



# **ROOT CAUSE ANALYSIS PROGRAM MANUAL**

**LBNL/PUB-5519 (2), Rev. 1**

**Effective Date: July 18, 2008**

**Ernest Orlando Lawrence  
Berkeley National Laboratory**

### REVISION HISTORY

<b>Revision</b>	<b>Date</b>	<b>Revision Description</b>
<b>1</b>	<b>7/18/08</b>	<b>To clarify when Root Cause Analyses may be required.</b>

## TABLE OF CONTENTS

1.0	INTRODUCTION .....	4
2.0	REFERENCES.....	4
3.0	PERFORMANCE.....	5
	Attachment 1 - Definitions .....	8
	Attachment 2 - Data Collection Guidelines .....	10
	Attachment 3 - Root Cause Analysis Report Preparation .....	12
	Attachment 4 - Root Cause Analysis Methods.....	13

## 1.0 INTRODUCTION

Root Cause Analysis (RCA) identifies the cause of an adverse condition that, if corrected, will preclude recurrence or greatly reduce the probability of recurrence of the same or similar adverse conditions and thereby protect the health and safety of the public, the workers, and the environment.

This procedure sets forth the requirements for management determination and the selection of RCA methods and implementation of RCAs that are a result of significant findings from Price-Anderson Amendments Act (PAAA) violations, occurrences/events, Significant Adverse Conditions, and external oversight Corrective Action Requests (CARs) generated by the Office of Enforcement (PAAA headquarters), the U.S. Environmental Protection Agency, and other oversight entities against Lawrence Berkeley National Laboratory (LBNL). Performance of an RCA may result in the identification of issues that should be reported in accordance with the *Issues Management Program Manual*.

Performance of an RCA as an Effectiveness Review must address the review criteria as identified in LBNL/PUB-5519 (1), *Issues Management Program Manual*.

The Office of Contract Assurance (OCA) oversees the RCA program.

Performance of this procedure produces the following records, which are maintained in accordance with the Regulations and Procedures Manual:

- RCA Report
- Other documentation supporting the RCA (i.e., written statements, photographs, reports, logs, etc.)

At a minimum, for an employee to qualify or act as an RCA Team Leader, the TapRoot® or industry-standard RCA course must be completed successfully and documented. Senior management may decide to subcontract an RCA. In this case, the subcontractor must be qualified by LBNL as capable of performing the RCA to an acceptable industry standard for this purpose. The senior line manager is responsible for requisitioning the subcontracted RCA service. RCA team members shall have the appropriate level of technical expertise in the areas to be investigated and shall be independent of the occurrence, event, or incident with no bias or vested interest in the results of the investigation.

## 2.0 REFERENCES

### 2.1 BASELINE DOCUMENTS

- 10 CFR Part 830, Subpart A, *Quality Assurance Requirements*
- 10 CFR Part 851, *Worker Safety and Health Program*

- Department of Energy Order (DOE O) 231.1A, Change 1, *Environmental, Safety and Health Reporting*
- DOE O 414.1C, *Quality Assurance*
- DOE O 5480.19, Change 2, *Conduct of Operations Requirements for DOE Facilities*
- LBNL/PUB-3000, *Health and Safety Manual*
- LBNL/PUB-3140, *Integrated Environment, Health and Safety Management System*

#### 2.2.1 REFERENCED DOCUMENTS

- *Regulations and Procedures Manual*
- LBNL/PUB-5519 (1), *Issues Management Program Manual*

### 3.0 PERFORMANCE

#### 3.1 ROOT CAUSE ANALYSIS

---

##### NOTE

An RCA team may consist of one or more qualified individuals. An RCA may be required if an incident is reportable in the PAAA Noncompliance Tracking System (NTS), reportable in Occurrence Reporting and Processing System (ORPS), recordable for Occupational Safety and Health Administration (OSHA) tracking, a Significant Adverse Condition, or as determined by management.

RCA teams and RCA Team Leaders are selected by the responsible Division Manager for Significant Adverse Conditions; the responsible Division Manager for ORPS Category 1 and 2 reportable events, PAAA NTS Reportable incidents; and the cognizant manager (CM) for ORPS Category 3 and 4 reportable occurrences/events, nonreportable occurrences/events, OSHA recordable incidents, internal and external oversight issues, and issues determined by management that require a RCA to be performed.

Senior management will determine when an RCA is to be subcontracted and will requisition the services of a qualified subcontractor.

An RCA report involving a Category 1 or 2 ORPS-reportable event shall be completed within 45 calendar days of the onset of the occurrence or event. An RCA report involving a serious OSHA recordable incident shall be completed within 7 days of the employee reporting the incident.

- 
- 3.1.1 RCA Team Leader: determine the method of RCA using Attachment 4, *Root Cause Analysis Methods*, and initiate RCA.

- 3.1.2 RCA Team Leader: obtain all data collected from initiating organization.
- 3.1.3 RCA team: collect additional data using Attachment 2, *Data Collection Guidelines*.
- 3.1.4 RCA team: analyze data collected.

---

**NOTE**

A RCA report generated as a result of a Significant Adverse Condition, PAAA NTS-reportable incident, ORPS Category 1 or 2 reportable incident or OSHA recordable incidents, must be included as part of the Corrective Action Plan (CAP) data package.

Recommended corrective actions for issues identified in a RCA Report must meet the following criteria:

- Prevent recurrence
- Are feasible
- Are appropriate
- Clearly state new risks
- Allow the primary objectives and mission to be met

- 
- 3.1.5 RCA Team Leader: document all issues, determinations, and recommended corrective actions consistent with the format outlined in Attachment 3, *Root Cause Analysis Report Preparation Guidelines*.
  - 3.1.6 If one or more members of an RCA team do not agree with the outcome of the RCA, perform the following:
    - [ A ] Disputing party(ies): document the issue via formal correspondence to file.
    - [ B ] Disputing party(ies): sign and date formal correspondence.
    - [ C ] RCA Team Leader: review formal correspondence.
    - [ D ] RCA Team Leader: sign and date formal correspondence.
    - [ E ] RCA Team Leader: attach formal correspondence to the report.
  - 3.1.7 RCA Team Leader or senior manager for subcontracted RCAs: submit the report and associated documentation for review and approval to the CM of the responding organization(s) and as follows:
    - Significant Adverse Conditions: OCA
    - PAAA NTS Reportable Incidents:
      - 10 CFR 851 Incidents: 851 Program Manager
      - 10 CFR 835 Incidents: 835 Program Manager and Radiological Control Manager (RCM)

- Occurrences/Events, Reportable: Environmental, Health and Safety (EHS) Division Manager
- OSHA Recordable: Incident Review Program Manager

3.1.8 RCA team: work with reviewers to incorporate appropriate changes.

3.1.9 If further analysis or investigation is warranted, RCA team: perform Steps 3.1.3 through 3.1.6 and submit new report for review and approval per Step 3.1.7.

3.1.10 RCA Team Leader: submit the original approved report and associated documentation to the CM of the responding organization(s), PAAA Coordinator(s), OCA, and as follows:

- Significant Adverse Conditions: OCA
- PAAA NTS Reportable Incidents:
  - 10 CFR 851 Incidents: 851 Program Manager
  - 10 CFR 835 Incidents: 835 Program Manager and RCM
- Occurrences/Events, Reportable: EHS Division Manager
- OSHA Recordable: Incident Review Program Manager

3.1.11 CM: develop corrective actions based on the analysis and recommendations identified in the RCA report in accordance with the LBNL/PUB-5519 (1).

## Attachment 1 - Definitions

**Analysis, Barrier:** A systematic process that can be used to identify physical, administrative, and procedural barriers or controls that should have prevented the occurrence.

**Analysis, Change** A systematic process that is generally used for a single occurrence and focuses on elements that have changed. Typically used when the problem is obscure.

**Analysis, Events and Causal Factor:** Identifies the time sequence of a series of tasks and/or actions and the surrounding conditions leading to an occurrence. This type of analysis is typically displayed in an Events and Causal Factor chart that gives a picture of the relationships of the events and causal factors.

**Causal Factor Chain (Sequence of Events and Causal Factors):** A cause and effect sequence in which a specific action creates a condition that contributes to, or results in, an event. This creates new conditions that, in turn, result in another event. Earlier events or conditions in a sequence are called upstream factors.

**Cause (Causal Factor):** A condition or an event that results in an effect, typically found within eight major cause (causal factor) categories.

**Chain-of-Custody:** The documented trail of the people who have, or have had, collected data in their possession so the data can be found and accessed easily.

**Condition:** Any as-found state, whether or not resulting from an event, that may have adverse safety, health, quality assurance, security, operational, or environmental implications. A condition is usually programmatic in nature (i.e., an existing error in analysis or calculation, anomaly associated with or resulting from design or performance, or an item indicating a weakness in the management process).

**Contributing Cause:** A cause that contributed to an occurrence, but by itself would not have caused the occurrence.

**Direct Cause:** The cause that directly resulted in the occurrence.

**Direct Derivation:** An informal process of utilizing and analyzing the best available data to determine the cause of an occurrence, event, or incident.

**Event:** A real-time occurrence or anything that could adversely impact DOE or contractor personnel, the public, property, the environment, or the intended mission of this DOE facility.

**Event, Emergency:** The most serious occurrences that require an increased alert status for on-site personnel and, in specified cases, for off-site authorities.

**Event, Off-Normal:** Abnormal or unplanned events or conditions that adversely affect, potentially affect, or are indicative of degradation in the safety, safeguards and security, environmental or health protection, performance, or operation of a facility.



## **Attachment 1 – Definitions (Continued)**

**Event, Unusual:** Non-emergency event that exceeds the off-normal threshold or is related to safety, safeguards, and security, environmental or health protection, performance, or operation of a facility that requires immediate notification to the DOE.

**Facility** Any equipment, structure, system, process, or activity that fulfills a specific purpose.

**Human Performance Evaluation:** Identifies those factors that influence task performance, focusing on operability, work environment, and management factors.

**Quarantine Area:** An area that is blocked off, utilizing barrier tape, rope, or other means to preserve the integrity of an area under investigation.

**Reportable Occurrence:** An event or condition to be reported according to the criteria defined in DOE Order 231.1A.

**Root Cause:** The most basic cause that can reasonably be identified that management has control to fix, and when fixed, will prevent or significantly reduce the likelihood of the problem's occurrence or existence.

**TapRoot<sup>®</sup> Root Incident Investigation System:** A comprehensive system that assists investigators in performing consistent and accurate investigations that pinpoint the fixable root causes of equipment and human performance related incidents.

## Attachment 2 - Data Collection Guidelines

### DATA COLLECTION

Data collection must be initiated immediately following occurrence identification to ensure that data is not lost, but must be done without compromising safety or recovery. Information collected consists of conditions before, during, and after the occurrence; personnel involvement; environmental factors; and other information having relevance to the condition or problem. Every effort must be made to preserve physical evidence. *This should be done despite operational pressures to restore equipment to service.* Occurrence participants and other knowledgeable individuals should be identified. Data must be verified to ensure accuracy. Establish a quarantine area or tag and segregate material for all failed equipment. Areas to consider when determining what information is needed include, but are not limited to:

- Activities related to the occurrence of initial or recurring problems
- Hardware or software associated with the occurrence
- Recent administrative program or equipment changes
- Physical environment or circumstances

### I. Physical Evidence

Physical evidence shall be gathered and assigned to categories, and a record made of all facts from all sources, including witness statements and interview transcripts as soon as they become available. Photographs, videotapes, and sketches shall be used, as appropriate, to record and document the accident scene. When physical evidence is identified, either it shall be collected and secured, or the area in which it is located is secured to preserve the integrity of the evidence. A strict chain of custody (documentation showing physical custody) shall be maintained on all evidence. Security and custody of evidence are necessary to prevent alteration and to establish the accuracy and validity of the physical material, photographs, and documents collected.

### II. Conducting Interviews

Interviews are conducted with the following types of individuals:

- Witnesses to a specific event
- Coworkers
- Supervisors
- Managers
- Injured parties
- Emergency response personnel
- Individuals first on the scene
- Medical personnel/physicians
- Other organizational personnel

## **Attachment 2 - Data Collection Guidelines**

Interviewing techniques include the following:

- Plan the interview.
- Establish rapport before the interview begins.
- Provide a standard opening statement to ensure consistency for all interviews.
- Ask the interviewee to describe the events in his or her own words prior to asking specific questions.
- Ask open-ended questions (i.e., questions that cannot be answered by "yes" or "no" responses).
- Be unbiased and nonjudgmental.
- Schedule effectively.

### **III. Reviewing Records**

Relevant documents or portions of documents shall be reviewed and reference shall be made regarding their use in support of the RCA. Dates and times associated with the event/incident shall be recorded on all documents reviewed. Documents to review may include operating logs, correspondence, inspection/surveillance records, maintenance records, computer process data, procedures and instructions, vendor manuals, design documentation, equipment history records, related quality control evaluation reports, ORPS, trend charts and graphs, facility parameter readings, work orders, sample analysis and results, etc.

### **IV. Acquiring Related Information**

Related information that should be considered may include evaluating laboratory tests, viewing physical layout of equipment, developing layout sketches of the area, taking photographs to better understand the condition, and determining if operating experience information exists for similar events at other facilities.

## Attachment 3 - Root Cause Analysis Report Preparation Guidelines

**Title:** Title of Report

**Date:** Date report was generated

**Table of Contents:** Self-explanatory

**Acronyms:** Self-explanatory

- 1.0 Executive Summary:** Include event date, description of event, event discovery, affected equipment, descriptions of the scope of the investigation, and its purpose and methodology employed in conducting the investigation. Include a brief account of the essential facts surrounding the occurrence and major consequences; the conclusions and root cause(s) based on factors such as the organizational management system and line management oversight deficiencies that allowed the occurrence to happen and actions needed to prevent recurrence.
- 2.0 Facts:** Include the facts related to the accident including those pertinent to physical hazards, controls, and other related factors and management systems. Focus on events connected to the accident and causal factors that allowed those events to occur. Include a description of the accident, chronology and description of the responses to the accidents. Include facts pertinent to physical hazards, controls and other related factors and management systems.
- 3.0 Immediate Actions Taken, if applicable:** Identify any immediate actions that were taken to mitigate the situation.
- 4.0 Similarity with Other Events or Incidents:** List other events/incidents that are similar to this one and explain how they are similar.
- 5.0 Extent of Condition:** The extent of condition may be addressed in the RCA report or as part of the Corrective Action Plan (CAP). Identify the extent and impact of the condition.
- 6.0 Analysis:** Include types of analysis used, brief descriptions, and results of various analyses that were conducted (i.e., events and causal factors analysis, barrier analysis, change analysis, etc.).
  - 6.1 Root Cause(s) and Recommended Corrective Actions:** Provide a summary of causes and recommended corrective actions based on the analysis method performed. Identify the Contributing Causes (up to three), the Direct Cause (one), and the Root Cause (one), as appropriate.

**Appendices, if applicable:** Attach supporting documentation/evidence such as graphs, figures, photographs, reports, etc.

**Signatures:** Identify each member of the RCA team and obtain signatures on the final RCA report.

## Attachment 4 - Root Cause Analysis Methods

Root causes can be determined using numerous automated and manual techniques. A manual version of root cause analysis, such as compliance/noncompliance or tier diagramming, is acceptable. Commercially available automated techniques are widely used in the DOE complex. Whatever technique is used, investigators should assure that actual root causes are determined, not just contributing causes. The contributing causes are important; however, the need to find concise and justified root causes should be the main intent of using these analytical techniques.

RCA methods shall incorporate the following elements: identification of the problem, determination of the significance, identification of the causes immediately preceding and surrounding the problem, identification of the reasons why the causes in the preceding step existed by working back to the root cause. For significant and high risk issues, the recommended RCA method at LBNL is TapROOT<sup>®</sup>, which encompasses Barrier Analysis, Change Analysis, and Event and Causal Factors Analysis. For those items that do not require the rigor of TapROOT<sup>®</sup>, or where the cause is apparent, direct derivation may be used.

### Barrier Analysis

The basic premise of barrier analysis is that there is energy flow associated with all accidents. This energy may be kinetic, potential, electromagnetic, thermal, steam, other pressurized gases or liquids, or other types of energy. It is the isolation, shielding, and control (barriers) of this energy (hazard) from people, property, or the environment (targets) that prevents accidents. Barriers generally fall in the following categories: equipment, design, administrative (procedures and work processes), supervisory/management, warning devices, knowledge and skills, and physical. Therefore, identifying the energy sources and the failed or deficient barriers and controls in an accident investigation provides the means for identifying the causal factors of the accident.

If barriers were installed and one failed partially or totally, an investigator would examine the secondary safety systems, if any, that were in place to mitigate the failure. The investigator would also determine what events led up to and through the failure sequence, paying particular attention to changes made in the system. To accomplish this, the entire sequence of events can be broken down into a logical flow from the beginning to the end of an accident. Questions are asked about the practicality of the barriers and controls selected, why they failed, or why none were selected for use. The principal benefits of barrier analysis are that it identifies safety system elements that failed, and the results can be succinctly presented. Another benefit of barrier analysis is that the results can easily be presented graphically. A graphical flowchart (diagram) can clearly and concisely portray the energy flows and failed or unused barriers that led to the accident. Thus, barrier analysis is valuable in understanding the accident and the sequence of events that led to it.

### Change Analysis

Change analysis is a systematic approach to problem-solving that can help identify accident causes. Change analysis is a simple, straightforward process that is relatively quick and easy to learn and apply. Change is a necessary ingredient for progress; however, changes to systems and their impact also contribute to errors, loss of control, and accidents. The purpose of change analysis is to identify and examine all changes systematically and to determine the significance

or impact of the changes. The use of this technique in accident investigation is particularly well-suited for finding quick answers and identifying causal factors that are not otherwise obvious.

It has been demonstrated that, when problems arise for any functional system that has been operating satisfactorily (i.e., up to some standard), changes and differences associated with personnel, plant and hardware, or procedures and managerial controls are actual causal factors in creating these problems. Change can be thought of as stress on a system that was previously stable. Change can also be viewed as anything that disturbs the planned or normal functioning of a system.

RCA teams need to carefully evaluate all the changes identified during the investigation. Did the change really cause the result, or did the change merely bring an existing system deficiency to light? The investigation must focus on the systemic deficiencies that allowed the accident to happen and not just accept the changes identified as being the sole cause of the accident. Often, change analysis will lead to further insight into areas that must be explored by other analytical techniques.

## **Direct Derivation**

Direct derivation is an informal approach to problem analysis that can help to identify accident causes. Direct derivation is a simple, tabletop process utilizing the best available information, such as critiques, log entries, engineering judgment, etc., to determine the cause of an incident. This method is used in instances where the cause of the incident is apparent. Normally, RCA team would not be necessary, nor would formal interviews be conducted, though contacts would be made with personnel to verify or clarify information. The results of direct derivation shall be documented on numbered correspondence. Direct derivation is documented via internal correspondence.

## **Events and Causal Factors Charting and Analysis**

Identifying systemic causal factors requires understanding the sequence of events over time and the interaction of those events and their causal factors. This sequence proceeds from an initiating event through the final loss-producing occurrence. A meticulous tracing of unwanted energy transfers and their relationships to each other and to the people, plant, procedures, and controls involved in an accident will usually reveal a definable sequence for an accident.

Two basic principles are helpful in defining and understanding these sequences of events, causal factors, and energy transfers:

- Accidents result from a set of successive events that produce unintentional harm (i.e., personal injury, property damage).
- The accident sequence occurs during the conduct of some work activity (i.e., a series of events directed toward some anticipated or intended outcome other than injury or damage).

Events and causal factors charting is an integral and important part of the DOE accident investigation process. It is used in conjunction with other key tools (such as root cause analysis,

## Attachment 4 - Root Cause Analysis Methods (Continued)

change analysis, and barrier analysis) to achieve optimal analytical results in accident investigation. An events and causal factors chart is a graphic representation that produces a picture of the accident: both the sequence of events that led to the accident and the conditions that were causal factors.

Events and causal factors analysis is an effective means of integrating other analytical techniques into a concise and complete investigative summary. Events and causal factors analysis depicts, in logical sequence, the necessary and sufficient events and conditions for accident occurrence. It provides a systematic accident analysis tool to aid in collecting, organizing, and depicting accident information; validating information from other analytical techniques; writing and illustrating the accident investigation report; and briefing management on the results of the investigation.

Use Tables 4.1 and 4.2 in this attachment as guidance for choosing the best root cause analysis method for the event that took place. One method or a combination of methods may be used to determine the causal factors, contributing causes, direct cause, and the root cause. The TapRoot<sup>®</sup> method may be used in conjunction with each root cause analysis method to assist with the determination of the root cause.

**Table 4.1**

<b>Problem Nature</b>	<b>Barrier Analysis</b>	<b>Change Analysis</b>	<b>Event and Causal Factors Analysis</b>
Organizational	Best	Good	--
Activity or Process	Best	Good	Good
Reorganization	Good	Best	--
New or Changed Activity	Better	Best	Good
Personnel	Best	Good	Better
Accident or Incident	Better	Good	Best

**Table 4.2**

<b>Method</b>	<b>When to Use</b>	<b>Advantages</b>	<b>Disadvantages</b>
Barrier Analysis	Use to identify barrier and equipment failures and procedural or administrative problems.	Provides a systematic approach	Requires familiarity with the process to be effective
Change Analysis	Use when cause is obscure. Useful in evaluating equipment failures.	Simple six-step process	Limited value because of the danger or accepting wrong "obvious" answer(s).
Event and Causal Factors Analysis	Use for multifaceted problems with long or complex causal factor chain.	Provides visual display of analysis process. Identifies probable contributors to the condition.	Time-consuming and requires familiarity with the process to be effective