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ABSTRACT

This instructional unit is intended for use in training operations personnel and others involved in scram analysis at nuclear power plants in the techniques of root cause analysis. Four lessons are included. The first lesson provides an overview of the goals and benefits of the root cause analysis method. Root cause analysis techniques are covered next. Section 3 presents a scenario exercise, and section 4 provides an overview and summary of the root cause analysis technique. The unit includes a terminal objective, enabling objectives, a list of study questions, and instructional text. Abstracts of 10 documents for root cause analysis are appended. (MN)

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Root Cause Analysis: Methods and Mindsets

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ROOT CAUSE ANALYSIS

COURSE TITLE

INTRODUCTION TO ROOT CAUSE ANALYSIS

APPLICABILITY

1. OPERATIONS PERSONNEL

2. OTHERS INVOLVED IN SCRAM ANALYSIS

PREREQUISITES

PERSONNEL MUST BE FAMILIAR WITH BASIC NUCLEAR POWER PLANT OPERATIONS

INSTRUCTIONAL MATERIALS

ARTICLES

APPENDIX A: ABSTRACTS

TRAINEE HANDOUTS/REFERENCES AVAILABLE IN CLASSROOM

1. COPIES OF TERMINAL AND ENABLING OBJECTIVES

2. PRINT COPIES OF TRANSPARENCIES

3. COPIES OF REFERENCES LISTED IN ATTACHMENT ONE

4. COPIES OF ABSTRACTS FOR REFERENCE ARTICLES

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OBJECTIVES

A. TERMINAL OBJECTIVE

Improve usefulness of BWR Owner's Group Root Cause Coding database by increasing personnel knowledge of Root Cause Analysis methods, goals, and benefits.

B. ENABLING OBJECTIVES

1. Identify the characteristics of a Root Cause.

2. Compare the outcome of investigations done with and without Root Cause Analysis techniques.

3. Compare application of each of the following techniques to Root Cause Analysis:
   a) Kepner Tregoe
   b) MORT
   c) Events and Causal Factors
   d) HPES

4. Evaluate Root Cause Analysis benefits
   a) Benefits of using Root Cause Analysis
   b) Detriments of not using Root Cause Analysis

5. Determine the strengths and weaknesses of each Root Cause Analysis technique.
   a) Kepner Tregoe
   b) MORT
   c) Events and Causal Factors
   d) HPES

6. Use the BWROG Scram Root Cause Coding Flow Chart as an Application of RCA in Categorizing Root Cause and/or Finding Root Cause.

INTRODUCTION TO ROOT CAUSE ANALYSIS

OBJECTIVES (cont.)

7. Evaluate the outcome of a Root Cause Analysis process for completeness, accuracy, consistency with common-sense expectations.

NOTE

The following objective will be accomplished by the site training department using the site's preferred root cause analysis methodology. The scenario with some basic root causes is provided, and the method can be exercised under the site training department direction.

8. Demonstrate Several RCA techniques on sample events.
   a) Use the Basic Root Cause methodology.
   b) Follow use of technique on sample event.

Submitted by ______________________________

Approved by ______________________________

Reviewed by ______________________________

INTRODUCTION TO ROOT CAUSE ANALYSIS

Background

The Boiling Water Reactor Owner's Group (BWROG) chartered it's Scram Frequency Reduction program to conduct Operations Activity programs such as information exchange meetings, engineering design studies for plant modifications and plant maintenance practices to reduce the frequency of reactor scrams to the NUMARC goal of 3 scrams per year, decreasing to 2 scrams per year by 1990. The Operations Activity group commissioned this introductory training program in Root Cause Analysis.

Root Cause Analysis, as applied to Scram Frequency Reduction, is a powerful tool that involves plant personnel in improving plant operations in a directly measurable, high dollar value area; unplanned reactor scrams. Incremental removal of root causes by corrective action cumulatively improves overall plant operations.

Questions you'll be able to answer after this course

1. What is Root Cause Analysis? What is Root Cause?
2. What are the reasons for doing Root Cause Analysis? What are the reasons for doing Root Cause Coding flowcharts?
3. What techniques are used for Root Cause Analysis? Is any technique robust enough to satisfy the goals?
4. What mistakes have been made in Root Cause Analysis/Coding in the past? Where are the opportunities to leverage the results in the future?
5. Why is your station management concerned enough with Root Cause Analysis to train more personnel in this technique?

This Root Cause Analysis introductory training was developed by the General Electric Company, Nuclear Training Services.

I. INTRODUCTION TO ROOT CAUSE ANALYSIS

Section I training objectives:

1. Identify the characteristics of a Root Cause.
2. Compare the outcome of investigations done with and without Root Cause Analysis techniques.
4. Evaluate Root Cause Analysis benefits
   a) Benefits of using Root Cause Analysis
   b) Detriments of not using Root Cause Analysis

What is Root Cause Analysis? Quite simply, analysis of data after an event to determine the Root Cause(s). And what is the "Root Cause?" According to M. Paradies and D. Busch of Savannah River Plant, Root Causes are "the most basic causes that can be reasonably identified and over which the ... management team has control to fix." D. Gano, in "Root Cause and How to Find it", says Root Causes are "the most basic reasons for an effect, which if corrected will prevent recurrence." Outside the nuclear industry, Root Cause is "the most basic cause of an event/problem that, when corrective action is taken, prevents recurrence, or minimizes the effect of recurrence of, the event/problem."

These definitions include the success criteria for corrective reaction to root causes. Without success criteria, we can define root causes as "the most basic causes for an effect that can be reasonably identified."

Using that definition, let's look at two examples.

ROOT CAUSE ANALYSIS

A Non-Power Industry example

A large bank's staff felt that a significant number of customers waited more that two rings for the phone to be answered. Survey results show callers neglected for 5 or more rings became irritated, and would not call the bank again. Callers answered in two rings or less were reassured and comfortable with doing business by phone.

Rather than recommend more operators, the staff performed root cause analysis to determine why the phone rang more than two times before being answered. They found that Customer B waited more than two rings while:

Operator 1 routed Customer A's call;

- --because Operator 2 was on break;
- --because the person Customer A was calling (receiver) was unavailable <u>and</u> Operator 1 was unaware;
- --because Customer A's receiver was helping another Customer, and no substitute is available;
- --because Customer A could not identify correct receiver.

Operators 1 <u>and</u> 2 routed Customer calls;

- --because receiver was unavailable <u>and</u> Operator was unaware;
- --because receiver was helping another Customer, and no equivalent is available;
- --because Customer could not identify correct receiver.

The analysis also shows possibilities such as Operator inadequately trained, too few Operators, etc. The staff recorded how often each cause resulted in a caller kept waiting. The checksheets showed that <u>one operator out of office</u> was the most frequent cause, followed by <u>receiving party not present</u>, <u>no substitute available</u>, <u>customer unaware of section and name of receiver</u>, and several causes grouped under <u>other</u> due to relative infrequence.

One operator out of office by itself was incomplete, as the frequency study and further investigation show the frequency of calls increasing at the same time that one operator was out of the office; specifically, lunch time! Many customers call the Bank during their lunch hour, and the receiver was most frequently unavailable when the phone traffic was heaviest, further complicating the problem.

Figure One shows one version of a cause and effect diagram for this problem. The root causes and groupings are:

Operator
- --Does not understand message;
- --Does not know receiver's job responsibilities;

Receiver
- --Not at desk;
- --Out of office;
- --Absent;
- --Busy with another customer;

Customer
- --Does not know receiver name or section;
- --Lengthy discussion with operator;
- --Complaining;
- --Starts to leave a message;

Operator working system
- --Lunch time rest;
- --Telephone call rush;
- --Absent.

Other.

ROOT CAUSE ANALYSIS

A Power Plant example

After a reactor scram, management asks a team to investigate the cause. The event summary: a technician assigned to test instrument channel "A", mistakenly connects the test equipment to channel "B" and causes the scram. Obviously a personnel error, but we have to do the paperwork.

Further investigation by the team reveals several interesting facts:

* the technician usually works in the other reactor plant at the same site;
* the channel designations are not labelled on the test panel;
* the channel test connections are mirror-image from the other reactor plant panel;
* the test panel does not have "bypassed channel" indication;
* the technician is qualified to do work;
* the designated channel was bypassed correctly;
* the technician was using the procedure step-by-step.

Figure 2. shows the simplified cause and effect chart.

The "obvious personnel error" is contestable, if not totally incorrect, considering these facts.

Are these valid root causes? If compared to the initial results (not enough operators, <u>obvious</u> personnel error), the causes are definitely more basic. Are they the result of reasonable investigative effort and expenditure? Without more detailed information to the contrary, we would have to say yes.

Corrective Reactions
Did Root Cause Analysis Pay Off?

Root cause analysis, as used in the nuclear industry, gives both root cause(s) and suggestions for corrective reactions. Let's check the examples for content validity by comparing the corrective reactions against our definitions.

The corrective reactions for the non-power industry example may include:

* stagger the operator lunch time rest outside peak call times;
* hire temporary help for peak call times;
* ensure receivers notify operators of unavailability (and give them the tools to do so, like an attendance/location board);
* cross-train receivers in each other's expertise, so more than one resource is available to customers;
* hook up a dedicated line with a prerecorded messages with general information.

The corrective reactions for the power industry example may include:

* only allow technicians to work on one unit;
* label the channel designations on the test panel;
* move the test connections on one unit, removing the mirror-image problem;
* install channel bypassed indication on test panel;

Adding the recurrence prevention criterion, both analyses yield suggested reactions that will minimize or preclude recurrence. The management team has power to fix the causes in both examples, satisfying that criteria.

ROOT CAUSE ANALYSIS

Corrective Reactions without Root Cause Analysis: What's wrong with this picture?

The proof of valid root cause analysis may be to contrast these causes and their corrective reactions with the original "causes" and reactions. In the first example, hiring more operators is kinder than most reactions in real life. The existing operators could have been given time off without pay, replaced completely, or subjected to training in how to do their job better. In the second example, the real-world results may include all of those reactions, plus unnecessary procedure revisions, administrative awareness programs to improve operator attentiveness, and, of course, several recommendations from operations consultants/advisors.

Dean Gano from Washington Public Power Supply System quotes the criteria for root cause solutions as:

1. A solution that prevents recurrence;
2. A solution that is within our control;
3. A solution that allows us (the power station) to meet our other objectives, such as to produce power efficiently.

The reactions in the examples when true root cause analysis is <u>not</u> used do not satisfy these criteria. When root cause is not found, not only do events recur, but the process becomes less efficient with each repetition. Perhaps more importantly, incorrect reactions may not only allow recurrence of the same event, they may in fact allow other new events.

> An operator/technician is punished by time off without pay, insulted by unnecessary training, or <u>blamed</u> in some other way for a mistake made after being "set up" by procedures, design, or policy. He will understandably hesitate to cooperate with the process in the future. When a procedure is <u>blamed</u> for problems originating in inadequate component design, the procedure changes merely allow someone to <u>overcome</u> poor design. When design changes are made to systems that merely need clearer procedures, unnecessary funds are spent, and one design change may yield more than one effect when subjected to the complex interactions of a nuclear power plant. It may be the root cause for another event.

It becomes clear, as root cause analysis is studied in more depth, that the existing "place the blame" methods, and the data from those methods, are neither accurate nor helpful. How do we know that the data is not helpful? The scrams from those "root causes" continue to occur. In the 1983 Significant Event Report root cause analysis by INPO "Human performance problems (44 percent of the total) is the dominant category of the root cause. Based on those facts, there should have been a massive drive to further automate plants, moving a dominant "root cause" further away from the plant. There was not such a movement, perhaps because training improvements were a more palatable alternative, perhaps because there never was any faith in those "root causes". There are also practical limits on the amount of resources, including time, manpower, and money, to make the hardware and design changes suggested. Mark Paradies and David Busch, from the E.I. du Pont de Nemours Co. Savannah River Plant, said, "We didn't want to blame every incident on God (the ultimate root cause) or to blame every incident on the operator (a handy root cause because they were there when the (incident) took place. In fact, we didn't want to blame anyone."

Does this mean that human performance "miscues" never cause reactor scrams (or other undesirable effects)? No, but there are often other contributory, if not controlling, factors.

An event can be coded to personnel error, using the root cause coding descriptions from the BWR Owner's Group Scram Frequency Reduction Committee, when an event occurs where a well-trained, properly-directed person, working in an environment conducive to the task, following an accurate effective procedure on correctly designed equipment. . . (etc., etc.) makes an error because: (1) lack of concentration/ attention to the task being performed led to the error; (2) procedure for the task was not followed; or (3) attitude problem resulted in employee not concentrating on the task he should have been doing.

Current evaluations show, when accurate root cause analysis is used, that personnel error due to one of these three problems is only about 10% of the total causes of events. The emphasis on blaming personnel is a result of not looking deep enough for root cause, not knowing what other things contribute to personnel error, and lack of accurate information from personnel who are _taught_ to conceal facts by the reaction to openness and candor. It is obvious that placing blame on personnel incorrectly leads to a weaker RCA process. Personnel learn.

Why do Root Cause Analysis?

Given that the current process is not as effective as possible, let's examine why the process is used. This may allow us to determine the characteristics of a process that will work.

Why analyze for the most basic cause? In the aviation industry the answer is a little more dramatic, if not more obvious; to prevent "events" from recurring. As most of us travel by air periodically, this seems to be a goal with merit.

In the nuclear industry, however, there are several objectives. A primary industry goal is to gather information available after events so it can be used by other applicable units to prevent the same or similar events. This is the basis for the BWROG SFRC root cause coding system. The primary goal for the event plant is to prevent recurrence at the same facility. The goal at forward-looking utilities may be to prevent similar events from recurring by simultaneously omitting similar root causes.

Are these really the goals of Root Cause Analysis? An analogy can be drawn with nuclear training's recent history. Despite attention being focussed on parts of training, such as task analysis and accreditation, the real goal was improved on the job performance. The real reason for Root Cause Analysis is <u>not</u> just reducing the number of scrams or unplanned shutdowns, or increasing the availability, but improving performance of the plant. It is vitally important to keep this in mind when examining the techniques for Root Cause Analysis. When selecting an RCA technique, a monitoring parameter should be the potential for improving plant performance. In other words, the process is the <u>key</u> to improved plant performance, not the result (reducing the number of scrams). We discuss ways to monitor effectiveness of Root Cause Analysis in Section IV.

The answer to "Why do root cause analysis?" is to improve plant performance by corrective reactions based on accurate root causes. By the way, the process can be applied to any event, or to determine why something works so well. We are unnecessarily limiting root cause analysis' potential if it is just applied to reducing the number of scrams, but that will be discussed in more detail in the summary section.

Mr. Mark Paradies made an interesting comment during a BWROG SFRC presentation. He said, "We don't think the big problems, the Three Mile Islands, are caused by a single problem usually. We've beat that down in the nuclear industry. We don't have single failure points.... but we do have some multiple failure points, and the only way to address those is to get rid of as many as possible and to learn as much as you can from this operating experience." This seems to summarize the objectives of Root Cause Analysis very well.

How should I do Root Cause Analysis,
& How do I know I'm there?

The Root Cause Analysis (RCA) technique that works best is determined by each user, but there are proven methods for the process, regardless of the technique chosen.

In the interest of learning from others, let's examine root cause analysis as performed by Electricité de France.

The French utility, having generic reactor designs (thirty-two 3-loop 900 MWe units and fourteen 4-loop 1300 MWe units) benefits more from sharing information about common components. The payoff from the investigative efforts is shared by all common units, and the risk to generic units from common failure is much more severe. Therefore, the support for operation experience utilization is systematic, company-wide.

There are four segments to the organization EdF uses for the "utilization and processing of operating experience based on a group-oriented approach." The four segments are:

a structure for gathering information resulting from the failures or incidents;

a structure for analyzing these incidents for failures and for deciding the corrective action to take;

a system for storing and retrieving the information;

a system for <u>circulating</u> the information and the corresponding <u>decisions</u> and corrective (re)actions (emphasis added).

When does it start? Usually (unfortunately) after an event. Section IV will explain the "unfortunately."

Who does it? In most cases, the investigation is done by a team, usually independent from the involved personnel. One utility uses a team that reports to the plant manager, with "no particular allegiance to any department," to gain the most objective viewpoint of the incident. Although they make a list of recognized experts that are available when needed, that plant recommends the following team makeup:

* a Human Performance Evaluator; this is a person who is specifically trained in evaluating all aspects of human performance and documenting the results and recommendations, usually in accordance with the INPO Human Performance Evaluation system or an equivalent.
* System/Component Experts;
* Operations Experts;
* Discipline Experts (stress analysts, chemists, etc.).

The Savannah River Plant (SRP) uses an independent group from the Corporate organization to investigate the root cause. They are trained in how to conduct the personnel interviews, with special attention paid to <u>not</u> placing blame on any person during the investigation.

It is worth noting that the BWROG SFRC feels participation in the root cause analysis effort should increase. The more teams of people that input information into the analysis, the better the result, as a general rule.

It is also worth noting a difference in the two examples presented earlier. In the bank case study, the staff did the study themselves. In the nuclear industry example, a team was tasked with the investigation by management. The message in that distinction is subtle but clear; principles of total employee involvement result in voluntary, effective, valid improvements.

How is the Root Cause Analysis done? The investigative team uses one of the techniques described in Section II to ask questions about the event. Several experts tell us that the analysis must start with the Primary Effect; typically, the reactor scram.

The most common technique used in initial RCA is Events and Causal Factors, where the Scram is the initial event, and the major causal factors are known or easily attainable. The Savannah River Plant uses the Events and Causal Factors method (developed by EG&G for the Department of Energy) to develop a timeline to ensure complete analysis of all events. A tip from Washington Public Power Supply System (WPPSS) is to try to develop two or more causes (or causal factors) for each event, then determine two or more causes for each cause, and so on These methods help ensure that the effort to pursue root cause is not abandoned too early.

In his book, KAIZEN - the Key to Japan's Competitive Success, Masaaki Imai states that "problem solvers are told to ask 'why' not once but five times. Often the first answer to the problem is not the root cause. Asking why several times will dig out several causes, one of which is usually the root cause." Don't stop asking questions too quickly!

Another caution from the experts is to keep an open mind. Pre-judging the root cause(s) dooms the team into conspiring for recurrence. The most basic causes must be found to answer each question.

There is not one root cause per event, according to several sources. J.L. Burton reported in Power Engineering that River Bend Nuclear Station found 9.5 root causes per scram, average. This should lead the investigators to keep probing.

WPPSS recommends tying the event and causal factor to a recommendation for a solution. They compare the combined cause, effect, and solution to the root cause criteria discussed earlier.

The French utility, Electricité de France, ensures their investigative teams find the same, basic information whether the event initiating the investigation is "important-to-safety" or "with a bearing on safety and/or having an important financial impact". That basic information includes:

description of the circumstances;

damage observed;

assessment of the consequences on the equipment and the plant;

assessment of the probable root cause and sequence of events;

immediate corrective action taken;

suggestions for a definite solution (preventive maintenance, modification) or an acceptability of event recurrence.

When the root causes are found, the goal of the BWROG SFRC can be addressed. The root causes are coded, which allows the "operational experience gained" to be shared with others. The only condition on this wealth of experience is that it be understandable. The standardization of root cause coding, such as that proposed by the BWROG SFRC, will allow industry-wide sharing of experience. Every plant participating can accumulate hundreds of reactor years of operating experience annually.

SRP uses a peer review group to ensure the RCA and coding are complete and accurate. The primary coding engineer presents the events and causal factors charting, the root cause analysis, the root cause coding, and the investigation history, and the peer review group does a QA check. Sometimes additional investigation is required, and sometimes the process is just exchange of information. The group must reach consensus on the root cause before the causes are recorded.

How do we know when we are done? To assist the investigator, SRP assigns names to three levels of cause. There are six basic root cause categories, with near root cause at the next lower level, and finally the root cause. By their method, the investigator knows by the coding when root cause is reached. SRP also acknowledges that root cause is not always identified.

Most RCA methods don't stop at finding the root causes. The investigation team is not disbanded until the event reaction recommendations or solutions are made. The investigative team recommendations are given to the management team, which prioritizes the recurrence prevention reactions. The investigation team should track the effectiveness of the reactions, as they are intimately familiar with the causes and the recommendations.

One of the critical points in the root cause, corrective reaction determination, and correction implementation process is confirming the results. Finding root causes and matching corrective reactions is futile if the event recurs, <u>or</u> if the root causes precipitate another event. The highly respected Dr. Deming, a Quality Control specialist, fit the process into a loop, termed the PDCA cycle (<u>P</u>lan, <u>D</u>o, <u>C</u>heck, <u>A</u>ction). The corrective reaction is the Plan, the implementation is the Do, the Check is confirming the results, and Action means "preventing recurrence and institutionalizing the improvement as a new practice to improve upon." At this point, the practice enters the loop again. We will discuss the Deming cycle more in Section IV.

Now that we know the methods and goals for Root Cause Analysis, let's discuss the techniques commonly used for Root Cause Analysis in more depth.

II. ROOT CAUSE ANALYSIS TECHNIQUES

Section II training objectives:

3. Recognize the potential for applying one or more of the following techniques when performing Root Cause Analysis:
   a) Kepner Tregoe
   b) Management Oversight and Risk Tree (MORT) system
   c) Events and Causal Factors charting
   d) Human Performance Evaluation System (HPES)
   e) Cause-and-Effect technique
   f) Root Cause Coding Flow Chart method

5. Describe the limitations of RCA techniques with regard to finding practical solutions.

Root Cause Analysis is nothing more than a series of questions; First, what happened?, when did it happen?, who caused it to happen?, and most importantly why did it happen? Unfortunately in some cases, while performing a root cause analysis, it appears that the only question asked is; who caused it to happen? Several techniques or tools may be used to find the answers to these questions. Systematic techniques seek to consistently solve these questions so the root causes of an event can be found.

All analysis techniques have only one goal; to determine the root causes of an event. Once these causes have been determined, corrective reactions are developed to prevent their recurrence. It is not significant which technique or tool is used to perform Root Cause Analysis. If performed properly, all methods should point to the same causes for any given event.

These methods or techniques, as well as those used at a specific plant, are systematic approaches for investigating an event or incident. As such, these methods are guidelines to determine the questions to ask, and identify when a root cause is achieved.

ROOT CAUSE ANALYSIS TECHNIQUES (cont.)

The root cause analysis tools commonly used are:

a) Kepner Tregoe
b) Management Oversight and Risk Tree (MORT) system
c) Events and Causal Factors charting
d) Human Performance Evaluation System (HPES)
e) Cause-and-Effect technique
f) Root Cause Coding Flow Chart method

This list is not all inclusive; other tools and/or methods can be developed to perform the same functions. As stated earlier, it doesn't matter which tool is used as long as the root causes of an event can be determined. In most cases, the methods that have been developed are derived from portions of the Kepner-Tregoe, MORT, Events and Causal Factors, or Cause-and-Effect techniques, or some combination of these.

KEPNER TREGOE TECHNIQUE

The Kepner Tregoe (KT) method is a systematic, logical, method of resolving concerns. This method, or a portion of this process, is used by almost everyone, even those who have never received formal training in it. The KT method labels, and arranges in a logical sequence, the normal thought processes commonly used when making a decision or solving a problem.

The KT method is divided into four, smaller processes. One process is called Situation Appraisal. This process sorts out complex or ill defined situations. With the situation properly sorted, and its associated concerns prioritized, you can determine which of the other three processes to enter; Decision Analysis, Potential Problem Analysis, or Problem Analysis.

Decision Analysis, as its name implies, is used when a decision must be made. This process shifts the focus from alternatives to the objectives which must be met by a decision. By carefully defining the objectives, a more carefully reasoned decision based on information and analysis can be made.

Potential Problem Analysis helps anticipate the difficulties that may arise when any decision or action plan is implemented. This process also helps determine if plans need to be developed which will protect the original decision or action plan, if the foreseen difficulties do occur.

As can be seen in the above paragraphs, the decision analysis and potential problem analysis processes relate to a root cause analysis when causes have been determined and a corrective reaction plan has been developed to prevent recurrence. The situation appraisal process can identify the events which require root cause analysis.

KEPNER TREGOE TECHNIQUE (cont.)

The fourth process of the KT method most closely relates to the actual performance of a root cause analysis. This process is called Problem Analysis (sometimes referred to as Change Analysis). Problem analysis is a systematic process for finding the cause of a deviation and is made up of three basic steps. The deviation, as regards to root cause analysis, is the event or incident which is to be analyzed.

The steps which make up the problem analysis process of the KT method are:

1. Describe the Problem

   The problem is described by clearly stating the deviation, or stating what _should_ have occurred and what _actually_ occurred.

   As an aid in clearly stating the deviation, information should be gathered to answer the following questions:

   a. What is the deviation(s)?
   b. Where is the deviation(s)?
   c. When did the deviation(s) occur?
   d. To what extent did the deviation(s) occur?

   With this information in place, the next step of clearly understanding the deviation is to develop an IS and IS NOT comparison chart. This chart should contain what, where, when, and to what extent the deviation(s) IS along with what, where, when, and to what extent the deviation(s) IS NOT.

2. List the Possible Causes

   This second basic step of the Problem Analysis process develops a list of possible causes for the specified deviation. This list is generated by listing the distinctions and/or changes that have occurred between the items of the IS and IS NOT lists. The causes of the distinctions or changes are then investigated.

KEPNER TREGOE TECHNIQUE (cont.)

3. Finding the True Cause(s)

   The last basic step of the Problem Analysis process is finding the true cause of the deviation. This step tests the list of possible causes for the most probable causes. This is done by comparing all of the possible causes with the observed specifics (the IS/IS NOT chart) of the deviation. If the cause could produce <u>all</u> of the same observed specifics, it can be classified as a probable cause.

   When all the probable causes have been determined, then the True Cause must be found and verified. This is done by further investigation, experimentation, observation, etc. of the most probable causes.

As shown, the KT technique for performing a root cause analysis does provide the basic benefits of a good analysis tool. This technique is a structured guideline to an investigator in determining the information needed, the questions to ask, and when to stop; i.e., when the root causes have been achieved.

The major drawback to this technique when performing root cause analysis or determining their corrective reactions is, as in any "thought" process, extensive training in the technique is required and constant practice in its use is necessary. Also, a significant amount of time, energy and resources may be required in the verification of the true causes of the event.

This method, however, does provide a good base for the development of a more specific analysis tool to find the root causes of reactor plant events.

CAUSE-AND-EFFECT TECHNIQUE

This technique in determining root cause depends on only two items; the definition of a root cause, and the question: "Why did this effect or event occur?". As such, this tool is very easy to use and is only limited to the knowledge and experience levels of the user.

The definition of a root cause is fundamentally important to the use of this technique. The definition used determines the criteria to be met by any root cause developed by this technique. For example; the root cause is defined as: **The most basic reasons for an event, which if corrected will prevent recurrence.** This definition tells us that a root cause must be correctable; if it isn't, it may be considered a cause but not a root cause; and the correction must also prevent event recurrence. It is implied that the correction must be within our control, and allow us to meet our other goals or objectives. Other criteria could also be derived from this definition, depending on where within the structure of the analysis it is used.

Using the CAUSE-AND-EFFECT technique is simply starting with the most significant event and determining the cause(s) of it. The cause(s) for this event's cause(s) are then determined, and this chain of events and causes is continued until no other causes can be determined. These causes are then verified by determining if the root cause criteria have been met. For example:

> The most significant event is a reactor trip from the reactor protection system (RPS). Therefore, why did the reactor trip from RPS? Answer: due to actuation of the RPS low water level switches. Why did the RPS low water level switches actuate? Answer: due to low reactor water level. Why was there a low reactor water level? , etc.

CAUSE-AND-EFFECT TECHNIQUE (cont.)

Causes are not always as straightforward as those in this example. In most cases, the causes found for each event depend on the investigator's experience and knowledge levels. Therefore, when using this method for determining root cause, it is strongly suggested that an expert team perform the analysis. This broadens the experience and knowledge used in conducting the investigation and determination.

As the causes are being determined for each event, it is also suggested that a corrective reaction or solution be prescribed for each cause. This gives the investigative team a benchmark for determining when the root cause has been reached. When a reasonable solution, which can be controlled or implemented by management, is reached then the associated cause may be called a valid root cause.

The primary drawback to this technique is the implied suggestion that only one solution can correct a root cause. It also lays a significant burden on the investigative team, in that a "reasonable" solution determined by them may not be an "acceptable" solution for management to implement. Extreme care needs to be taken to prevent "short cuts" or predetermined assumptions from occurring when performing this technique as well. As can be seen in the example, each event must be listed as a single item and only provable facts or qualified judgements are used for the associated causes.

An addendum to this technique strongly suggests that the investigative team provide at least two causes for each event/effect. This requirement ensures that all possible causes are considered for a single event and no "root causes" are overlooked.

EVENTS AND CAUSAL FACTORS CHARTING

This technique was originally developed by the National Transportation Safety Board (NTSB) as an analytical tool for accident investigation. This method creates a chart (or diagram) which depicts, in a logical sequence, the events and their causal factors that lead to an accident occurrence. With very little or no modification this method may be used for root cause analysis in a nuclear power plant.

This method can be used by itself as a mechanism for performing a root cause analysis, but is often used in conjunction with one or more of the cause coding tree methods discussed later in this section. In application, the events and causal factors flow charting begins in much the same manner as the cause-and-effect technique discussed earlier.

Starting with the most significant event, i.e. a reactor trip, a sequence of factual or observed events is built which lead to the most significant event. These events should be written to meet the following suggested criteria:

1. Each event should describe an occurrence or happening and not a condition, state, circumstance, issue, conclusion, or a result; i.e., "the pipe ruptured", not "the pipe had a crack in it".

2. Each event should be described by a short sentence with one subject and one action verb; i.e., "mechanic checked valve fastener tightness", not "mechanic checked valve fastener tightness and opened valve".

3. Each event should be precisely described; i.e., "operator placed pump switch to START", not "operator started the pump".

4. Each event should be quantified when possible; i.e., "reactor water level decreased by 36 inches", not "reactor water level decreased".

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EVENTS AND CAUSAL FACTORS CHARTING (cont.)

5. Each event should be derived directly from the event(s) and conditions preceding it; i.e., "operator placed pump switch to START" which then goes to "operator verified normal pump discharge pressure reading of 800 psig," then "operator placed discharge valve switch to OPEN" which goes to "discharge piping pressure increased to 800 psig" which leads to "the pipe ruptured" that goes to "reactor water level decreased by 36 inches",etc. Each event is derived logically from the one preceding it, if this is not the case, it usually indicates that one or more steps of the sequence have been left out.

These single events are then investigated to determine their cause, or "contributing factors". When all the events and their contributing factors leading to the incident have been determined, they are placed into their proper sequence to form a time line of the accident or incident.

This time line is then charted using the following suggested format:

1. Events should be enclosed in rectangle and connected together, in sequence, with solid arrows.

2. The sequence of events should be depicted in a straight horizontal line with the events arranged chronologically from left to right.

3. If there are any secondary events, or event sequences, these should also be connected to the primary sequence of events in their chronological order.

4. Contributing conditions and factors should be enclosed in ovals and connected with each another or with their associated events by dashed lines or arrows.

The events and their contributing factors should track in a logical progression from beginning to end of the incident/accident sequence.

EVENTS AND CAUSAL FACTORS CHARTING (cont.)

The contributing factors are then evaluated, one at a time, to determine which factors, if prevented, would have prevented or significantly mitigated the incident. These contributing factors are called "causal factors". The causal factors are annotated on the chart by small triangles. If contributing factors (or causal factors) of an event are developed further, they will lead to the root causes of the incident.

The main drawback to this system in determining root causes, and the associated corrective reactions is that no specific guidance is given on how much further to develop the causal factors found above.

As stated earlier, this method is usually used in conjunction with one of the cause coding tree techniques. In this respect, the causal factors are used as the starting point for coding. Each causal factor is coded to the lowest possible level for which there are answers in the appropriate tree. At that point the root causes have been determined.

Using Events and Causal Factors charting has three benefits. It meets the objectives of incident investigation by determining what happened and why it happened, to prevent the same or similar occurrences in the future. It helps conduct the investigation by showing the need for in-depth analysis, illustrating multiple causes and the chronology of events, and visually portraying the interactions and relationships of all involved individuals and organizations. It aids in writing the investigation report by checking investigative logic completeness, identifying matters requiring further investigation, and differentiating between the analysis of the facts and the resultant conclusions.

These benefits result when the following seven key elements are met when applying this technique.

EVENTS AND CAUSAL FACTORS CHARTING (cont.)

1. Begin the technique as soon as accumulating factual information about the incident is started.

2. Use the suggested guidelines as a method for getting started and for staying on track with the investigation.

3. Proceed logically using all available data.

4. Use an easily updated chart, as additional facts and conditions are continually discovered during the investigation.

5. Validate the results of this method with other investigative tools.

6. Select the appropriate level of detail to investigate, if not already suggested by the investigation appointment authority.

7. Condense the Events and Causal Factors chart into a short executive summary chart whenever it is necessary to refer to a concise and easy-to-follow version of the incident sequence.

MANAGEMENT OVERSIGHT AND RISK TREE (MORT) SYSTEM

The management oversight and risk tree (MORT) system is an event oriented, working tool which can perform two functions. The MORT system can determine the root causes of an accident or incident that has occurred, and to evaluate an existing safety program to determine the likelihood that a significant accident is about to occur.

In order to perform these functions the MORT system incorporates four basic key features:

1. An analytical "logic tree" or diagram which arranges safety program elements in an orderly, coherent, and logical manner.

2. A schematic representation of an "ideal" safety system model by using Fault Tree Analysis methodology.

3. A methodology for analyzing a specific safety program.

4. A collection of philosophical statements and general advice relative to the application of the MORT system safety concepts and a listed criteria which can be used to measure the effectiveness of their application.

As we are only concerned with Root Cause Analysis, only the use of the MORT system as it pertains to analyzing accidents and incidents will be addressed. It should be noted however, that this system is also an effective management tool in evaluating and developing specific safety programs within the industry.

As stated earlier, the MORT system supplies a "logic" tree which allows for determining, using a visual display, the root cause(s) of an accident or incident. This tree uses some standard "logic" symbols within its body to control the investigator's path as he works through the tree to determine the cause(s) of the accident. These symbols are:

MANAGEMENT OVERSIGHT AND RISK TREE (MORT) SYSTEM (cont.)

1.	Rectangle	This symbol encloses an event. Either the first event or those events resulting from the combination of more basic events acting through logic gates.
2.	AND Gate Symbol	Use of this symbol indicates that all of the input values (normally found at the bottom of the symbol) must be present in order to lead to the output (condition or event).
3.	OR Gate Symbol	Use of this symbol indicates that only one of the input values (normally found at the bottom of the symbol) must be present in order to lead to the output (condition or event).
4.	Oval	This symbol encloses a condition or constraint that is connected to either an event block or to one of the gate symbols. When connected to a gate symbol, the stated condition or constraint will specify how and when the gate will function.
5.	Risk Symbol	Indicates that the investigator should transfer to the "Assumed Risk" branch of the tree. It is used for problems with no known or practical countermeasures.
6.	Triangle	This symbol indicates a connection or transfer from one branch of the tree to another. The "transfer out" symbol (triangle with a line connected to one of its legs) normally contains a number or code which transfers the investigator to another branch via a "transfer in" symbol (triangle with a line connected to one of its points) containing the same number or code.

MANAGEMENT OVERSIGHT AND RISK TREE (MORT) SYSTEM (cont.)

7.	Circle	This symbol encloses an event described by a basic component or part failure. This event is independent of other events within the tree.
8.	Diamond	This symbol encloses an event that has not been developed to its cause. The sequence is usually terminated for a lack of information or lack of consequences from the event.
9.	Scroll	This symbol encloses an event that is normally expected to occur.
10.	Stretched Circle	Encloses an event that is satisfactory. This is normally used to show the completion of a logical analysis.

The MORT diagram is entered at its TREE TOP with the event box, marked with a T, which specifies the losses that occurred. Since the diagram can also be used as an evaluation tool, a second event box, connected by dashed lines, for future undesired events may be used to enter the tree.

Following entry into the tree, the first decision point is reached (as indicated by an OR logic gate). Was the loss that was incurred the result of an Oversight and/or Omission or was it an assumed risk? All events are considered to be an Oversight and/or Omission unless the investigator has been specifically informed by upper management that it was an assumed risk. Following the oversight and omission event box the logic tree, the investigator is directed into two branches by an AND logic gate. One branch specifically addresses the management factors associated with the accident or incident. The other branch addresses the specific control factors, human and mechanical, that were involved.

MANAGEMENT OVERSIGHT AND RISK TREE (MORT) SYSTEM (cont.)

Following the specific controls (S) branch leads the investigator to the event box labeled "accident". From the accident event box the main body of the MORT chart is entered. The investigator works downward, through the tree, following each connecting branch until the questions posed by the circled statements of the chart are answered either "yes" or "no". At this point the analysis ends.

As can be seen from the description above the MORT system provides all of the benefits of using a logical, visual, and analytical method for performing root cause analysis. The primary drawbacks with this system, and developing the resulting corrective reactions, is the time it takes to learn and to use the system. The MORT tree is extremely large, due to the number of items it encompasses, and difficult to use for specific accident or incident evaluations.

The advantages of using the MORT tree, however, are apparent. This system ensures that each cause is considered and provides a good visual di play of the path of the investigation. Because of these significant advantages the MORT system has been used as a model for other "tree" type root cause charting techniques.

HUMAN PERFORMANCE EVALUATION SYSTEM (HPES)

Following the accident at Three Mile Island Unit 2, industry wide screening and analysis of plant events intensified. The results of these analyses revealed the frequent presence of human error. Human error, due to today's complex technology and organizational structures, can be caused by many external factors. The objective of the human performance evaluation system (HPES) is to improve overall plant operations by reducing human error through correcting the conditions which cause these errors.

This technique in determining root causes evaluates the human performance during an accident or incident in a reactor plant. The technique uses three basic analyses to determine the root causes of an event. These analyses are performed in conjunction with filling out established forms which direct the investigator to the appropriate information required to complete these analyses. These analyses are:

1. Situational Analysis

   This analysis determines when, where, and what event happened, as well as the job category, experience level, work schedule, and the general task(s) that plant individuals were working when the event occurred.

HUMAN PERFORMANCE EVALUATION SYSTEM (HPES) (cont.)

2. Causal Factor Analysis

This analysis determines the causal factors, with regards to human factors, that effected the event. The causal factors are found by grading the appropriate elements on charts which cover the following categories:

a. Communications (both written and verbal)
b. Interface design or equipment condition
c. Environmental conditions
d. Work schedule and practices
e. Work organization and/or planning
f. Supervisory methods
g. Training and/or qualification methods and content
h. Change management
i. Resource management
j. Managerial methods

3. Behavioral Factor Analysis

This analysis tells how the event happened by grading a series of causes within the following categories:

a. The type of inappropriate action that occurred.
b. The behavioral function in which the inappropriate action occurred.
c. The internal factors affecting the ability to order/direct, sense, interpret, or to act.
d. The external factors affecting the ability to order/direct, sense, interpret, or to act.
e. The behavioral shaping factors (causal categories) that led to the inappropriate actions.

HUMAN PERFORMANCE EVALUATION SYSTEM (HPES) (cont.)

This program augments and supports line management's function of managing human performance and carries the bonus of strengthening the plant team relationship. The nonpunitive reporting climate, fostered by this program, leads to more error reporting and frequently to the correction of underlying causes prior to an actual event. The utility also benefits through an increase in employee job satisfaction, resulting from fewer task errors and from employee participation in solving identified problems.

The major drawback to this system, and its resulting corrective reactions, is that the system primarily deals with root causes in a human factors methodology. Other causes could be easily overlooked if they do not fit with the "human performance" framework.

ROOT CAUSE CODING FLOW CHART TECHNIQUE

This method combines two previous techniques, the events and causal factors flowcharting and an abbreviated MORT chart. The method was devised by the BWR Owner's Group for consistency in reporting and storing root causes reactor events. Consistency in charting among the Owner's Group utilities will allow for easier understanding of the root causes and their corrective reactions to other members of the Group.

This technique starts with determining the causal factors of an event using the events and causal factors charting method, discussed earlier. When the event's causal factors have been determined, each factor is coded through the B Owner's Group cause coding chart. This chart is similar to the MORT tree, discussed earlier.

The MORT tree has been abbreviated and adjusted to correspond to the specific concerns of a BWR plant. such, the cause coding tree starts with a causal factor. From this starting point three major categories may be entered; Equipment Malfunction, Personnel Miscue, and/or Act of Nature/Man. The major categories are further divided into subcategories.

1. Act of Nature/Man contain;

    a. Acts of Nature which includes

        - Lightning
        - Flood
        - Tornado/Wind
        - Hurricane
        - Icing
        - Aquatic Life
        - Seismic

ROOT CAUSE CODING FLOW CHART TECHNIQUE (cont.)

1. Act of Nature/Man contain (cont.);

   b. Man-made Cause which includes:

      - Electrical Grid Failure
      - Crash of an Airplane
      - Sabotage
      - Vandalism

2. Personnel Miscue contain;

   a. Operations

   b. Technical Support

   c. Maintenance

   These subcategories each contain the same eight components which are:

   - Procedures
   - Communications
   - Training
   - Human Factors
   - Management System
   - Immediate Supervision
   - Quality Assurance (QA,
   - Personnel

   A note is attached to the personnel section of these subcateb .ies which directs that this section of the chart should only be used if no other cause can be found. This is an effort to prevent the investigator from taking the "easy" way out of performing his evaluation.

ROOT CAUSE CODING FLOW CHART TECHNIQUE (cont.)

3. Equ pment Malfunction contains:

   a. Operation

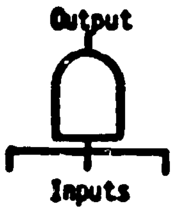
   b. Maintenance

   c. Equipment Reliability and/or Design

   d. Construction and/or Fabrication Modification

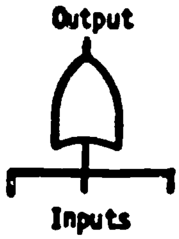
   These subcategories are also further divided into sections.

Each section within a subcategory is further divided until the root cause level for that subcategory is reached. When using this chart, each causal factor of an event is coded to the lowest possible level in the tree and then the next causal factor is coded. Sometimes it will not be possible to code a factor all the way down to the root cause level of the tree. In that case, the coding should stop at the lowest level of the tree for which the questions can be answered. At other times a causal factor may result in two or more root causes being coded from the tree. This result is satisfactory since, in most cases, there probably are more than one root cause that needs to be established.



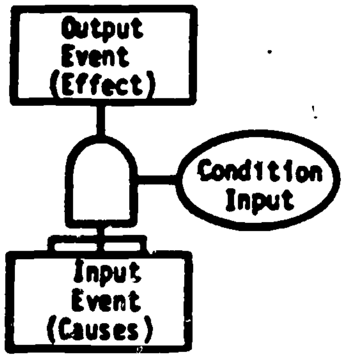
AND-Gate Symbol

Coexistence of all inputs required to produce output.



OR-Gate Symbol (Nonexclusive)

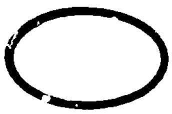
Output will exist if at least one input is present.



CONDITIONAL AND-Gate Symbol (Can also be OR)

Input pruduces output provided conditional input is satisfied. Description of condition is written in the oval.

(Sometimes called a CONSTRAINED-Gate or an INHIBIT-Gate.)



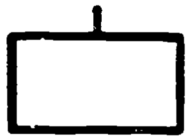
CONSTRAINT Symbol

Applies conditions or constraints to basic logic gate or output event. When applied to basic AND-gate or OR-gate, creates special conditional gate such as Inhibit, Priority And, Exclusive Or, etc.

RISK Symbol

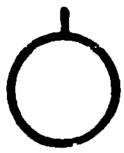
Indicates transfer to "Assumed Risk" branch of tree. Used for problems with no known or practical countermeasure.

Figure 3. MORT Logic Symbols



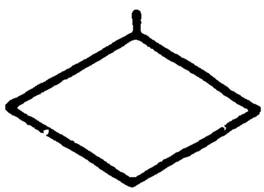
RECTANGLE

An event resulting from the combination of more basic events acting through logic gates.



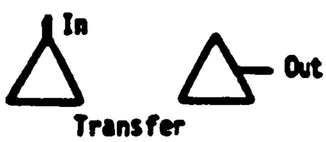
CIRCLE

An event described by a basic component or part failure. The event is independent of other events.



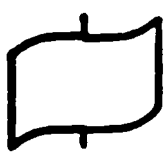
DIAMOND

An event not developed to its cause. Sequence is terminated for lack of information or lack of consequences.



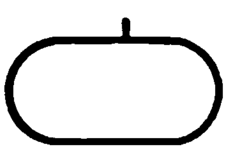
TRIANGLE

A connecting or transfer symbol. All tree construction below the "out" triangle is transferred in at "in" triangle location(s).



SCROLL

An event that is normally expected to occur.



STRETCHED CIRCLE

An event that is satisfactory. Used to show completion of logical analysis.

Figure 4. MORT Event Symbols

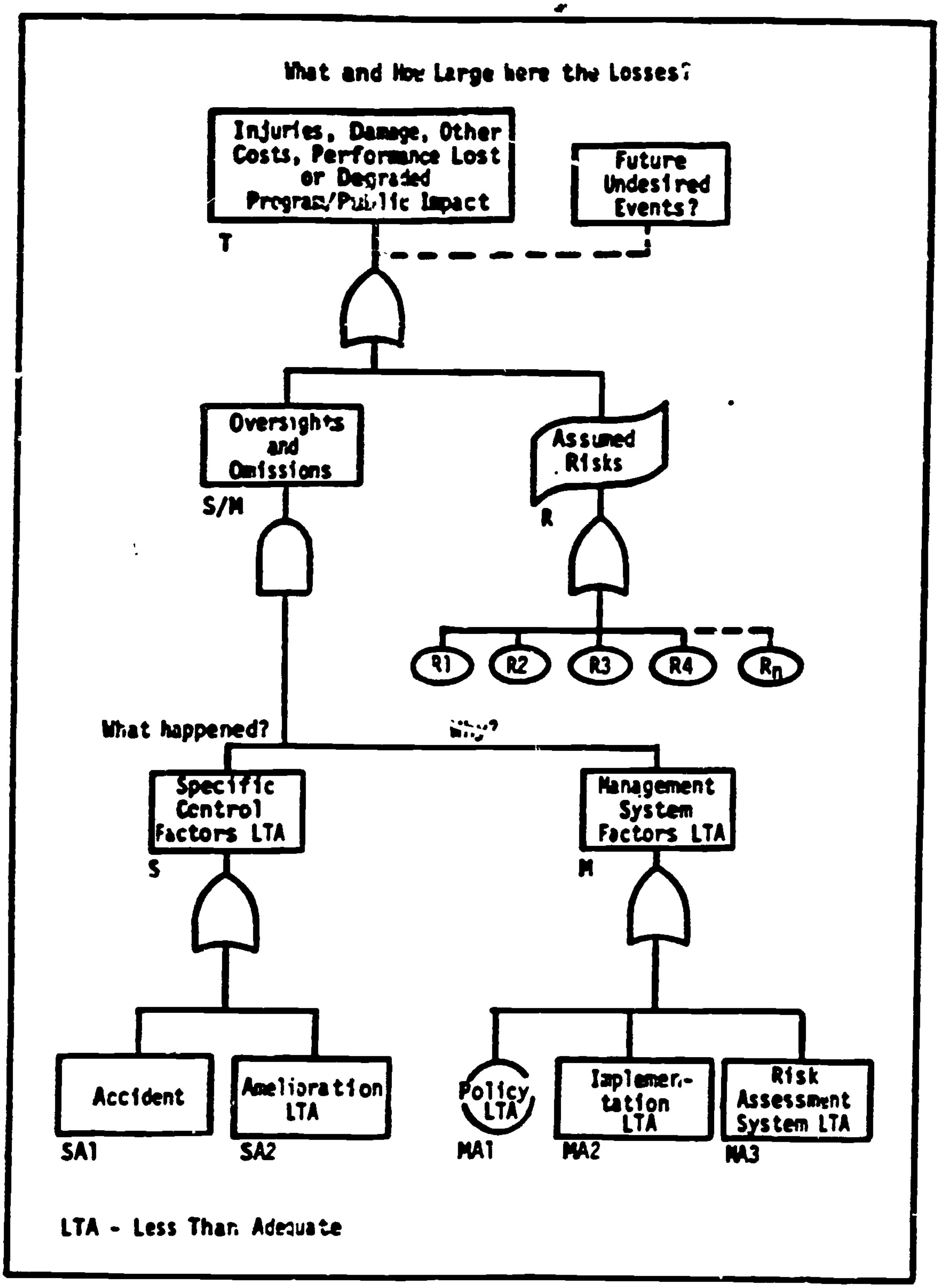


Figure 5. MORT TOP Events

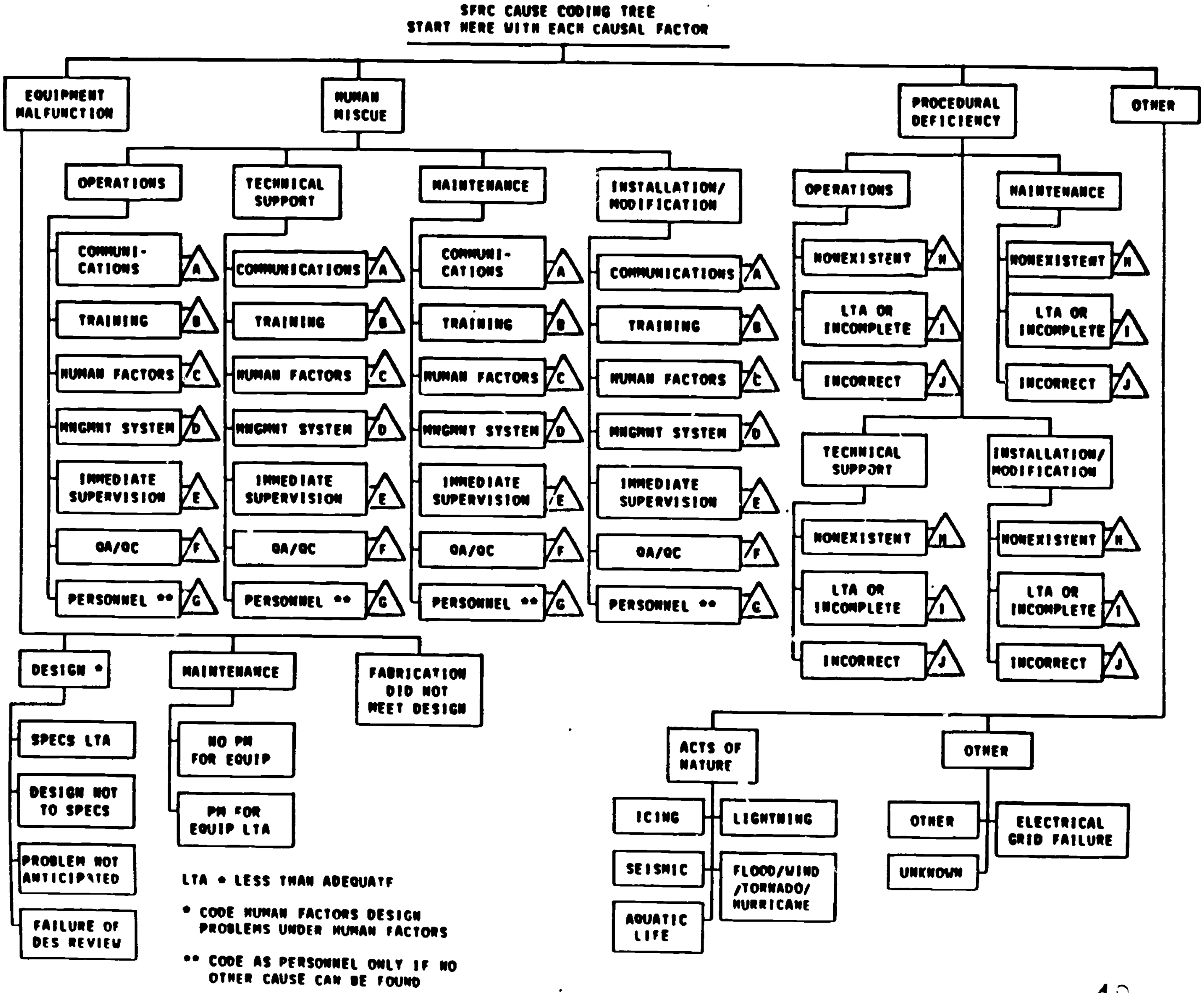


Figure 6. Cause Coding Tree

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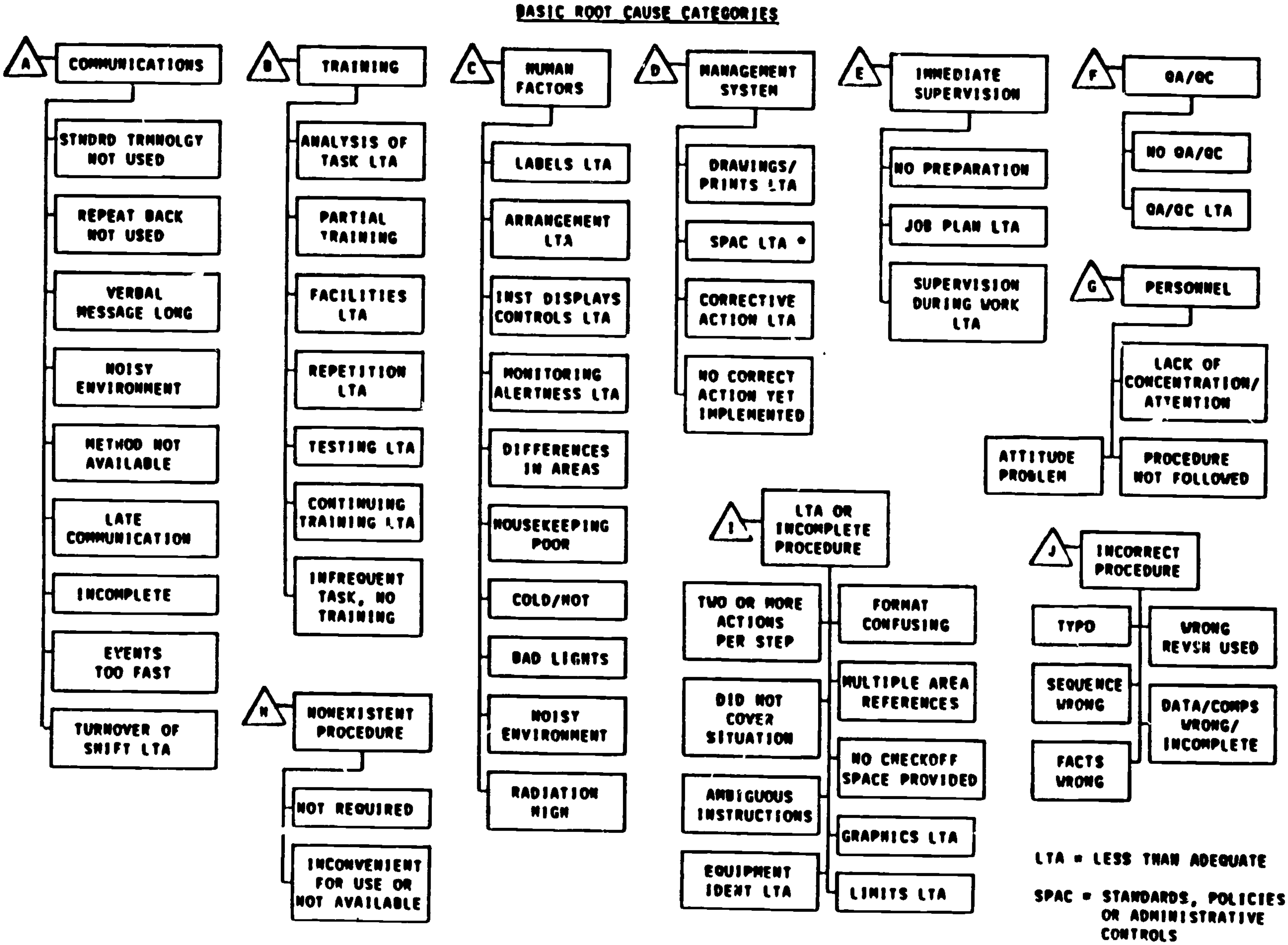

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Figure ~~7~~6. Cause Coding Tree (Continued)

III. ROOT CAUSE ANALYSIS SCENARIO EXERCISE

Section III training objective:

8. Demonstrate RCA techniques on sample events using the Basic Root Cause methodology.

Two short scenarios are provided to introduce application of RCA techniques and the Root Cause Coding Flow Chart.

The scenarios were chosen to keep detailed plant specific information at a minimum. Plant specific information, when used, is explained.

The material in this section should be supplemented with previously analyzed events which occurred at your plant.

Section IV. ROOT CAUSE ANALYSIS OVERVIEW AND SUMMARY

Section IV training objectives:

7. Evaluate the Outcome of a Root Cause Analysis process for completeness, accuracy, and consistency with common-sense expectations.

The earlier sections of this text describe the definitions, techniques, strengths and weaknesses, and outcome of Root Cause Analysis, and exercised a technique. In this section we will define some parameters to measure the outcome, and discuss the potential future benefits of Root Cause Analysis.

Measuring the RCA Process:
The Outcome vs. the Expectation

As stated earlier, the real objective of the Root Cause Analysis (RCA) process is: to improve plant performance by corrective reactions based on accurate root causes. We can derive the parameters to evaluate Root Cause Analysis outcome from this objective; accurate root cause, corrective reactions, and improved plant performance.

ACCURATE ROOT CAUSE

Jun 87.

Specific measurements within "accurate root cause" might be ALL root causes, the right root cause, and something the Japanese call warusa-kagen.

Finding ALL root causes might seem to be an unachievable goal, but it is not unreasonable. A valid reason for attempting to find ALL root causes is to not succeed. Any investigator who believes ALL root causes are found has stopped short. If we define a problem as an opportunity for improvement, we can state in the inverse that where there is room for improvement there are problems, and therefore are root causes. A plant that finds ALL root causes has no room for improvement.

The right root cause is similarly difficult to measure. Perhaps the proof is in the alternative; DON"T find the wrong cause! It is well documented that finding the wrong root cause can be more damaging than not finding the right cause. When ALL the root causes are found, ensure that the subset of right root causes is complete. Challenge every root cause to break it down into its most basic components. Check to ensure a root cause can, and did, cause the event. Ensure the root cause, in isolation, can cause the event. It may be a contributing factor without being a root cause.

Finally, root cause accuracy should address the concept of warusa-kagen. This is a Japanese term that refers to things that are not really problems but are somehow not quite right. If warusa-kagen are not fixed, they may develop into serious trouble and cause substantial damage. In the context of Root Cause Analysis, warusa-kagen may comprise facts discovered during the RCA which are not root causes, maybe not even contributing factors, but which are things that are not quite right. A component of accurately determining root cause should include documenting these things. It helps us meet the objective of RCA.

CORRECTIVE REACTIONS

New pg.

Ideal corrective reactions have several descriptors: prevent recurrence; don't cause other events; within our control; allow other objectives to be accomplished.

Preventing recurrence of the subject event is a major reason for Root Cause Analysis and Root Cause Coding. Although this usually means preventing the same event at the same station/plant, it may be preferable to expand the scope, perhaps to all plants at the same station, all similar plants owned by the same utility, all plants in that model line (e.g., BWR/6), all the plants supplied by that NSSS vendor, etc. Whatever scope is chosen for measurement, the temptation to reduce the scope should be avoided, and when scope is expanded that action should be rewarded.

Avoid scopes such as preventing recurrence of all scrams from Scram Discharge Volume instrument rack shaking resulting from contractor drilling for modification equipment installation that occur during the summer peak loads. An exaggeration, to be sure, but it demonstrates the logic of expanding the recurrence prevention scope. A more useful example of corrective reaction might be to prevent recurrence of scrams caused by contractor modification drilling by only doing such work in sensitive areas during outages, disarming sensitive instruments in the area (if allowed by specifications, of course), or finding a non-disruptive method of performing modification.

Events caused by the corrective reaction to another event are something we try to avoid, and is mentioned only to remind us of the possibility. Corrective reactions should be active in recurrence prevention, and passive for another event as both a root cause or as a contributing factor.

A plant must meet objectives to be economically feasible. The corrective reactions must prioritized according to the corporate objectives and policies. In the best of times, not many root cause derived corrective reactions have to wait for a significant geological-theological event, like hell freezing over, to be implemented, but there are realistic limits on the corrective reactions, such as the ability to make plant modifications during a particular condition of the plant. The cost of implementing corrective reactions is also a concern, but caution should be paid to saving a dollar this quarter, only to pay ten dollars for replacement power next quarter. Shortsightedness costs, in event recurrence. Reality says personnel promotion is largely based on quarterly cost control, yet Operations and Maintenance costs continue to rise steadily. Does long-term plant performance deserve as much attention as short-term cost control? Absolutely.

Jean-Paul Bemer of Electricitė de France said "An accurate determination of the root cause of a failure will allow the utility to consider different corrective (re)actions corresponding to different technical solutions." The implied message is that, as mentioned earlier, management reserves the right to manage and make those decisions. Unless the root cause analysis methods are thorough in finding all the root causes, the management decision is based on incomplete information. No one wants their manager to make decisions that could affect long-term financial health of their company based on incomplete information.

IMPROVED PLANT PERFORMANCE

Plant performance improvements can be measured in several ways, all of which have merit. Some of the more common performance measures are less Licensee Event Reports, more availability, and, of course, less scrams.

Licensee Event Reports may actually increase as a result of the implementation of Root Cause Analysis programs INITIALLY. When increasing the awareness and participation of plant personnel in the process of determining root causes, implementing corrective reactions and monitoring the performance of the plant related to that cause and event, the number of reportable events may rise just due to more things being noticed. However, as corrective reactions are implemented and monitored, the events should decrease. If not, the effectiveness of the RCA process should be reexamined.

Availability of the plant to generate electrical power is near and dear to plant management's heart, as it should be. Availability is easily measured (although there seems to be several "standard" methods to calculate it by), and is highly visible. Corrective reactions must be weighed against the effect on availability, and again the caution against the short-term effect is valid.

Reducing the number of scrams is the goal of this course's sponsor. The BWR Owner's Group Scram Frequency Reduction Committee efforts in achieving specific goals related to the number of scrams are manifold. The NUMARC goals are specific targets and the Japanese plants are often referred to as models.

In his discussion of Root Cause Analysis at the BWROG SFRC meeting, Dean Gano of WPPSS mentions the Japanese power plant statistics for scram frequency. "First of all, they've only had 97 scrams in their entire history of power operation of nuclear power plants ... ninety-seven, that's all they've ever had. Also, personnel error, where an individual made a mistake, only happened every two or three years. So, there's something there. I don't know what it is. It may be cultural."

Mark Paradies recalls the philosophy of Japanese plant management from a speech delivered at a previous meeting; "The Japanese plant philosophy on how to prevent scrams ... and it was, you beat it to death. You didn't start that plant up again until you addressed what I would call the root causes, AND YOU FIXED THEM. If it took thirty days, it took thirty days. You didn't start back up again until you had it fixed, because you weren't going to have that next scram happen again, ever, period." Mark went on to relate how vendor representatives, kept on call 24 hours a day, were called immediately to find out why that plant scrammed and get it fixed, because they weren't going to start that plant up until it was fixed.

Mr. Zenzaburo Katayama, the assistant manager at Toyota Motor's Total Quality Control Department, gave an example of the "culture" relating to plant shutdown.

> "At Toyota, we stop the entire line when we find a defective part. Since all plant operations are coordinated, it means that when one plant stops, the effect ripples back to the previous process, and eventually the Kamigo plant, which manufactures engines, stops too. If the stoppage is prolonged, all the plants have to stop operation.
>
> Stopping the plant is a serious blow to management. And yet, we dare to stop it because we believe in quality control. Once we have taken the trouble of stopping the plant operation, we have to make sure that we find the cause of the trouble and adopt a countermeasure so that the trouble never recurs."

The cultural difference Dean Gano referred to deserves further consideration. One cultural difference is the Japanese attitude toward constant improvement. This process of continual incremental improvement is something the Japanese call _kaizen_. In his book, _KAIZEN - The Key to Japan's Competitive Success_, Masaaki Imai says, "The essence of KAIZEN is simple and straightforward:KAIZEN means improvement. Moreover, KAIZEN means ongoing improvement involving everyone, including both managers and workers. The KAIZEN philosophy assumes that our way of life - be it our working life, our social life, or our home life - deserves to be constantly improved." Let's see how Root Cause Analysis' objectives can be satisfied more efficiently with KAIZEN principles.

KAIZEN

Key to Future Root Cause Analysis?

One more time; what is the goal of Root Cause Analysis? to improve plant performance by corrective reactions based on accurate root causes. RCA is just one effort to improve plant performance. Some of the difficulties and shortcomings of Root Cause Analysis have been briefly mentioned earlier in the text. Let's examine how RCA can be improved, with KAIZEN in mind, which logically should result in improved plant performance by improving the process.

Dean Gano emphasizes the importance of the knowledge level of the expert team performing the investigation. The facts gathered in their RCA efforts need interpretation, the expert members' role. However, this merely touches on the potential application. The facts gathered by the personnel involved in the incident overwhelm the facts gathered by mechanical or electronic means. The message is simple; get everyone involved. Remember, KAIZEN is ongoing improvement involving everyone. Any effort by an expert team dwindles in comparison to a team effort by the personnel involved in the actual event. Even the interviewer concept is weakened by the time required to establish the kind of trust necessary for openness and honesty. The team, working together, should be able to reconstruct the event efficiently, as they will counter and question and prompt each other during the process. Have the participants in the event participate in the RCA process.

A question worth exploring now is, Why don't people participate now? There is probably not an RCA investigator anywhere who has a "KEEP OUT" sign posted on his/her door. Why doesn't anyone come in, except by mandate? It might be because no one asked, or because nothing has ever been done about suggestions (or problems pointed out) before, or because the result favored for openness and honesty is punishment, either direct or indirect. This is not a question to be answered by anyone other than the plant staff.

However, it is a question that must be answered to make any form of RCA effective. Another quote from M. Imai may hold a key: "I would suggest that information rots ... Information that is collected but not properly used rots rapidly. Any manager who does not forward the information to the interested parties, and any management that does not have a system to use information, is doing a great disservice to the company and creating massive waste in the form of lost opportunities and wasted executive time."

Another reason for non participation is the lack of participation in forming the corrective reaction, and the resulting lack of ownership, to the extreme of taking delight in failure of non-owned reaction. "The permanent approach (to Group-Oriented KAIZEN) ... calls for the full PDCA cycle (Plan, Do, Check, Action) and demands that team members not only identify problem areas but also identify the causes, analyze them, implement and test new countermeasures, and establish new standards and/or procedures." Dean Gano touched on this subject at his presentation at the BWROG SFRC meeting, saying that since they started getting the operation personnel involved in the root cause analysis <u>and</u> the solution, there are a lot less complaints about the "stupid" causes and solutions found when only the non-operations staff was involved.

Last, but not least, when the KAIZEN concept of <u>warusa-kagen</u> becomes part of the Root Cause Analysis process, not only are the actions reactive, they are preventive. When preventative actions outnumber corrective reactions, Root Cause Analysis will have accomplished its full potential.

APPENDIX A

ABSTRACTS OF DOCUMENTS FOR

ROOT CAUSE ANALYSIS

Abstract for: **APPENDIX B, TRIP INVESTIGATION/ROOT CAUSE DETERMINATION PROGRAM** written by/for the Babcock & Wilcox Owners Group

This document describes the benefits, and contains the overall guidelines to the Babcock & Wilcox (B&W) Owners Group utilities, for establishing a thorough event investigation and root cause determination program. These guidelines suggest the amount and type of on-site and off-site resources which the utilities should use, when developing and implementing this type of program.

The document also suggests the conditions under which this program should be activated, as well as, the tools, techniques and the analysis processes the program should contain. These program elements will allow the utilities to identify the causal factors of reactor trips, plant transients, and other performance anomalies. Once the causal factors are identified, recommendations for effective corrective action can be made and prioritized to most effectively prevent the recurrence of these events.

TAKE AWAY ITEMS:

o Guidelines provide specific program elements for identifying causal factors.

o Identifying causal factors allows:
  - effective corrective actions to be recommended
  - prioritizing these corrective actions

o Dedicated team of investigators, outside normal organization is recommended to provide:
  - reliability
  - accountability
  - objectivity
  - broad spectrum of plant operating expertise
  - peer review and consultation features

- o Develop plan for supplementing utility's investigation with outside resources.
  - Using transient categories defined in Transient Assessment Program Description, assistance can be given to determine causal factors or the more serious events.

- o Minimum conditions a root cause investigation should be actuated are:
  - an unplanned reactor trip
  - planned trips where expected post-trip response doesn't occur
  - safety system actuations per INPO performance indicators
  - equipment malfunctions which degrade or prevent control of the basic control functions or result in an unexpected transient.

- o Develop a procedure to provide a written guide that contains the following process elements.
  - Obtain factual information relevant to the event from sources which should include (but are not limited to):
    * Personnel Interviews
    * Recorded Instrument Data
    * Computer Alarm Printouts
    * Procedures
    * Logs
    * Transient Monitor Data
    * Completed Work Requests
    * Previous Event Reports
    * Interoffice Correspondence
    * NPRDS and other data bases
  - Clearly reconstruct the event
  - Using a structured analytical tool identify:
    * the less obvious causal factors
    * the conditions
    * all pertinent events/actions
  - Classify entire event categorize significant causal factors
    * allows for effective data base entry

- Develop a procedure to provide a written guide that contains the following process elements. (Continued)
  - Document any corrective actions needed to prevent recurrence of the event.
  - Generic issues should be communicated to other B&W utilities.

- Management Oversight and Risk Tree (MORT) and Event and Causal Factor Charting are recommended for use.
  - are supported by training and implementation materials from outside sources and are used and supported by INPO.

- MORT has two meanings pertinent to the B&W program:
  - Total safety program concept focused on <u>programmatic</u> control of industrial safety hazards.
  - An actual logic diagram which displays the structural set of interrelated safety program elements and concepts.

- As a safety management system, MORT was designed to:
  - Prevent safety-related oversights, errors, and omissions
  - Identify, assess, and refer residual risks to proper management levels for appropriate actions.
  - Optimize allocation of resources to the safety program.

- MORT encompasses several specific tools and techniques, two have been selected for implementation, Event and Causal Factor Charting and MORT Tree Analysis.

- Change analysis in MORT, incorporates concepts of Kepner-Tregoe method so it isn't used.

- Other tools and techniques may be adopted at a later date.

Abstract for: **SAVANNAH RIVER EXPERIENCE USING A CAUSE CODING TREE TO IDENTIFY THE ROOT CAUSE OF AN INCIDENT** written by Mark Paradies and David Busch in October, 1986.

This document describes the Cause Coding Tree developed at the Savannah River Plant by their Reactor Safety Evaluation Division. This Cause Coding Tree was developed to systematically evaluate incidents at the Savannah River Plant, identify their root causes, record these root causes, and analyze the trends of these causes. By providing a systematic method to identify correctable root causes, the system helps the incident investigator to ask the right questions during the investigation. It also provides the independent safety analysis group and management with statistics that indicate existing and developing trouble spots.

A description of the Savannah River Plant Cause Coding Tree is included in the article, as well as, some discussion of the differences, and the reasons for these differences, between it and the systems it was drawn from.

TAKE AWAY ITEMS

- o New system was created from the best parts of:
  - INPO's Human Performance Evaluation System's (HPES's) root cause analysis
  - INPO's Significant Event Report root cause identification system
  - EG&G's Management Oversight and Risk Tree (MORT) system for root cause identification
  - Methods used at Savannah River Plant to identify incident causes
  - Events and Causal Factors Charting

- o Root Cause defined as: The most basic cause that can reasonably be identified and that management has control to fix.

- o When enough questions are asked it becomes easy to specify corrective actions to fix <u>system</u> problems.

- The criteria used to develop the Savannah River Plant Cause Coding Tree was developed considering the plants needs and included:
  - Make system usable with current incident investigation system.
  - Make system point to the root cause of incident or as close as possible.
  - Make system provided statistics answer the questions Savannah River Plant wants to answer now, but flexible so that if different questions arise in future, system will be able to provide statistics to answer them.
  - Make system easy for the beginner to use.

- Three methods used to make use of varied backgrounds but still arrive at a standardized coding.
  - Require a "Events and Causal Factors Chart" for each incident.
    * Helps to logically analyze incident
    * Determine if facts of incident have been uncovered
    * Relate corrective actions to causal factors
  - Hold group peer reviews of coding of each event.
    * Incorporates various expertise of personnel
    * Causes are recorded after group reaches consensus on the cause(s).
  - Developed list of "repeat failures" to standardize this coding part.

Abstract for: **USING ROOT CAUSE ANALYSIS OF OPERATING EXPERIENCE TO IMPROVE MANAGEMENT'S PERFORMANCE** written by Mark Paradies and David Busch

One of the most important factors in the operation of the plant, the plant's management, is often left with very little feedback on their own performance. This paper shows a technique to provide management feedback on their performance. The technique, developed to help improve the safety performance of the reactors at Savannah River Plant, involves the use of Events and Causal Factors Charting in combination with a Root Cause Coding Tree to analyze plant incidents. This analysis provides data that can be used to identify developing problem areas and correct the root causes so that similar incidents can be avoided in the future. The advantages observed at Savannah River Plant since implementing this system are also provided.

TAKE AWAY ITEMS

- Accurate feedback on management performance is critical to good, safe system operation.

- Describes a system for analyzing the root cause of incidents
  - Two techniques are combined to identify all root causes.
    - * Events and Causal Factors Charting is used to determine causal factors that were contributory causes to the incident.
    - * Contributory causes are analyzed with Root Cause Coding Tree to identify the root causes of the incident.

- Two main ways of using the data from this analysis process:
  - Design measures that will prevent the recurrence of a specific incident.
  - Look for trends in the root causes over a period of time
    - * Used to go from a specific problem identified in a particular incident to generic (system) problems.
    - * Can predict growing problem areas which require correction before any more specific problems occur.

- o Operating experience can provide management performance feedback by:
  - Provides a Basic Root Cause Category that deals with three main functions of management.
    * Setting standards and policies, and developing administrative controls to prevent incidents.
    * Auditing the use of standards and controls and ensuring that the standards are applied.
    * Taking timely, effective corrective action to fix discrepancies.
  - By reviewing trends, management can see where more resources are required to improve the plant's performance.

- o Benefits derived from system implementation at Savannah River Plant:
  - Provided data that confirmed beliefs previously not supported by hard facts.
    * Problems easier to recognize and address.
  - Started a trend away from placing blame on those involved and toward finding corrective actions that prevent recurrence.
    * Increased trust and cooperation between managers and operators.
  - Provides investigators with a systematic investigation methodology.
    * Aids in determining the types of questions to ask.
    * Graphically shows when a root cause is achieved.
  - Corrective actions to identified problems easier to see.
    * Higher percentages of actions adopted because they appear obvious.
  - Provides another method for management to measure its performance.
    * Goals can be set and monitored.
    * Performance trended from year to year.
    * Isolated areas of improvement can be identified.

Abstract for: **USER'S GUIDE FOR REACTOR INCIDENT ROOT CAUSE CODING TREE** written by Mark Paradies and David Busch in December, 198_

The Reactor Incident Cause Coding Tree is designed to allow identification of root causes of reactor incidents at the Savannah River Plant, thereby leading to trending of useful information and the development of corrective actions to prevent their recurrence. This document defines the terminology of the Reactor Incident Cause Coding Tree at the Savannah River Plant and explains how to use this tree in a step-by-step manner.

TAKE AWAY ITEMS

- Guide allows consistency of coding among all incident investigators.

- First, find all causal factors for which root causes need to be determined.
  - Causal factors are actions or failures that, if eliminated, would have prevented the incident from occurring or significantly mitigated it.

- Determine root causes of causal factors with Root Cause Coding Tree.

- Tree has six levels (A through F)
  - Least detail cause near top of tree
  - Most detailed cause near bottom of tree

- Each Causal Factor is coded, one at a time, starting at the top of the tree and working down as far as known information will allow.

- The lowest level of codable detail should be listed as the root cause(s).

Abstract for: **ROOT CAUSE ANALYSIS EXECUTIVE SUMMARY** written by/for the BWR Owners' Group (BWROG)

This document, along with a letter from C.L. Larson of GE to B. Williamson of TVA entitled; "SFRC Root Cause Analysis, Events and Causal Factors Charting", describes the usefulness of charting the causal factors leading to a reactor scram in determining the root causes for that scram. Events and Causal Factors Charting, as described in the report DOE/SSDC-76-45/14, Events and Causal Factors Charting, and adapted from the Savannah River Plant's "User's Guide for Reactor Incident Root Cause Coding Tree" document, is a technique for logically displaying the events related to a scram, illustrating multiple causes of a scram, and ensuring that the investigation of a scram has not overlooked any causes. This type of charting also helps in identifying where corrective actions are needed.

As described, the methodology of developing the Events and Causal Factors Charts is not significant though some consistency of charting causal factors is recommended. This will make understanding easier for all members of the BWR Owners' Group. These documents provide a method, with a few general rules, for charting the causal factors leading or contributing to a reactor incident. Also included in these documents is an example of a Cause Coding Tree.

TAKE AWAY ITEMS

- Events and Causal Factors Chart should contain all details of the incident investigation.
  - allows identification of all contributing causes
  - allows eventual identification of all root causes

- Sequence of the incident is laid out in a time line with each event leading to it
  - Events are investigated to determine their cause(s).
  - Causal factors of the incident are determined.

- Root cause(s) of the causal factor(s) is determined using the cause coding tree.
  - Each causal factor is coded to the lowest possible level in the tree.
  - Stop at the lowest level of the tree for which the questions can be answered if its not possible to code to the root cause level of the tree.

- At times a causal factor will result in two or more root causes being coded from the cause coding tree.
  - Called dual coding

Abstract for: **EVENTS AND CAUSAL FACTORS CHARTING (DOE 76-45/14, SSDC-14)** prepared by: JR Buys and JL Clark

This document discusses the goal of the Department of Energy (DOE) to build and maintain an accident investigation process that utilizes state-of-the-art investigative and analytical methods. This process is used to identify the various causes of an accident occurrence so that action can be taken to prevent their recurrence. The document also discusses the nature of accident investigation and describes the technique of Events and Causal Factors charting as an investigative tool.

Within the description of the technique of Events and Causal Factors charting, a general format is suggested and the criteria for determining the events which make up the accident sequence is given. This document also contains a typical application ("simple" accident) as an example for using Events and Causal Factors charting.

The document also discusses the seven key elements in the practical application of this technique and the benefits derived from using Events and Causal Factors.

TAKE AWAY ITEMS

- Vital factors in accident causation emerge as sequentially and/or simultaneously occurring events, which interact with existing conditions to form a multifactorial path to the accident.

- Two basic foundation principles are suggested:
  - Accidents are the results of successive events that produce unintentional harm.
  - The accident sequence occurs during the conduct of some work activity

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- Experience shows that accidents are rarely simple and almost never result from a single cause.
  - Usually multifactorial
  - Develop from a series of events which include:
    - * performance errors
    - * changes
    - * oversights
    - * omissions

- Events and Causal Factors chart should begin as soon as investigator starts gathering factual data of the accident.
  - Several benefits for starting chart quickly:
    - * Organizes the accident data
    - * Helps in guiding the investigation
    - * Aids in validating and confirming the true accident sequence
    - * Helps identify and validate the factual findings, probable causes and contributing factors
    - * Aids in simplifying the investigation report
    - * Illustrates the accident sequence in the investigation report

- Most effective when used with other MORT tools that provide supportive correlation.

- Use whatever method of application of this technique that seems to work best.

- Suggested Format:
  - Events should be enclosed in rectangles, conditions in ovals.
  - Connect events with solid lines
  - Connect conditions with dashed lines
  - Base events and conditions on factual evidence, presumptive items should be denoted by dashed line rectangles and ovals
  - Primary sequence of events depicted in straight horizontal line joined by bold printed arrows
  - Secondary event sequence , contributing factors, or systemic factors depicted in horizontal lines above or below the primary sequence
  - Arrange events in chronological order from left to right
  - Events should track in a logical progression

o Suggested criteria for event descriptions
  - Describe an occurrence or happening and not a condition, state, circumstance, issue, conclusion, or result
  - A short sentence containing only one subject and one active verb
  - Event should be precisely described
  - Event should be quantified when possible
  - Each event should be derived directly from the event(s) and condition(s) preceding it

o Benefits of the Events and Causal Factors charting technique:
  - Meets the general purposes of accident investigation
    * Provides a cause-oriented explanation
    * Provides a basis for beneficial changes to prevent recurrence
    * Helps delineate areas of responsibility
    * Ensures objectivity in investigation conduct
    * Provides a quantitative data organization
    * Provides an operational training tool
    * Provides an effective aid for future systems design
  - Helps in conducting the investigation
    * Aids in developing evidence, detecting all causal factors and in determining the need for in-depth analysis.
    * Clarifies reasoning
    * Illustrates multiple causes
    * Visually portrays interactions and relationships of involved organizations and individuals
    * Illustrates the chronological sequence of events
    * Provides flexibility in interpretation and summarization of collected data
    * Communicates facts in a logical and orderly manner
    * Links specific factors to organizational and management control factors

- Benefits of the Events and Causal Factors charting technique (Cont.):
  - Helps in writing the investigation report
    * Provides a check for completion of investigative logic
    * Provides a method for identifying matters requiring further investigation or analysis
    * Provides a logical display of facts where valid conclusions can be drawn
    * Provides consistent subject titles for "discussion of facts" and "analysis" paragraphs
    * Provides method for determining if purpose and specific objectives of the investigation have been met
    * Provides differentiation between analysis of facts and conclusions reached
    * Simple method of describing the accident sequence and its causes to a reading audience of different backgrounds
    * Source of identification of organizational needs and the formulation of recommendations to meet those needs
    * Provides a method for evaluating the factual basis of possible recommendations
    * Useful in solving unanticipated problems with preparing the final report of specific accident investigations

- Seven key elements in the practical application of Events and Causal Factors charting:
  - Begin early
  - Use the guidelines
  - Proceed logically using available data
  - Use an easily updated format
  - Correlate with other MORT investigative tools
  - Include appropriate detail and sequence length
  - Make a short executive summary chart when necessary

Abstract for: **HUMAN PERFORMANCE EVALUATION SYSTEM** written for INPO in August 1984

The Institute of Nuclear Power Operations (INPO), working with several member and participant utilities, has developed a nonpunitive program designed to identify, evaluate, and correct situations that involve human performance errors. The program is called Human Performance Evaluation System (HPES). Its primary goal is to improve human reliability in overall plant operations by reducing human error through correction of the conditions that cause the errors.

This document describes the Human Performance Evaluation System goals, its scope, the methodology and the benefits derived from using this system. Also included within this document are the various forms used when performing the Human Performance Evaluation System after an event.

TAKE AWAY ITEMS

- Program was founded on the following premises:
  - Human error can be reduced and minimized
  - Causes of minor events are often the same as those for major events
  - Management is of key importance
    * People want to perform well
    * Punitive actions often do not correct underlying causes and discourages reporting of mistakes
  - Identification and correction of causes can prevent repeat events and reduce opportunities for similar events
  - Utility sharing of lessons learned promotes better plant and industrial understanding and correction of human error causes

- Root cause analysis methodology does not ask who did it; but asks what, where, when, how, and why it happened.

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- o Program's primary implementation elements are:
  - Reporting
  - Analysis
  - Corrective Actions
  - Feedback

- o The following plant personnel are involved in program implementation:
  - Line management
    * Uses program results to resolve causes of human performance problems
  - Reporters
    * All personnel who report human error events to the program coordinator
  - Program coordinator
    * Specially trained individual who analyzes events, determines their causes, recommends corrective actions, and provides feedback to reporters
  - Evaluators
    * Specially trained individuals who assist the program coordinator in evaluating human performance problems

- o INPO provides the following support for program implementation:
  - Training of program coordinators and evaluators
  - Program implementation assistance
  - Report screening
    * A reviewer provides comments or experience-based information from other participants
  - Maintenance of a human performance data base
  - Regular data base analysis and feedback
  - A quarterly newsletter focusing on human performance
  - Operation of an information exchange network
  - Meetings to discuss lessons learned, new developments, and advanced evaluation techniques
  - Sponsorship/support of related workshops
  - Materials for program operation and training
  - Annual reviews of program methodology and effectiveness

Abstract for: **METHOD IDENTIFIES ROOT CAUSES OF NUCLEAR REACTOR SCRAMS** an article written by JL Burton for Power Engineering magazine in October 1987

This article discusses the evaluation done at the Gulf States Utilities' River Bend Station in which a root cause analysis was performed for each unplanned reactor scram. The utilities' Independent Safety Engineering Group (ISEG) analyzed all River Bend Station scrams not due to testing that have been experienced from the plant's initial criticality date through December of 1986.

This analysis was intended to provide three results, which were:

1) Identify trends relating to scrams to focus attention on problem areas.

2) Identify and rank scram root causes to allow management allocation of resources in the most effective manner possible.

3) Identify corrective actions for the scram root causes to prevent their recurrence, thereby reducing scram frequency.

This article also discusses the Management Oversight and Risk Tree (MORT) technique that was used to perform the root cause analysis of this evaluation.

TAKE AWAY ITEMS

o MORT techniques were modified slightly
  - An importance score was assigned to each root cause, based on its level of contribution to the scram
  - These scores were weighted by frequency of occurrence to develop root cause rankings for each scram and for a composite of all scrams

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- MORT is based on the concept that risks are a combination of three distinct elements:
  - a hazard (or energy release)
  - a target which can be damaged by the hazard
  - one or more barriers which separate the hazard from the target
    * Undesirable effects (accidents or scrams) occur due to the breakdown of these barriers allowing a hazard to reach its target

- The extreme level of detail and its complex structure limits the feasibility of using the MORT technique for the analysis of numerous events

- All scrams analyzed, could be traced to more than one root cause
  - an average of 9.5 root causes per scram were identified

Abstract for: ROOT **CAUSE AND** HOW TO **FIND IT** written by Dean Gano of WPPSS

This article documents what has been learned through participation in the BWR Owners Group (BWROG) Scram Frequency Reduction Committee (SFRC) over the past two years. This docum nt provides an in-depth discussion of the definition of root cause, the use of the cause-and-effect process to find the root cause, and the use of proper cause categorization as a means to better understand the nuances of root cause. It also provides a detailed statistical breakdown of reactor trips at boiling water reactors for 1986 as compiled from `WR Owners' Group Scram Frequency Reduction Committee data.

TAKE AWAY ITEMS

- Root cause definition: The most basic reason(s) for an effect, which if corrected will prevent recurrence.

- Method used to determine root cause is unimportant, as long as goal (to prevent recurrence) is achieved.

- Root cause criteria:
  - A solution that prevents recurrence
  - A solution that is within our control
  - A solution that allows us to meet other objectives

- Root cause process:
  - Use an expert team
  - Start with the primary effect (reactor trip)
  - Use cause-and-effect process in conjunction with the root cause criteria
  - After a root cause has been determined, apply the definition of a root cause and verify it

- Cause categorization provides an order for counting and comparing similar recurring events.

- Three major cause categories:
  - People
  - Procedures
  - Hardware

- Subcategories for Personnel Error (37% of 1986 BWR scrams)
  - Procedures not followed
  - Training deficiency
  - Lack of mental attention
  - Programmatic deficiencies
  - Communication deficiencies

- Subcategories for Procedural Error (16% of 1986 BWR scrams)
  - Procedure incomplete or nonexistent
  - Incorrect procedure information

- Subcategories for Equipment Failure (48% of 1986 BWR scrams)
  - Design deficiency
  - Maintenance deficiency
  - Premature wearout
  - Installation/manufacturer deficiency

Abstract for: **ROOT CAUSE CODE DETERMINATIONS** letter from CL Larson of GE Reliability Engineering Services to BWROG Scram Frequency Reduction Systems Design Activity of February 1988

This letter contains a revision to the cause coding tree and a document which explains each box of the tree. The changes to the tree were mostly cosmetic and also included the elimination of duplication.

TAKE AWAY ITEMS

o SFRC cause coding tree has four major categories:
- Equipment Malfunction
- Human Miscue
- Procedural Deficiency
- Other

o The equipment malfunction category has three subcategories:
- Design
- Maintenance
- Fabrication did not meet design

o The human miscue category has four subcategories:
- Operations
- Technical Support
- Maintenance
- Installation/Modification

o The procedural deficiency category has four subcategories:
- Operations
- Technical Support
- Maintenance
- Installation/Modification

o The other category has only two subcategories:
- Acts of nature
- other

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