QUALITY BASICS

Root Cause Analysis For Beginners

by **James J. Rooney and Lee N. Vanden Heuvel**

Root cause analysis (RCA) is a process designed for use in investigating and categorizing the root causes of events with safety, health, environmental, quality, reliability and production impacts. The term "event" is used to generically identify occurrences that produce or have the potential to produce these types of consequences.

Simply stated, RCA is a tool designed to help identify not only *what* and *how* an event occurred, but also *why* it happened. Only when investigators are able to determine why an event or failure occurred will they be able to specify workable corrective measures that prevent future events of the type observed.

Understanding why an event occurred is the key to developing effective recommendations. Imagine an occurrence during which an operator is instructed to close valve A; instead, the operator closes valve B. The typical investigation would probably conclude operator error was the cause.

This is an accurate description of what happened and how it happened. However, if the analysts stop here, they have not probed deeply enough to understand the reasons for the mistake. Therefore, they do not know what to do to prevent it from occurring again.

In the case of the operator who turned the wrong valve, we are likely to see recommendations such as retrain the operator on the procedure, remind all operators to be alert when

In 50 Words Or Less

- **Root cause analysis helps identify what, how and why something happened, thus preventing recurrence.**
- **Root causes are underlying, are reasonably identifiable, can be controlled by management and allow for generation of recommendations.**
- **The process involves data collection, cause charting, root cause identification and recommendation generation and implementation.**

manipulating valves or emphasize to all personnel that careful attention to the job should be maintained at all times. Such recommendations do little to prevent future occurrences.

Generally, mistakes do not just happen but can be traced to some well-defined causes. In the case of the valve error, we might ask, "Was the procedure confusing? Were the valves clearly labeled? Was the operator familiar with this particular task?"

The answers to these and other questions will help determine why the error took place and what the organization can do to prevent recurrence. In the case of the valve error, example recommendations might include revising the procedure or performing procedure validation to ensure references to valves match the valve labels found in the field.

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Identifying root causes is the key to preventing similar recurrences. An added benefit of an effective RCA is that, over time, the root causes identified across the population of occurrences can be used to target major opportunities for improvement.

If, for example, a significant number of analyses point to procurement inadequacies, then resources can be focused on improvement of this management system. Trending of root causes allows development of systematic improvements and assessment of the impact of corrective programs.

Definition

Although there is substantial debate on the definition of root cause, we use the following:

1. Root causes are specific underlying causes.
2. Root causes are those that can reasonably be identified.
3. Root causes are those management has control to fix.
4. Root causes are those for which effective recommendations for preventing recurrences can be generated.

Root causes are underlying causes. The investigator's goal should be to identify specific underlying causes. The more specific the investigator can be about why an event occurred, the easier it will be to arrive at recommendations that will prevent recurrence.

Root causes are those that can reasonably be identified. Occurrence investigations must be cost beneficial. It is not practical to keep valuable manpower occupied indefinitely searching for the root causes of occurrences. Structured RCA helps analysts get the most out of the time they have invested in the investigation.

Root causes are those over which management has control. Analysts should avoid using general cause classifications such as operator error, equipment failure or external factor. Such causes are not specific enough to allow management to make effective changes. Management needs to know exactly why a failure occurred before action can be taken to prevent recurrence.

We must also identify a root cause that management can influence. Identifying "severe weather" as the root cause of parts not being delivered on time to customers is not appropriate. Severe weather is not controlled by management.

Root causes are those for which effective recommendations can be generated. Recommendations should directly address the root causes identified during the investigation. If the analysts arrive at vague recommendations such as, "Improve adherence to written policies and procedures," then they probably have not found a basic and specific enough cause and need to expend more effort in the analysis process.

Four Major Steps

The RCA is a four-step process involving the following:

1. Data collection.
2. Causal factor charting.

FIGURE 1 Causal Factor Chart

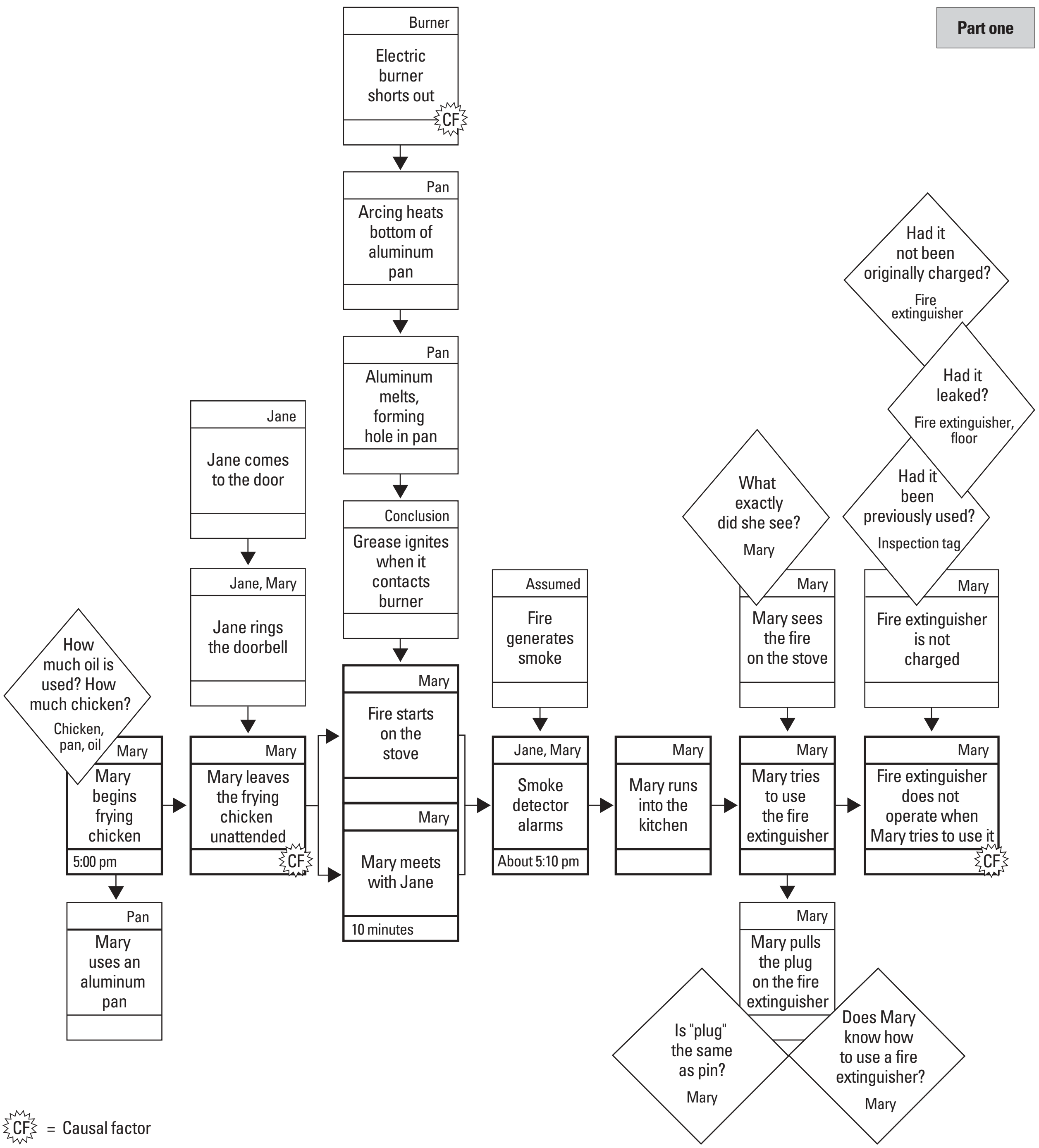
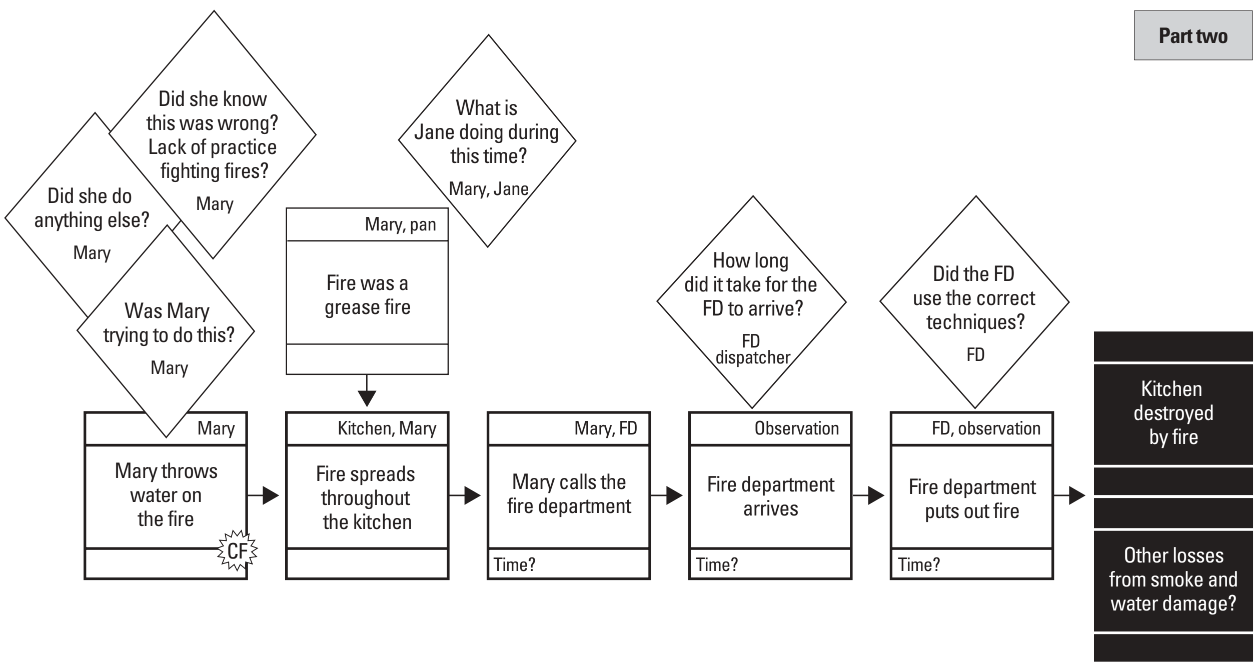


Figure 1 continued on next page



3. Root cause identification.
4. Recommendation generation and implementation.

Step one—data collection. The first step in the analysis is to gather data. Without complete information and an understanding of the event, the causal factors and root causes associated with the event cannot be identified. The majority of time spent analyzing an event is spent in gathering data.

Step two—Causal factor charting. Causal factor charting provides a structure for investigators to organize and analyze the information gathered during the investigation and identify gaps and deficiencies in knowledge as the investigation progresses. The causal factor chart is simply a sequence diagram with logic tests that describes the events leading up to an occurrence, plus the conditions surrounding these events (see Figure 1, p. 47).

Preparation of the causal factor chart should begin as soon as investigators start to collect information about the occurrence. They begin with a skeleton chart that is modified as more relevant facts are uncovered. The causal factor chart should drive the data collection process by identifying data needs.

Data collection continues until the investigators are satisfied with the thoroughness of the chart (and hence are satisfied with the thoroughness of the investigation). When the entire occurrence has been charted out, the investigators are in a good position to identify the major contributors to the incident, called causal factors. Causal factors are those contributors (human errors and component failures) that, if eliminated, would have either prevented the occurrence or reduced its severity.

In many traditional analyses, the most visible causal factor is given all the attention. Rarely, however, is there just one causal factor; events are usually the result of a combination of contributors. When only one obvious causal factor is addressed, the list of recommendations will likely not be complete. Consequently, the occurrence may repeat itself because the organization did not learn all that it could from the event.

Step three—root cause identification. After all the causal factors have been identified, the investigators begin root cause identification. This step involves the use of a decision diagram called the Root Cause Map (see Figure 2, p. 50) to identify the underlying reason or reasons for each causal factor.

The map structures the reasoning process of the investigators by helping them answer questions about why particular causal factors exist or occurred. The identification of root causes helps the investigator determine the reasons the event occurred so the problems surrounding the occurrence can be addressed.

Step four—recommendation generation and implementation. The next step is the generation of recommendations. Following identification of the root causes for a particular causal factor, achievable recommendations for preventing its recurrence are then generated.

The root cause analyst is often not responsible for the implementation of recommendations generated by the analysis. However, if the recommendations are not implemented, the effort expended in performing the analysis is wasted. In addition, the events that triggered the analysis should be expected to recur. Organizations need to ensure that recommendations are tracked to completion.

Presentation of Results

Root cause summary tables (see Table 1, p. 52) can organize the information compiled during data analysis, root cause identification and recommendation generation. Each column represents a major aspect of the RCA process.

- In the first column, a general description of the causal factor is presented along with sufficient background information for the reader to be able to understand the need to address this causal factor.
- The second column shows the Path or Paths through the Root Cause Map associated with the causal factor.
- The third column presents recommendations to address each of the root causes identified.

Use of this three-column format aids the investigator in ensuring root causes and recommendations are developed for each causal factor.

The end result of an RCA investigation is generally an investigation report. The format of the report is usually well defined by the administrative documents governing the particular reporting system, but the completed causal factor chart and causal factor summary tables provide most of the information required by most reporting systems.

Example Problem

The following example is nontechnical, allowing the reader to focus on the analysis process and not the technical aspects of the situation. The following narrative is the account of the event according to Mary:

> It was 5 p.m. I was frying chicken. My friend Jane stopped by on her way home from the doctor, and she was very upset. I invited her into the living room so we could talk. After about 10 minutes, the smoke detector near the kitchen came on. I ran into the kitchen and found a fire on the stove. I reached for the fire extinguisher and pulled the plug. Nothing happened. The fire extinguisher was not charged. In desperation, I threw water on the fire. The fire spread throughout the kitchen. I called the fire department, but the kitchen was destroyed. The fire department arrived in time to save the rest of the house.

Data gathering began as soon as possible after the event to prevent loss or alteration of the data. The RCA team toured the area as soon as the fire department declared it safe. Because data from people are the most fragile, Mary, Jane and the firefighters were interviewed immediately after the fire. Photographs were taken to record physical and position data.

In many traditional analyses, the most visible causal factor is given all the attention.

The analysts then developed the causal factor chart (see Figure 1, p. 47) to clearly define the sequence of events that led to the fire. The causal factor chart begins with the event; Mary begins frying chicken at 5 p.m. As the chart develops from

FIGURE 2 Root Cause Map

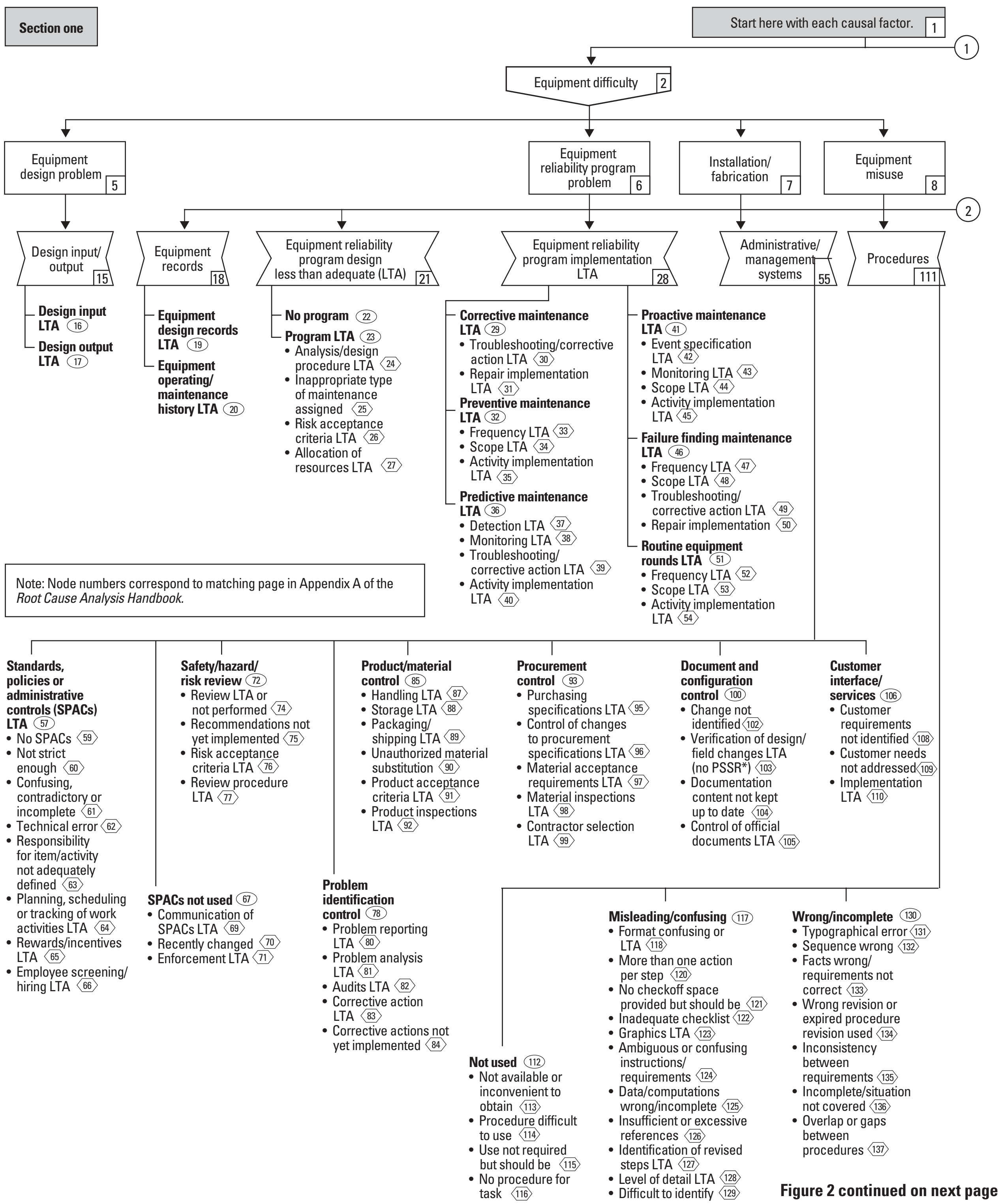
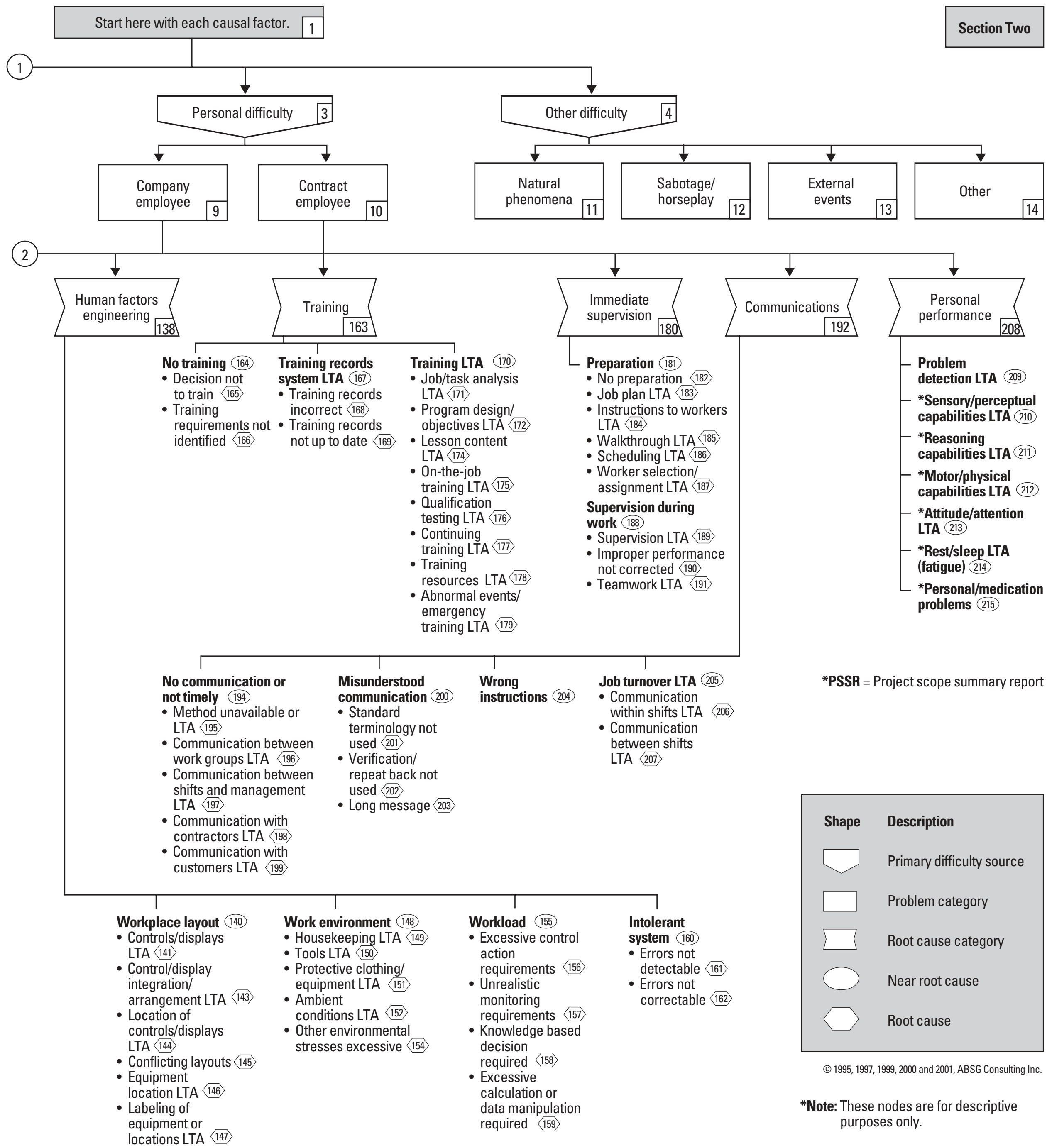


Figure 2 continued on next page


Start here with each causal factor. 1
Section Two
1
Personal difficulty 3
Other difficulty 4
Company employee 9
Contract employee 10
Natural phenomena 11
Sabotage/ horseplay 12
External events 13
Other 14
2
Human factors engineering 138
Training 163
Immediate supervision 180
Communications 192
Personal performance 208
No training 164
• Decision not to train 165
• Training requirements not identified 166
Training records system LTA 167
• Training records incorrect 168
• Training records not up to date 169
Training LTA 170
• Job/task analysis LTA 171
• Program design/ objectives LTA 172
• Lesson content LTA 174
• On-the-job training LTA 175
• Qualification testing LTA 176
• Continuing training LTA 177
• Training resources LTA 178
• Abnormal events/ emergency training LTA 179
Preparation 181
• No preparation 182
• Job plan LTA 183
• Instructions to workers LTA 184
• Walkthrough LTA 185
• Scheduling LTA 186
• Worker selection/ assignment LTA 187
Supervision during work 188
• Supervision LTA 189
• Improper performance not corrected 190
• Teamwork LTA 191
Problem detection LTA 209
*Sensory/perceptual capabilities LTA 210
*Reasoning capabilities LTA 211
*Motor/physical capabilities LTA 212
*Attitude/attention LTA 213
*Rest/sleep LTA (fatigue) 214
*Personal/medication problems 215
No communication or not timely 194
• Method unavailable or LTA 195
• Communication between work groups LTA 196
• Communication between shifts and management LTA 197
• Communication with contractors LTA 198
• Communication with customers LTA 199
Misunderstood communication 200
• Standard terminology not used 201
• Verification/ repeat back not used 202
• Long message 203
Wrong instructions 204
Job turnover LTA 205
• Communication within shifts LTA 206
• Communication between shifts LTA 207
*PSSR = Project scope summary report
Workplace layout 140
• Controls/displays LTA 141
• Control/display integration/ arrangement LTA 143
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• Conflicting layouts 145
• Equipment location LTA 146
• Labeling of equipment or locations LTA 147
Work environment 148
• Housekeeping LTA 149
• Tools LTA 150
• Protective clothing/ equipment LTA 151
• Ambient conditions LTA 152
• Other environmental stresses excessive 154
Workload 155
• Excessive control action requirements 156
• Unrealistic monitoring requirements 157
• Knowledge based decision required 158
• Excessive calculation or data manipulation required 159
Intolerant system 160
• Errors not detectable 161
• Errors not correctable 162
Shape
Description
Primary difficulty source
Problem category
Root cause category
Near root cause
Root cause
*Note: These nodes are for descriptive purposes only.

TABLE 1 Root Cause Summary Table

Event description: Kitchen is destroyed by fire and damaged by smoke and water. **Event #:** 2003-1

Causal factor # 1	Paths Through Root Cause Map	Recommendations
Description: Mary leaves the frying chicken unattended.	• Personnel difficulty. • Administrative/management systems. • Standards, policies or administrative controls (SPACs) less than adequate (LTA). • No SPACs.	• Implement a policy that hot oil is never left unattended on the stove. • Determine whether policies should be developed for other types of hazards in the facility to ensure they are not left unattended. • Modify the risk assessment process or procedure development process to address requirements for personnel attendance during process operations.
Causal factor # 2	**Paths Through Root Cause Map**	**Recommendations**
Description: Electric burner element fails (shorts out).	• Equipment difficulty. • Equipment reliability program problem. • Equipment reliability program design LTA. • No program.	• Replace all burners on stove. • Develop a preventive maintenance strategy to periodically replace the burner elements. • Consider alternative methods for preparing chicken that may involve fewer hazards, such as baking the chicken or purchasing the finished product from a supplier.
Causal factor # 3	**Paths Through Root Cause Map**	**Recommendations**
Description: Fire extinguisher does not operate when Mary tries to use it.	• Equipment difficulty. • Equipment reliability program problem. • Equipment proactive maintenance LTA. • Activity implementation LTA.	• Refill the fire extinguisher. • Inspect other fire extinguishers in the facility to ensure they are full. • Have incident reports describing the use of fire protection equipment routed to maintenance to trigger refilling of the fire extinguishers.
	• Equipment difficulty. • Equipment reliability program problem. • Administrative/management systems. • Problem identification and control LTA.	• Add this fire extinguisher to the audit list. • Verify that all fire extinguishers are on the quarterly fire extinguisher audit list. • Have all maintenance work requests that involve fire protection equipment routed to the safety engineer so the quarterly checklists can be modified as required.
Causal factor # 4	**Paths Through Root Cause Map**	**Recommendations**
Description: Mary throws water on fire.	• Personnel difficulty. • Company employee. • Training. • Training LTA. • Abnormal events/emergency training LTA.	• Provide practical (hands-on) training on the use of fire extinguishers. Classroom training may be insufficient to adequately learn this skill. • Review other skill based activities to ensure appropriate level of hands-on training is provided. • Review the training development process to ensure adequate guidance is provided for determining the proper training setting (for example,classroom, lab, simulator, on the job training, computer based training).

Paths Through Root Cause Map is a trademark of ABSG Consulting.

left to right, the sequences begin to unfold. The loss events—kitchen destroyed by fire and other losses from smoke and water damage—are the shaded rectangles in the causal factor chart.

Although we read the chart from left to right, it is developed from right to left (backwards). Development always starts at the end because that is always a known fact. Logic and time tests are used to build the chart back to the beginning of the event. Numerous questions are usually generated that identify additional necessary data.

After the causal factor chart was complete (additional data were gathered to answer the questions shown in Figure 1), the analysts identified the factors that influenced the course of events. There are four causal factors for this event (see Table 1). Elimination of these causal factors would have either prevented the occurrence or reduced its severity. Note the recommendations in Table 1 are written as if Mary's house were an industrial facility.

Notice that causal factor two may be unexpected. It wasn't overheating of the oil or splattering of the oil that ignited the fire. If the wrong causal factor is identified, the wrong corrective actions will be developed.

The application of the technique identified that the electric burner element failed by shorting out. The short melted Mary's aluminum pan, releasing the oil onto the hot burner, starting the fire.

The analyst must be willing to probe the data first to determine *what* happened during the occurrence, second to describe *how* it happened, and third to understand *why*.

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JAMES J. ROONEY *is a senior risk and reliability engineer with ABSG Consulting Inc.'s Risk Consulting Division in Knoxville, TN. He earned a master's degree in nuclear engineering from the University of Tennessee. Rooney is a Fellow of ASQ and an ASQ certified quality auditor, quality auditor-hazard analysis and critical control points, quality engineer, quality improvement associate, quality manager and reliability engineer.*

LEE N. VANDEN HEUVEL *is a senior risk and reliability engineer with ABSG Consulting Inc.'s Risk Consulting Division in Knoxville, TN. He earned a master's degree in nuclear engineering from the University of Wisconsin. Vanden Heuvel co-authored the* Root Cause Analysis Handbook: A Guide to Effective Incident Investigation, *co-developed the* RootCause Leader *software and was a co-author of the Center for Chemical Process Safety's* Guidelines for Investigating Chemical Process Incidents. *He develops and teaches courses on the subject.*

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