, and Verification

The integrity of data that the Root Cause Investigator utilizes during the investigation is very important. There are three steps involved in maintaining the integrity of pertinent data: qualification, validation, and verification.

1. **Qualification**

   The investigator should ask: Who is the observer? Who is the transmitter? How was the information obtained?

2. **Validation**

   The investigator should ask: Is the information self-consistent? Is the information sufficiently detailed?

3. **Verification**

   The investigator should ask: Is there an independent means to support the data validity? Is it consistent with our past experience or expectation?

By following these guidelines, the investigator can categorize data into two distinct groups, Information and Facts. Information is data that cannot be independently verified. Facts are data that have been independently verified.

3.6.3 Operating Experience

3.6.3.1 Significant ERCFA - The investigator should review industry operating experience (e.g., NPRDS, SOER, OER, FDT, CRDR history, Nuclear Network, etc.) and document results in an appendix to the ERCFA Report. (QATS 001012 Action 05)

3.6.3.2 Significant ERCFA - The investigator should perform a PVNGS maintenance history for the failed component and document results in an appendix to the ERCFA Report.

3.6.3.3 Adverse ERCFA - The investigator should consider a search of industry operating experience and PVNGS equipment history.

3.6.3.4 The results of the operating experience review should be used to assist the investigators in the root cause determination, and impact on other susceptible equipment (if applicable).

3.6.4 Independent Inspections/Verifications

3.6.4.1 Investigators may consider the need for temporary or permanent increases in independent inspections/verifications of future operations, maintenance or modification activities at PVNGS (i.e., as a result of corrective actions implemented).

3.6.4.2 When causal factors dictate, the conclusions from root cause failure evaluations may require additional independent verifications or Nuclear Assurance inspections of plant activities to occur.

3.6.4.3 If additional independent verifications/Nuclear Assurance inspections are necessary, it should be fully described in the corrective action section of the root cause failure report, communicated to the responsible organization (e.g., Nuclear Assurance-Maintenance, Operations Support, etc.) and identified in CATS.

3.7 Report Format and Content - SIGNIFICANT Analyses

ERCFA Reports completed in response to significant CRDRs should contain the following sections. These reports should contain the greatest level of detail. Report formats completed in response to ADVERSE CRDRs should be commensurate with the economic significance of the failure. Examples of various reports are available from the PM. The report format outlined below is the preferred format which can be used when reporting the results of the ERCFA investigation. As a minimum, ERCFA reports completed for ADVERSE CRDRs should conform with Section 3.8.

3.7.1 Cover Page

- Title of Report
- Date
- Revision of Issue
- Author(s) signatures (investigators are typically co-authors)
- PM concurrence
- Section Leader approval

3.7.2 Table of Contents (typically used for reports greater than four pages in length)

3.7.3 Executive Summary (typically used for reports greater than four pages in length)

- Brief overall description of the equipment failure
- Root cause(s) of the failure
- Scope of the failure (i.e., all susceptible equipment)
- Corrective actions prescribed by the investigation

3.7.4 Equipment Description

Provide a brief description of the subject component/equipment which includes basic operation, purpose within the system, and safety function, if appropriate. Associated Technical Specifications and Final Safety Analysis Report (UFSAR) references should be included. When referring to Plant Equipment the Equipment Identification (EQID) number and "noun" name should be used.

3.7.5 Failure Description

Provide a brief description of the failure. Include any pertinent information about operation or maintenance activities in progress at the time of the failure. Differences between the normal operating and failure conditions of the equipment should be evident in this description.

3.7.6 Sequence of Events (SOE)

Provide a chronological account of the events surrounding the failure. This should be constructed from a review of operating logs, work orders, surveillance test logs, interviews, etc. Date(s) and time(s) of occurrence should be included whenever possible. Source should be delineated on SOE.

3.7.7 Failure Mode Investigation

This section documents the majority of the failure investigation process. The following guidelines should be utilized when performing this activity:

- From the SOE, interviews, documentation review, etc., the investigators should assemble lists of facts and information.
- From a detailed review of the equipment/component principle of operation, operational service, Preventive Maintenance and Preventive Maintenance Basis, the investigators should assemble a comprehensive list of potential Failure Modes.

- After applying the facts and information to the list of potential Failure Modes, some will be eliminated. The result will be a list of Most Probable Failure Modes.
- The investigators will now be able to define Inspection, Testing, and Disassembly action plans to validate or eliminate the failure modes from the Most Probable List.
- Based on the identified Failure Mode(s), a Failure Scenario can be constructed. The Event and Causal Factors Chart can be utilized to construct the Failure Scenario.

3.7.8 Troubleshooting Plan

Provide detailed sections addressing inspection, testing, and disassembly based on the Failure Mode Investigation.

3.7.9 Troubleshooting Results

Document detailed information during execution of the Troubleshooting Plan. General guidelines for this section are provided in Step. 3.3.2.3.

3.7.10 Root Cause Determination

Indicate the Root Cause(s) of the subject failure. Once this has been identified, additional action should be taken to ensure correction of these causes would prevent recurrence. The following criteria should be met to validate potential and contributing root cause(s). Utilization of the Events and Causal Factors chart is helpful.

- Failure would not have occurred had the causes not been present
- Problem will not recur due to the same causal factors, if the causes are corrected or eliminated
- Correction or elimination of the cause(s) will prevent recurrence of similar conditions
- If preventive maintenance is recommended to remedy the problem, review the Preventive Maintenance Basis prior to determining corrective action.

3.7.11 Determination of Other Susceptible Equipment

Identify other equipment that may experience failures from similar Root Cause(s) to ensure specified Corrective Actions will be broad enough to prevent this specific failure as well as other susceptible component failures. Determine to what extent the equipment failure is transportable (could affect equipment in other units); could impact equipment OPERABILITY or may be reportable. Appropriate steps should be taken to notify the affected Unit Management.

3.7.12 Corrective Actions

Specify corrective actions for each Root Cause. Refer to the Events and Causal Factors Chart to determine effectiveness of proposed Corrective Actions. Include a reasonable timeframe for implementation. Consider the following questions prior to finalization of Corrective Actions:

- Will these Corrective Actions prevent recurrence of the condition?
- Is implementation of the Corrective Action within Arizona Public Service's (APS) capability?
- Does Corrective Action facilitate safe and reliable production of power?
- Have assumed risks been clearly stated?
- Has the Preventive Maintenance Basis been reviewed for applicability? (If Preventive Maintenance change is recommended)
- If a Preventive Maintenance change is requested, has the change been reviewed with Maintenance Support Leader?
- What is the most cost-effective methods for implementing the Corrective Action?
- If appropriate, identify any additional monitoring (other than CATS, TSCCR, CRDR, etc.) used to monitor performance of corrective actions.
- Will corrective actions result in achieving established Maintenance Rule performance criteria or goal or should the goal or performance criteria be modified?
- Is the root cause or apparent cause related to a procurement issue such as commercial grade dedication or a vendor related cause? Should Materials Engineering support be involved?

3.7.13 Maintenance Rule Goal

Indicate if a maintenance rule (a)(1) Goal should be established for the affected system, structure or component. Goals should be established for the following conditions;

- An established goal is not met due to a failure of an SSC;
- An established performance trigger is reached due to a failure of an SSC;
- Failures indicate a clearly declining trend;
- Multiple or repetitive failures are identified;

- Failed a key safety function as defined below (and in 30DP-9MT01, Assessing Risk when Performing Maintenance) on high risk significant or low risk significant standby systems, structures or components even if the goal or performance criteria is met.

A Goal may not be needed where the cause of the failure results in replacement or redesign as a corrective action, unless the failure is repetitive. This determination should be approved by the Expert Panel.

3.7.14 References

Provide a list of references for key data and calculation/evaluation criteria.

3.7.15 Appendices or Attachments

Provide additional supporting information (e.g., calculations, sketches, HPES investigation, drawings, photographs, vendor letters, significant telephone conversation notes, etc.). Appendix and/or Attachment topics should be clearly labeled.

The report should be submitted to the PM for concurrence and trending. The RSESL approves the report.

3.8 Report Format and Content - ADVERSE Analyses

ADVERSE CRDR Reports, if formally issued, should contain the following information:

- Executive Summary
- A brief description of the subject equipment.
- A brief description of the equipment failure.
- Other details pertinent to the failure, as appropriate (e.g., industry operating experience and PVNGS equipment history).
- The Apparent Cause.
- Corrective Actions (if required).
- Key Word(s) cause codes and References (identified on the CRDR Evaluation/Response Form)

The report should be submitted to the RSESL for approval. The PM is not required to approve ERCFA reports completed to resolve Adverse or Review CRDRs.

3.9 Information Dissemination

3.9.1 A copy of the ERCFA Report is intended to be used to disposition the initiating document (e.g., IIR, CRDR, etc.).

3.9.2 The Executive Summary from Significant ERCFA Reports should be distributed to the following individuals (as a minimum):

- Appropriate Vice Presidents/Asst. Vice President
- Responsible Director
- Operations Director
- Responsible System Engineering Department Leader
- Responsible Engineering Section Leader
- Other affected Directors and Managers
- Nuclear Materials Management and Budgets (NMMB) Graded QA Program Manager

3.9.3 The Executive Summary from Adverse ERCFA reports should be distributed to the following individuals (as a minimum):

- Responsible Director
- Operations Director
- Responsible System Engineering Department Leader
- Responsible System Engineering Section Leader
- Other affected Directors and Managers
- Nuclear Materials Management and Budgets (NMMB) Graded QA Program Manager

3.10 Corrective Action Tracking

3.10.1 All Corrective Actions prescribed in ERCFA Reports shall be tracked in accordance with 90GB-0CQ01, Commitment Action Tracking System (CATS).

3.10.2 Consider identifying specific follow-up action(s) for the System Engineer to perform in order to assure that the corrective action(s) resolved the original problem.

3.11 Document Turnover and Program Assessment

3.11.1 ERCFA Reports used to disposition initiating documents (CRDRs) will be retained in accordance with the applicable initiating document.

3.11.2 The PM also maintains a file of selected ERCFA Investigations.

3.11.3 The PM should complete a periodic status/assessment report on the ERCFA Program. This report should include information on the number of investigations performed and the type of report completed. Other pertinent information regarding the ERCFA Program, (i.e. effectiveness of corrective actions, may be included). The consistency of RCF analyses performed by various organizations should also be comparatively assessed.

4.0 DEFINITIONS AND ABBREVIATIONS

4.1 Definitions

4.1.1 **Apparent Cause** - The cause(s) determined from readily available information collected during a limited investigation which when corrected may prevent reoccurrence.

4.1.2 **Corrective Actions** - Actions taken to correct and prevent recurrence of equipment/component failure.

4.1.3 **Facts** - Independently verified data.

4.1.4 **Failure Modes** - The final condition or human behavior that initiates the observed event.

4.1.5 **Failure Scenario** - A series of chronological events beginning with an initiating event and ending with the identified failure mode.

4.1.6 **Functional Failure** - (See "Technical Dictionary", 01IG-0AP02 definition of "Functional Failure").

4.1.7 **Significant ERCFA** - An analysis involving equipment failure with reasonable potential to result in, or which has resulted in, significant negative impact on operational safety and cost. This is a formal analysis completed to resolve a Significant CRDR condition IAW 90AC-0IP04, generally resulting in determination of a Root Cause.

4.1.8 **Adverse ERCFA** - An analysis involving equipment failure that may have a negative impact on system operation, but does not cause significant economic or safety impact such as a unit trip or shutdown. This is an analysis completed to resolve an Adverse CRDR condition IAW 90AC-0IP04, generally resulting in determination of an Apparent Cause.

4.1.9 **Review CRDR** - An equipment failure that has no safety or economic significance. This is identified as a Review CRDR in 90AC-0IP04, where formal ERCFA reports are not required.

4.1.10 **Information** - Data from one source only (i.e., not independently verified).

4.1.11 **Plant Performance Criteria** - (See "Technical Dictionary", 01IG-0AP02 definition of "Plant Performance Criteria").

4.1.12 **Root Cause** - The fundamental cause(s) of equipment failure, determined thru rigorous application of engineering principles, that if corrected, will prevent recurrence of an event or adverse condition.

4.1.13 **Responsible Engineer (RE)** - An engineer from one of the engineering organizations assigned the responsibility for performing the ERCFA.

4.1.14 **Goal** - (See "Technical Dictionary", 01IG-0AP02 definition of "Goal").

4.2 Abbreviations

4.2.1 SED - System Engineering Division

4.2.2 HPES - Human Performance Enhancement System

4.2.3 TSCCR - Technical Specification Component Condition Record

4.2.4 SAD - Strategic Analysis Department

4.2.5 ERCFA - Equipment Root Cause Failure Analysis (e.g., Appendices E and F)

5.0 REFERENCES

5.1 Implementing References

5.1.1 30AC-9MP02, Preventive Maintenance
5.1.2 60AC-0QQ01, Control of Non-Conforming Items
5.1.3 81DP-0DC16, Engineering Document Change
5.1.4 70AC-0MT01, Maintenance Rule Expert Panel Activities
5.1.5 90GB-0CQ01, Commitment Action Tracking System - "P" CATS
5.1.6 94AC-0IP04, Condition Reporting
5.1.7 94AC-0LC01, Non-Routine Reporting
5.1.8 94AC-0LC02, Conditions Adverse to Quality for 10CFR21
5.1.9 90DP-0IP03, CRDR Screening and Processing
5.1.10 01IG-0AP02, Technical Dictionary

5.2 Developmental References

5.2.1 10CFR21
5.2.2 10CFR50
5.2.3 10CFR50.65
5.2.4 "Failure Diagnostic Guidebook - Guidelines and Diagnostic Charts for Root Cause Investigators", 1991.
5.2.5 NUMARC 93-01, "Monitoring the Effectiveness of Maintenance at Nuclear Power Plants", May, 1993

5.2.6 "Root Cause Guidebook - Investigation and Resolution of Power Plant Problems", 1989

5.2.7 "Root Cause Analysis", INPO 90-004, OE-907 Good Practice, January, 1990

5.2.8 "Significant Event Evaluation and Information Network (SEE-IN) Program Description", INPO 89-015, Program Description, December 1989

5.2.9 40AC-9OP15, Station Tagging and Clearance Rev. 2

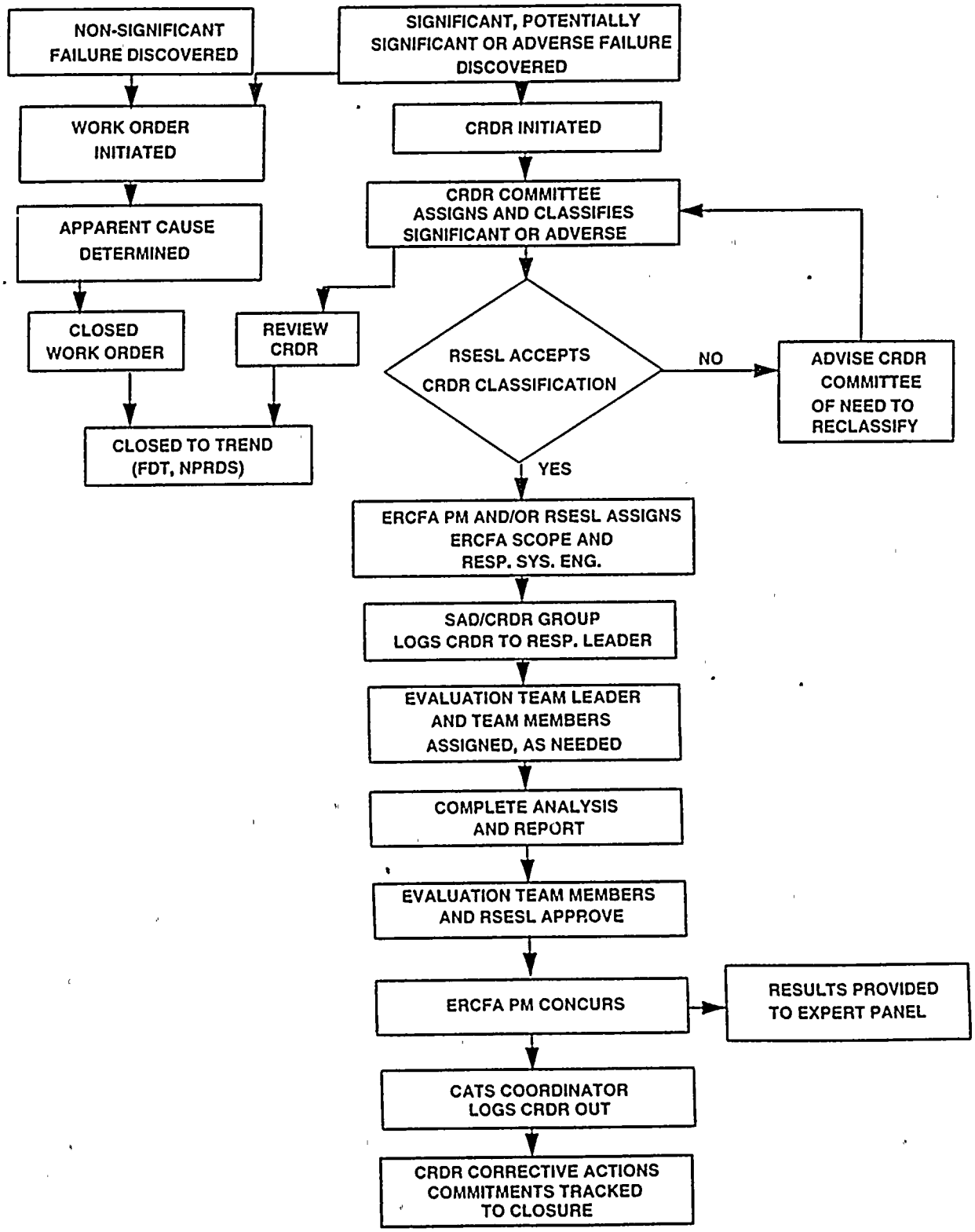
5.2.10 NUREG/CR 4780 Procedures for Treating Common Cause Failures in Safety and Reliability Studies, EPRI NP 5613.

5.2.11 Commitment Action Tracking System (CATS), Commitment Partition and Number.

RCTS	CRDR	OER	EXECMGT	QATS
036851 Action 01 Sect. 3.1	320102 Action 25 Appendix C - 1.	050297 Action 01 Procedure	050009 Action 02 Step 3.1.2	001012 Action 05 Step 2.3.9
		052540 Action 01 Procedure		290027 Action 05 Step 3.1.2
		052755 Action 01 Procedure		290027 Action 08 Step 3.1.2
				392034 Action 03 Step 3.1
				393148 Action 04 Step 2.3.13
	9-5-0438 Action 2 Procedure.			
	9-5-Q184 Action 5 App. D&E			

Appendix A - Intentionally Blank

Appendix B - Investigation Flow Diagram



Appendix C - Quarantine Guidelines

1. Purpose (CRDR 320102 Action 25)

- The purpose of this guideline is to control and document the quarantine or isolation of equipment for the purposes of performing an Equipment Root Cause of Failure Analysis (ERCFA) or other evaluation.
- Equipment quarantine is intended to ensure that physical evidence is preserved by limiting the access to, operation of, and work on equipment until the proper evaluation or troubleshooting plan can be performed or developed.

2. Scope

- This guideline shall be invoked immediately upon notification of a component or equipment failure (Significant CRDR initiated) in which ERCFA is required.
- The equipment quarantined may be of any safety or quality classification.
- The Shift Supervisor may invoke this guideline at other times at his discretion, for example on a condition which may be a Potentially Significant CRDR or Adverse CRDR.
- This guideline does not supersede the administrative requirements of "Control for Nonconforming Items" (60AC-0QQ01), "Corrective Action" (60AC-0QQ02), or other Nuclear Administrative and Technical Manual procedures, but may be used in conjunction with these guidelines.

3. Responsibilities

Shift Technical Advisor (STA):

- The duty STA has overall responsibility for:
  - Implementing this guideline.
  - Requesting assistance from the RE and maintenance personnel in the implementation of this guideline.
  - Identifying the equipment requiring quarantine.
  - Informing the appropriate department personnel on quarantined equipment.
  - Obtaining personnel statements regarding the condition under investigation.

Quarantine Guidelines (Cont'd)

Shift Supervisor/Assistant Shift Supervisor:

- The Shift Supervisor and/or Assistant Shift Supervisor is responsible for:
  - Concurring with the equipment quarantine boundary,
  - Directing resources as required to implement these quarantine guidelines,
  - Controlling work on and operation of the quarantined equipment commensurate with evidence preservation and plant operational needs.
  - Releasing quarantined equipment in the event the plant operational conditions warrant it.

Responsible Engineer (RE)

- The RE is responsible for:
  - Providing the work control planner with guidance on evidence preservation for inclusion into the work order during the maintenance process.
  - Assist the STA in the implementation of this guideline.
  - Keeping informed of equipment requiring quarantine.
  - Obtaining personnel statements regarding the condition under investigation.

Maintenance Personnel

- The Maintenance Personnel are responsible for:
  - Assist the Duty STA and/or RE in the preparation of the Corrective Maintenance Work Order for evidence preservation. Refer to Section 3.3 for Evidence Preservation guidance.
  - Performing work off the Corrective Maintenance Work Order or Procedural Logs to ensure evidence is preserved for the purpose of performing an ERCFA.
  - Contacting the RSESL when troubleshooting is initiated on components whose failure resulted in a safety or economically significant condition.
  - Documenting their observations and findings on a personnel statement or work activity sheet.

PVNGS Personnel

- PVNGS Personnel (e.g. Root Cause Investigation Team Leaders, plant management, Operations Personnel, Site Technical Support Engineers, etc.) are responsible to identify the need to quarantine plant equipment for root cause analysis. This need shall be communicated to the duty STA. They are also responsible for documenting their observations and findings on a Personnel Statement Sheet.

Quarantine GuidelineS (Cont'd)

4. Guidelines

- Upon notification of a component or equipment failure requiring a Technical Specification Component Condition Record (TSCCR) or CRDR for root cause determination, the Duty STA shall identify the equipment requiring quarantine immediately after plant stabilization following a plant transient, or as soon as practical after an equipment failure during normal plant conditions, (e.g. non-plant transient).
- During other instances where equipment requiring evidence preservation for the purposes of root cause analysis is required, the duty STA shall be notified verbally or in writing by an Investigation Team Leader, RE or senior manager.
- The written identification should consist of the following as a minimum:
  - Date component quarantined
  - Major Component ID, description, Unit and System
  - Subcomponent ID, description and location
  - Initiation Document Reference (IIR, etc.)
  - Name of STA responsible for quarantining the component/equipment.
- The Duty STA shall inform the Discipline RE, Maintenance Team Leader and Maintenance Department Leaders of quarantine items to ensure necessary controls are in place for evidence preservation.
- The Duty STA or RE should make every effort to obtain personnel statements regarding the conditions which led up to the quarantined equipment. This information will be necessary when determining the root cause of the failed component.
- The Shift Supervisor or Assistant/Shift Supervisor shall direct resources (e.g. Security, Station Services, Quality Assurance, etc.) as required to quarantine equipment.

Quarantine Guidelines (Cont'd)

4. Guidelines (continued)

- The Resource Organizations shall establish physical quarantine barriers as directed by the Shift Supervisor or the Assistant Shift Supervisor to prevent unauthorized operation of the equipment or unauthorized work on the equipment. Examples of quarantine barriers include:
  - Security Officer/Guard,
  - Shift Supervisor Clearance,
  - Locked enclosure,
  - Barrier Tape with CAUTION TAG or QUARANTINE sign with instructions which state:

CAUTION

QUARANTINED FOR EQUIPMENT ROOT CAUSE OF FAILURE ANALYSIS. CONTACT THE CONTROL ROOM PRIOR TO ENTRY OR USE.

- The Shift Supervisor or Assistant Shift Supervisor is responsible for controlling work on quarantined equipment via the normal work order process. Work Orders authorized on quarantined equipment shall include detailed steps to ensure that evidence is preserved for the purposes of root cause analysis.
- Steps should be included in the Work Order to ensure evidence is preserved during the maintenance process. Additionally, the following steps should be included in the Work Order:
  - a note that the equipment is quarantined for root cause analysis,
  - a note that troubleshooting steps not specifically addressed in the work order will not be performed unless a member of the root cause investigation team has approved the additional steps.
- Changes to the quarantine boundary, should be approved by the EFIT Leader or investigator, as appropriate, and the Shift Supervisor or the Assistant Shift Supervisor.
- Release of quarantined equipment shall be approved by the root cause investigation team leader and the Shift Supervisor or Assistant Shift Supervisor.

Appendix D - Failure Analysis Guideline

(SAMPLE)

This guideline may be used by the CRDR owner and the assigned engineer to assure the appropriate depth of the cause determination process.

CRDR: _____ Lead Investigator: _____ Section Leader: _____

- ☐ Statements/Interviews? Who: _____
- ☐ Quarantine Guidelines? What equipment: _____
- ☐ Investigation Action Plan, type of analysis (APP. F)_____
- ☐ Statements/Interviews? Who: _____
- ☐ Technical Reviews and Cross-Discipline Support
  Yes ___ No ___ - Teams Required?
  Yes ___ No ___ - Cross-Discipline: Elect __I&C __ Mech __ Specialty__?
  Yes ___ No ___ - Predictive Maint.__Consultants__?
  Yes ___ No ___ - Is an Independent Reviewer needed?
- ☐ System Expert Input (System, Maintenance, or Design)
- ☐ Look at PVNGS Failure History/FDT?
- ☐ Testing of Components - Action Plan
- ☐ IOER/Other Industry Contacts?
  INPO - Other/similar plants
  NPRDS
- ☐ Vendor Contacts Initiated? Vendor: _____
  - Review graded QA process and commercial grade dedication program.
- ☐ REI (Response to Emergent Issues) Tool/Review
  - Transportability; NRA contacted
  - Operability; Site Shift Manager
  - Reportability;
- ☐ Discussion with NRC Resident?
  - When action plan is developed

Additional guidance: _____

_____

Appendix E - Root Cause Analysis Suggested Topics and Questions

The following list suggests topics and questions to be considered in root cause determinations:

- ☐ What is the purpose/function of the system/component?
- ☐ How does the system/component really work?
- ☐ How is the system/component designed to work?
- ☐ How is the system/component really operated?
- ☐ How is the system/component supposed to be operated?
- ☐ What failed first?
- ☐ Did any thing else fail as a result of the first failure?
- ☐ When did the failure(s) occur? How do you know for sure?
- ☐ Have all reasonable failure modes been identified?
- ☐ Could something have failed earlier than the time of the event?
- ☐ Have similar failures occurred before at PVNGS or the industry?
- ☐ How was the failed component maintained?
- ☐ Are vendor operation and maintenance recommendations followed?
- ☐ What is the maintenance history for the system/component?
- ☐ What is the operating history for the system/component?
- ☐ What form of energy (e.g., motive power, control; power, instrument air, hydraulic fluid, etc.) caused the first component/subcomponent to fail?
- ☐ What form of energy (e.g., motive power, control power, instrument air, hydraulic fluid, etc.) caused the second, third, etc., component/subcomponent to fail?
- ☐ Was this energy (e.g., motive power, control power, instrument air, hydraulic fluid, etc.) supposed to be present or was it undesirable?
- ☐ What barriers existed between the energy (e.g., motive power, control power, instrument air, hydraulic fluid, etc.) and the first failure?
- ☐ Could the unwanted energy (e.g., motive power, control power, instrument air, hydraulic fluid, etc.) have been deflected or evaded?
- ☐ Were adequate human factors considered in the design of the equipment?
- ☐ Is the system/component properly labeled for ease of operation?
- ☐ Is there sufficient technical information for operating the component properly?
- ☐ Is there sufficient technical information for maintaining the component properly?
- ☐ Did the environment (e.g., humidity, vibration, etc.) have an effect on the problem?
- ☐ Could the graded QA process or commercial grade dedication process have contributed to the failure(s)?

Appendix F - Root Cause Determination Techniques and Elements

A. Root Cause Determination Techniques

1. Situation Analysis
2. Personal Interviews
3. Plant Walk-Downs
4. Walk-Through Task Analysis
5. Management Oversight and Risk Tree (MORT)
6. Events and Causal Factors Charting
7. Barrier Analysis
8. Change Analysis
9. Kepner Tregoe (KT) Problem Solving and Decision Making Process
10. Other (identify)

B. Root Cause Determination Elements

1. Perform a plant and industry history, information, and operating experience review with the assistance of the Nuclear Network Coordination in Technical Data.
2. Obtain a plant and industry reliability/availability data review from the L-RRA.
3. Obtain a list of support systems and interfacing systems.
4. Utilize applicable design basis documents.
5. Utilize applicable operating procedures.
6. Utilize applicable maintenance procedures.
7. Utilize applicable test procedures.
8. Utilize applicable administrative procedures.
9. Evaluate the effect of failure of affected components on safety, reliability, and availability of PVNGS.
10. Additional expertise required (e.g., system/component, operations, human performance, stress analysis, etc.).

Root Cause Determination Techniques and Elements

C. Root Cause Determination Technique Descriptions

SITUATION ANALYSIS

Although not often presented as a formal root cause determination technique, this method is commonly used by many people. It consists of asking the questions that come to mind when any condition occurs: "What?", "When?", "Where?", "How?", "Who?". It continues with the many subsequent questions that are more specific. The intent of this barrage of questions is to determine the "Why?".

Generally, this technique is not by itself sufficient for performing a root cause determination. It does, however, provide questions to be considered while using the other techniques. Review of these questions are of benefit when using the other techniques by helping to determine the areas where causal factors may lie.

Appendix E - Root Cause Analysis Suggested Topics and Questions gives some examples of questions that could be used in Situation Analysis.

WALK-THROUGH TASK ANALYSIS

A walk-through task analysis is a step-by-step reenactment of the task without actually performing any of the required actions. The purpose of this analysis is to determine how the task was actually performed. it is a good technique to use in identifying behavioral and environmental causal factors.

Like interviewing, walk-throughs are not a comprehensive root cause determination technique and are generally used in conjunction with other techniques. A walk-through can be part of an interview.

The walk-through should be performed with someone who performs the task as part of his normal job function. This could be the person(s) involved in the condition. The investigator will observe and make note of any differences between the actual performance reenactment and the accepted methods.

MANAGEMENT OVERSIGHT AND RISK TREE (MORT)

The MORT system, developed by the Department of Energy, leads the investigator through a comprehensive assessment of factors that could contribute to an event or problem. This method employes graphical root cause trees. The method is comprehensive but requires specific training in its implementation.

EVENTS AND CAUSAL FACTORS CHARTING

An event and causal factor chart provides a graphic display of the event on a time line. This technique is very effective because many of the causal factors become evident while plotting the time line for the event.

Root Cause Determination Techniques and Elements

Event and causal factor charting is very useful for complex and complicated situations and is better than long narrative descriptions. It shows the exact sequence of events from start to finish and allows the addition of barriers, other conditions, secondary events, presumptions, and causal factors that influenced the event.

BARRIER ANALYSIS

Barriers are devices employed to protect people and to enhance the safety and performance of the man-machine interface. Barriers can be physical or administrative in nature. Barriers are designed and erected to ensure consistent performance. Rarely is a single barrier relied upon; they are usually multiple and diverse. Barrier analysis is performed to determine which barriers failed and where barriers were nonexistent. This leads to identifying why they were missing or ineffective and where they need to be added or reinforced.

Human performance barriers are predominantly administrative (e.g., procedures or training), plant system barriers are predominantly hardware oriented (e.g., conservative design allowances or equipment interlocks).

CHANGE ANALYSIS

Change analysis is the comparison of the undesired condition to the same situation in which the condition was satisfactory. During the process of collecting information, all identified changes are written down. The differences are then analyzed for their resultant effects, if any, in producing the condition.

Change analysis points out specific causal factors and helps develop leads and questions toward other causal factors. For many conditions it can be an adequate stand-along root cause determination technique.

Root Cause Determination Techniques and Elements

A. Root Cause Determination Techniques Matrix

Method	Use	Advantages	Limitations
Situation Analysis	To get a quick overview of the condition; to identify areas of concern	Simple to use; may be adequate for uncomplicated conditions.	Danger of accepting wrong "obvious" answers; may not identify all root causes.
Interviewing	Provides firsthand information and insight into behavior involved with the condition.	Can be the most useful tool in data collection if done shortly after the event.	Requires skill; can be time consuming; interviewee may not recall details correctly.
Walk-Through Task Analysis	To break a task into subtasks; to identify deficiencies in training and discrepancies in procedures.	Identifies probable contributors to the condition; helps to identify where deviations occurred from accepted methods; familiarizes investigator with task	Time consuming; is most effective when performed with personnel normally responsible for the task.
Event and Causal Factor Charting	To show the exact sequence of events including all conditions that influence the event and presumptions made.	Organizes data; develops investigation; provides a cause-oriented explanation; helps ensure objectivity; very concise story of what happened and how it happened.	Requires up-front information to start; can be time consuming; rarely stands alone; can be enhanced by superimposing barrier analysis and change analysis.
Barrier Analysis	To identify physical and administrative barriers and to review them for effectiveness; to determine the "whys."	Helps identify probable causal factors and required corrective actions; good addition to events and causal factor charting.	Danger of not recognizing all failed barriers; possibility to overlook the effect of the rate and frequency of threats applied to a barriers.
Change Analysis	When causes of condition are obscure, and/or when change is suspected; when you don't know where to start.	Good starting point for an investigation; generates good questions for interviewing; good addition to events and causal charting.	Can produce more questions than answers; gradual changes and the compounding of changes can be over-looked; danger of incorrectly defining the change.