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ROOT CAUSE ANALYSIS AT THE SAVANNAH RIVER PLANT

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ABSTRACT

Events (or near misses) provide important information about ways to improve plant performance. Any particular event may have several "root causes" that need correcting to prevent recurrence of the event and, thereby, improve the safety of the plant. Also, by reviewing a large number of events, one can identify cause trends or "generic concerns." A method has been developed at Savannah River Plant (SRP) to systematically evaluate events, identify their root causes, record the root causes, and analyze the root cause trends. By providing a systematic method to identify correctable root causes, the system helps the event investigator ask the right questions during the investigation. It also provides an independent safety analysis group and management with statistics indicating existing and developing trouble spots.

DEVELOPING A ROOT CAUSE ANALYSIS SYSTEM

Although events at SRP's reactors were being investigated and reported in "Reactor Incident" (RI) reports, management and the independent safety evaluation groups were concerned that RIs didn't get to a level of detail that would allow correcting the event's root cause. Also, there was concern that the RI cause coding system didn't allow analysis of event cause trends for areas of generic concern. Therefore, in November of 1985, the Reactor Safety Evaluation Division (RSED) began to study methods to determine and analyze the root causes of events. We tried to find a system already in use in the utility industry that would meet our needs. However, we found little agreement on the definition of a root cause, much less on an accepted method to analyze it. This was especially true for root causes that involved human error. Therefore we created a new system by starting with the best parts of several systems we had studied.

The first task in creating this new root cause analysis system was to define a "root cause." Our definition is:

> ROOT CAUSE: The most ***basic*** cause that can ***reasonably*** be identified and that management has control to ***fix***.

The three key words in this definition are *basic*, *reasonable*, and *fix*. To attempt to reach a basic level in an event, the investigator (or investigating team) keeps asking additional "Why?" questions. However, there is only a limited amount of time and resources for any investigation, so the investigator must decide when a *reasonable* number of "Why?" questions have been asked. This is where the word *fix* plays an important role. When the root cause level is reached, the fix that will prevent the event from recurring seems obvious. If an investigation stops before this level is reached (or if it isn't possible to reach this level due to the type of event) then the fix will not be obvious and may or may not prevent recurrence of the event. So if a fix is obvious, then the investigation is both *basic* enough and *reasonable*. If a fix is still uncertain, then the investigator and management need to decide if continued effort to find a root cause is worth the benefit of preventing recurrence of the event.

Providing the investigators with a definition of a root cause was not enough to ensure that all the root causes were reached in a particular event. We wanted to give the investigators a fairly inclusive list of the types of root causes that they could find. We wanted to provide the list in an easy to understand format that would lead the investigator to the right answers. Therefore, we developed a root cause analysis system that starts with Events and Causal Factors Charting and includes a Root Cause Analysis Tree.

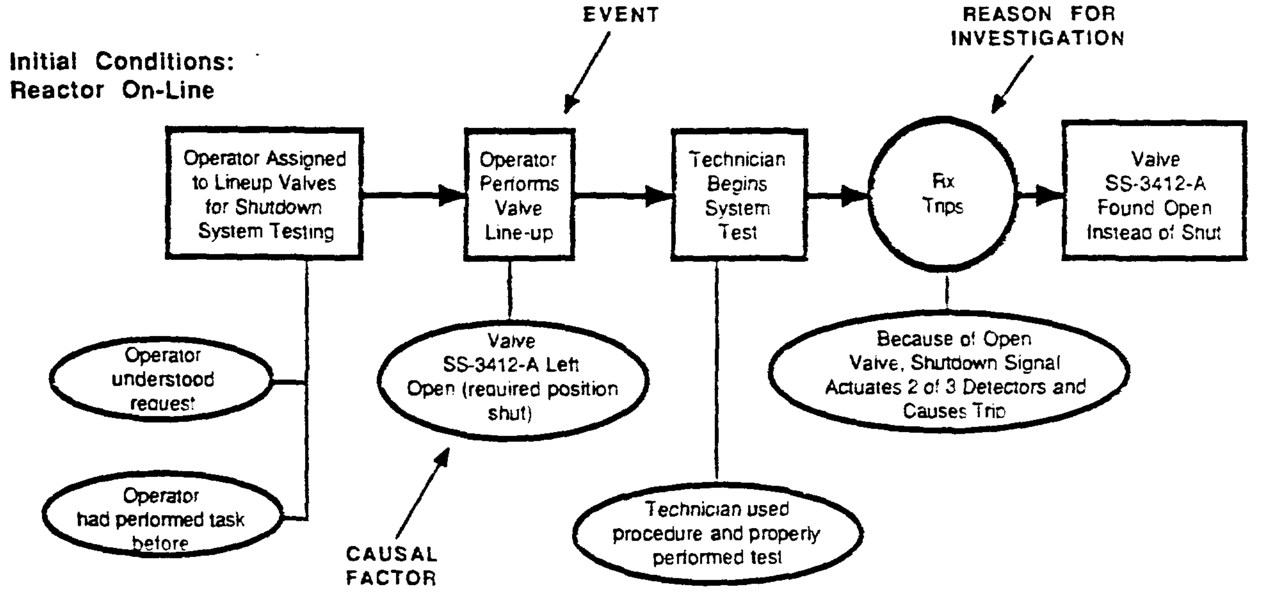

FIGURE 1: EXAMPLE EVENTS & CAUSAL FACTORS CHART

SRP's ROOT CAUSE ANALYSIS SYSTEM

Events & Causal Factors Charting

Events and Causal Factors Charting was developed by the National Transportation Safety Board (NTSB) to investigate transportation accidents. NTSB thought that accidents were really composed of a chain of events and to understand the accident, the investigator needs to thoroughly understand the sequence. Therefore, they developed a time line display of the event showing what happened (the "events") and the immediate reasons why the events occurred (the causal factors). Figure 1 provides a simple example of a hypothetical event and causal factors chart.

At Savannah River Plant, Events and Causal Factors Charting is the first step in the root cause analysis process. This technique helps the investigator see investigation inconsistencies and missing information. By providing an overview of the event, the investigator sees how multiple causes combine to trigger and propagate an event rather than fixating on a single event cause. At SRP the average event has 2.5 causes. Some events have had 10 or more causes, but these are rare.

When the investigator is satisfied with the events and causal factors chart, then he or she reviews the causal factors and determines which causal factors, if removed, would have prevented the event from occurring (or would have significantly mitigated the event). For each of these causal factors the investigator analyzes the root cause(s) using the Root Cause Analysis Tree.

Root Cause Analysis Tree

Tree Format: To make the system easy to use a tree format was chosen (Figure 2). For this system, coding starts at the top of the tree with an event or a causal factor and proceeds down the tree as far as possible to the root causes at the bottom. If enough information isn't available to reach a root cause, the investigator can stop at a higher level in the tree (as the example on the far left of Figure 2 does).

Top Coding Level: The first branching in the tree (top division of Figure 3) agrees with the tendency for investigators to classify events as "operator" or "equipment" problems. Although operators can cause equipment failure and equipment can cause operators to have difficulty, this somewhat arbitrary break gets the individual coding the event to the next step - determining the responsible department. Other possible divisions at the top level include, Technical Difficulty, Natural Phenomenon / Sabotage, and Other.

Operations Difficulty: Operations Difficulty describes problems encountered in operating the plant. The category divides the causes

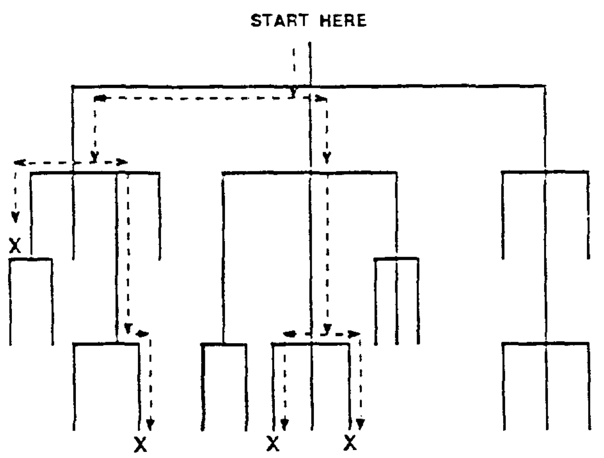

FIGURE 2: TREE FORMAT

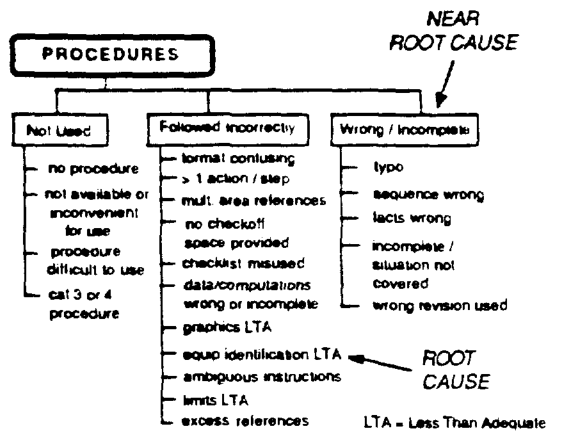

FIGURE 5: PROCEDURES BASIC CAUSE CATEGORY

between the responsible departments. The second division in Figure 3 shows the division of Operations Difficulty into two SRP departments (Reactor Operations Department and Power Department). When reviewing large numbers of statistics, this division allows determination of the department responsible for generic corrective action..

Basic Cause Category: Figure 5 shows the Basic Cause Category, Near Root Causes, and Root Causes for procedure problems (Figure 4 shows all the Basic Cause Categories). This hierarchical format guides the investigator to greater levels of detail in the investigation, allows stopping at a high level if more details are impossible to find, and provides correctable causes if the root cause level is reached.

Whole Tree: Figures 3 and 4 are the SRP Root Cause Analysis Tree. To make the tree easy to use, the tree was arranged it to fit on one piece of paper (front and back). The department level coding is for actual Savannah River Plant departments.

ROOT CAUSE ANALYSIS EXAMPLE

A simple example demonstrates the usefulness of the tree. Starting with the causal factor from Figure 1, the investigator can find the root cause(s) of the operator failing to close the proper valve.

Starting at the top of the tree, the investigator could easily see that the problem was related to an Operations Difficulty and that the operator was from the Reactor Department. The question remaining would be which of the seven Basic Cause Categories (Procedures, Communications, Human Factors, Training, Management System, Immediate Supervision, or Quality Control) were involved. Using the tree, the investigator might find the following:

- Training: The operator was well trained and understood the job.
- Immediate Supervision: The operator was clearly assigned to the job.
- Communications: Both individuals (the operator setting up for the test and the I&C technician who performs the test) were on the same step in the procedure and no miscommunication had occurred.
- Human Factors: The valve was appropriately labeled and the label matched the valve description in the procedure.
- Procedures: The operator and the technician were using the required procedure.

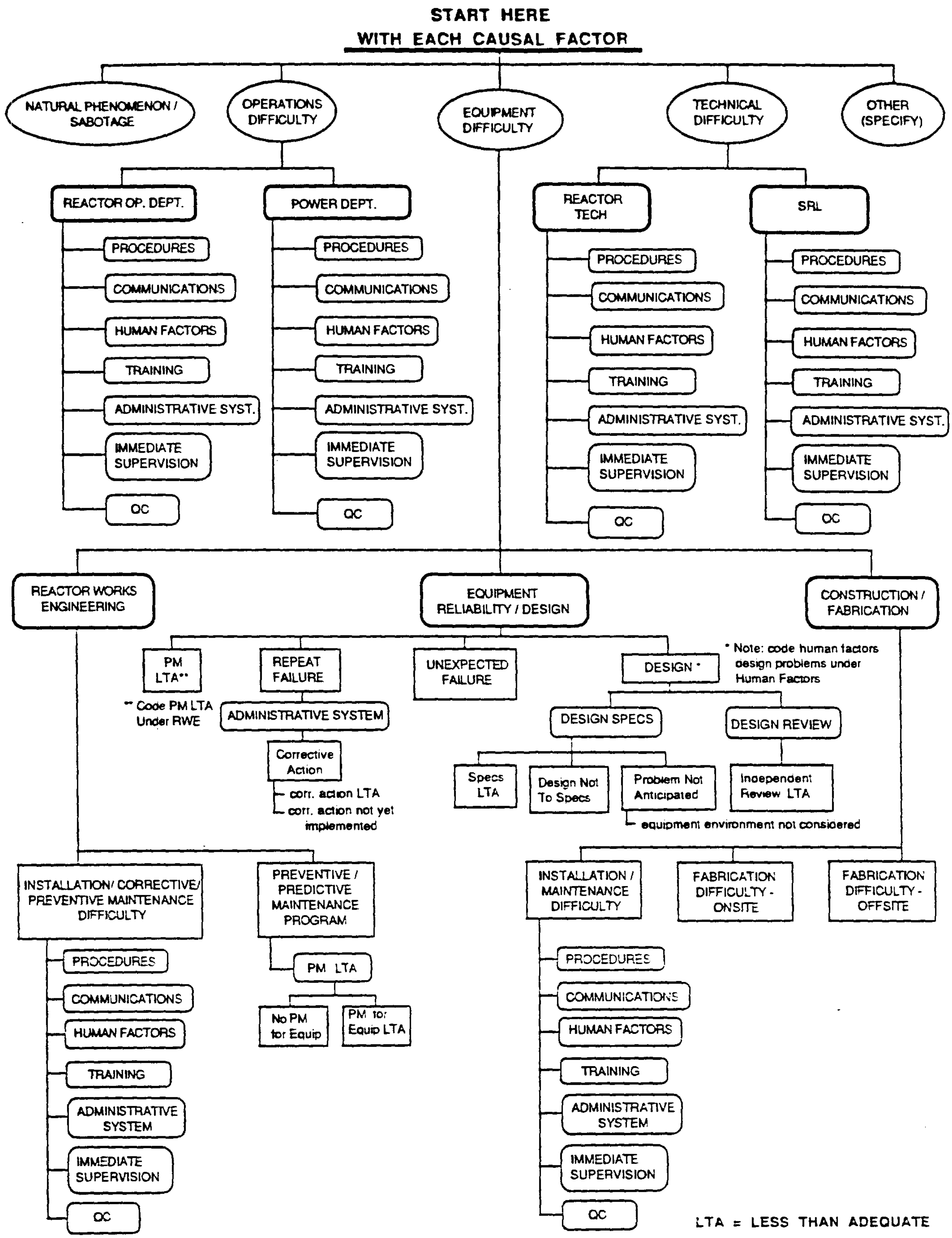

FIGURE 3: ROOT CAUSE ANALYSIS TREE

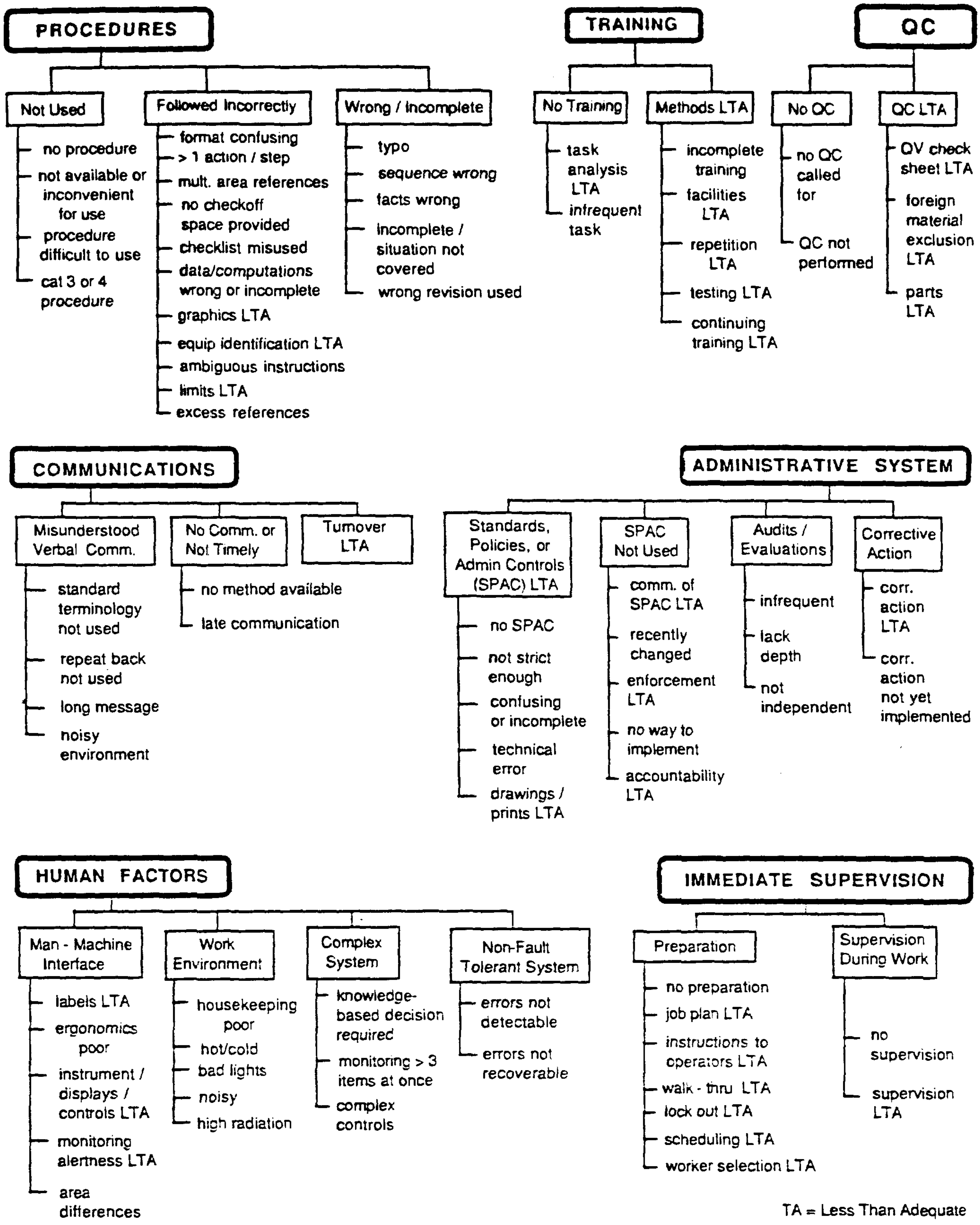

FIGURE 4: BASIC CAUSE CATEGORIES

- Procedures (Continued): The procedure was accurate and included a step to shut the appropriate valve before the test was performed.

  However, the procedure was written in paragraph format so that multiple action steps were buried in a paragraph of information. This type of format is known to cause steps to be missed as the operator tries to read the paragraph and perform all the steps.

Once the investigator finds this problem (Figure 5 under Procedures - Followed Incorrectly - >1 Action Per Step), the fix is obvious: rewrite the procedure with only one action per step and a checkoff box for each action. This helps the operator avoid skipping steps. (The operator can still skip a step, but the probability of skipping a step is greatly reduced.) Therefore the tree has helped lead the investigator to a fixable root cause.

At this point in the investigation two questions still remain. First, are more barriers needed to this event? Second, is this an isolated problem or is upgrading needed for all procedures? Both questions can be answered by reviewing the operating history data base. If these or similar events have occurred too frequently (the term "too frequently" needs to be defined by management) then more programmatic action (example: revising all procedures that could lead to similar failures and adding a person to second check valve line-ups and switch positions) should be taken.

ACCEPTANCE AND USE OF THE TREE

The Savannah River Plant root cause analysis system was developed to provide operating performance feedback for management. However, some of the managers at SRP were skeptical. They wondered why the "responsible individual" wasn't identified and why there wasn't a category for "operator's job performance substandard" or "operator just goofed up."

Our reasoning is that over 80% of all events in a complex system (such as nuclear power plants) are caused by "system" problems over which operators have no control, but management can fix. The other events (less than 20%) are strictly human failures. Some human failures can be corrected with good supervision and management, others are impractical to control. The SRP root cause analysis system was designed to attack the larger, more easily fixable category.

This does not mean that supervision and management should abandon efforts to reduce human failures; it just means that our system was not designed to affix blame. However, we have already seen that when all the "system caused" errors have been eliminated as possibilities, the human caused errors become more evident and are, therefore, easier to identify and correct.

This root cause analysis system is now being used for every RI (renamed Reactor Event Report when this system was implemented) at the three SRP production reactors (about 200 RIs per year). It is also being used for selected significant events in the chemical processes at SRP. In addition, Arkansas Nuclear One is using the system as the center of their scram reduction program, Louisiana Power & Light (Waterford 3) is using the system for their Non-Conformance Reports and as an input for a program they have developed to predict their SALP scores, and the BWR Owners Group Scram Reduction Committee has selected the system to use for their scram reduction effort.

CONCLUSION

Although SRP doesn't have 10 years of data to show a long term decrease in the number of events, the proven ability of this system to find correctable causes will eventually produce a long term reduction in events by reducing the number of "system caused" errors. We are convinced that this will significantly improve reactor safety and is well worth the effort.

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