Proven Approach to Investigating Near Misses

Greg Smith, Senior Engineer
Process Improvement Institute, Inc. (PII)
7502 Chad Road
Harrison, TN 37341
Phone: (423) 413-0038
Fax: (865) 671-4944
e-mail: gsmith@piii.com

Gerald D. Burch, Senior Engineer
Process Improvement Institute, Inc. (PII)
e-mail: gburch@piii.com

William G. Bridges, President
Process Improvement Institute, Inc. (PII)
e-mail: wbridges@piii.com

Revonda Tew, Senior Engineer
Process Improvement Institute, Inc. (PII)
e-mail: rtew@piii.com

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Steven (Greg) Smith, Senior Engineer
Process Improvement Institute, Inc. (PII)
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e-mail: gburch@piii.com

William G. Bridges, President
Process Improvement Institute, Inc. (PII)
e-mail: wbridges@piii.com

Revonda Tew, Senior Engineer
Process Improvement Institute, Inc. (PII)
e-mail: rtew@piii.com

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Abstract

Getting near misses reported is a major hurdle for most companies, one reason being is that the investigation system is not ready for the large influx of reports. Workers and management respond by being reluctant to potentially overload the investigation system (and overload themselves). This paper explains approaches to manage efficiency and effectiveness in near miss investigations that have been successful for handling near misses reporting within both large and small companies and to ensure high value from the investment of reporting and analysis. This paper builds on the updated paper presented in 2012 at GCPS on "Gains from Getting Near Misses Reported."

1. Introduction

Much attention has been given to the detection and correction of early warning signals as a means of improving safety performance.

Process safety events often have entirely different causal factors (human error, equipment malfunction, natural causes) and root causes (management system weaknesses) from those found in more traditional personal injuries.[1,2] Process safety incidents are more technical and complex in nature, usually involving multiple failures of protective barriers. The human actions and errors which cause them are often several steps removed from the incident itself. The human factors involved are not as obvious to investigators; the causes are more systemic than individual in their nature.

Even though personal injury rates have declined, significant injuries and financial losses have continued in a series of high profile, catastrophic (multiple injuries) process safety events. Because of inconsistencies in reporting standards and definitions, it is difficult to tell if these events are actually increasing in frequency or if their visibility has simply increased due to media attention and heightened public concerns. Either way, improved understanding and enhanced tools are required to improve our process safety performance.

In the process industries one such tool is near miss reporting, the early warning system equivalent to unsafe behaviors for process safety. Companies which have successfully developed the ability to recognize, report, investigate, and learn from near misses have shown dramatic reductions in loss events, losses, and injuries due to process incidents. In some cases, loss reductions of more than 90% have been achieved.[2]

2. Definitions

The following definitions are used throughout this article:

> *An incident is either an accident or a near miss.*
>
> *An accident is a sequence of unplanned events and conditions that result in harm to people, environment, process, product or image*.
>
> *A near miss is an unplanned sequence of events that could have caused harm if conditions were different or is allowed to progress, but did not in this instance.*
>
> *A causal factor is a human error (typically an error by the at-risk employee performing a task/job in the process) or a component fault/failure. Note that these human errors and component failures are probably caused by other humans making mistakes, and all errors are controlled by management systems. An incident typically has multiple causal factors. Natural phenomena can also be a causal factor.*
>
> *A root cause is a management system weakness that results in a causal factor. A casual factor typically has multiple root causes.*

The definitions above are the same as used in *Guidelines for Investigating Chemical Process Incidents, Second Edition* (CCPS, 2003).

3. Importance of reporting and learning from near misses

Investigating near misses is critical to preventing accidents, because near misses share the causes and root causes of accidents; they are one or two barriers away from the loss/accident. We are very likely preventing many apparently unrelated accidents when we prevent the ones that are obviously related. Figure 1 illustrates a hypothetical relationship between causal factors and root causes of accidents and those for near misses. From our experience, this relationship appears to be valid; see the case study section of this paper to see some of the proofs of this concept.

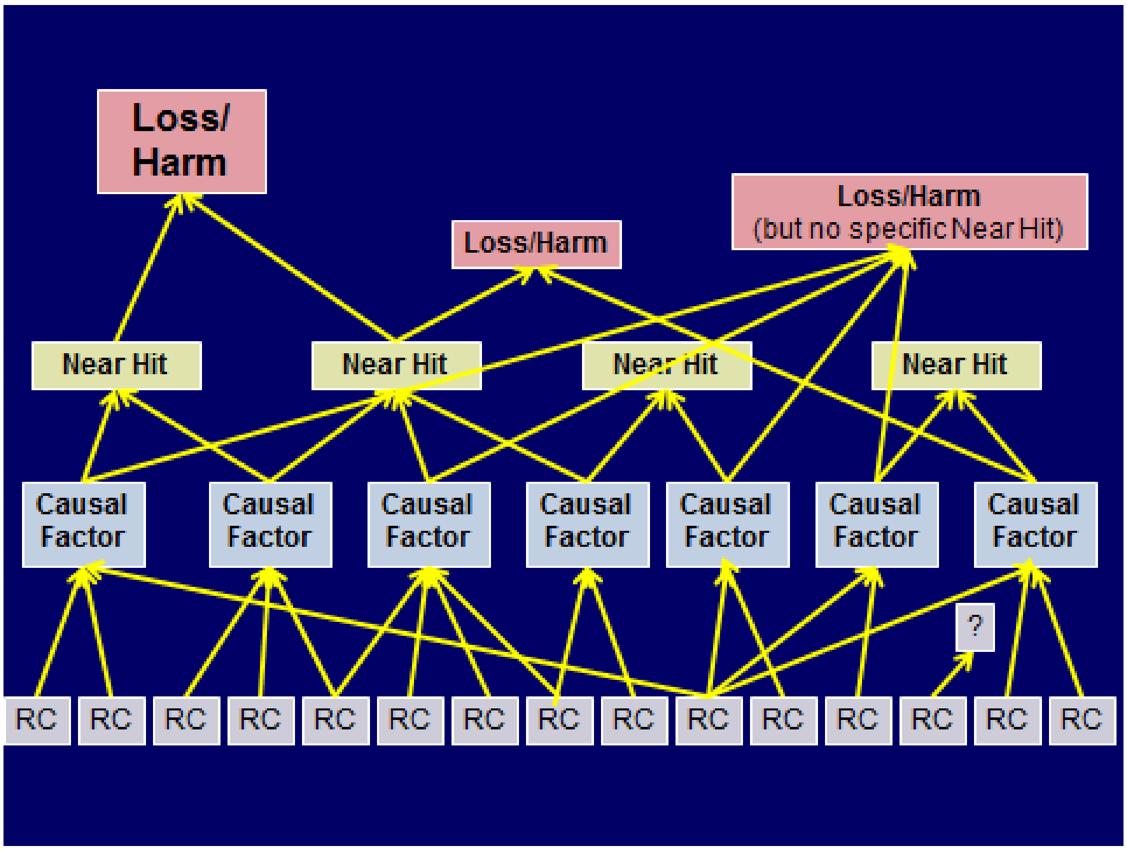

Figure 1 Interrelationship between the causes of Accidents (Losses) and the causes of Near Misses

As a brief explanation of Figure 1, root causes (management system weaknesses) make it more likely for a causal factor to occur. Combinations of causal factors (or in rare cases, perhaps a single causal factor) result in near misses. Additional causal factors result in losses (accidents) in increasing severity. A root cause can increase the likelihood of seemingly unrelated causal factors.

Formal and informal organizational surveys[3] detail the difficulties of implementing an effective near miss reporting system. In this paper, a number of barriers are outlined and potential solutions are proposed. The identified barriers are:

1. *Fear of disciplinary action*
2. *Fear of teasing by peers (embarrassment)*
3. *Lack of understanding of what constitutes a near miss versus a non-incident*
4. ***Lack of management commitment (no training provided on investigation techniques and procedures) and lack of follow-through once a near miss is reported (time is not allocated to investigate near misses, or corrective actions not implemented)***
5. ***An apparently high level of effort is required to report and to investigate near misses compared to low return on this investment***
6. ***There is No Way to investigate the thousands of near misses per month or year***
7. *Disincentives for reporting near misses (e.g., reporting near misses hurts the department's safety performance)*
8. ***Not knowing which accident investigation system to use (or confusing reporting system)***
9. *Company discourages near-miss reporting due to fear of legal liability if these are misused by outsiders*

4. Primary Barriers to Effective Investigation of Near Misses

Four of the barriers (4, 5, 6, and 8) tie directly to the organization’s ability to effectively and efficiently investigate and resolve near miss incidents.

Of the four barriers related to getting near misses reported, the two that are most related to effective near miss investigations are **Barriers 6 and 8.**

Overcoming these barriers is described below by looking at the experience of organizations as they implement these concepts.

4.1 Barrier 6. There is No Way to investigate all of the thousands of near misses per month or year!

Normally, when the discussion of having a huge number of near misses reported, such as four per worker per month, the reaction will be shock and then a statement such as Barrier 6. This barrier is closely related to Barrier 5*: An apparently high level of effort is required to investigate near misses compared to the small gain perceived*. If a site has 500 staff as operators and maintenance craftsmen, then likely 25,000 near misses could be reported. At first glance, it can appear impossible to cope with, let alone investigate that number of near misses (incidents).

Maybe the most important solution to Barrier 5 and 6 is to first decide which near misses and losses/accidents need to be investigated. The best solution is normally stated as:

Let front line foremen or supervisors decide if a near miss or accident needs to be investigated to root causes; the decision is made on the apparent Learning Value of the incident. How do you decide it a high or low learning value? The foremen or supervisors will easily decide based on their hands-on experience. *For instance, an additive pump failure may directly result in a minor and temporary impact to quality or production rates but does not appear to have the potential to cause a large loss. So the foreman of the shift decides to designate this as a low learning value incident and therefore not do an immediate RCA. But, then other similar pumps fail over a six month period. A query shows that after 12 months, there have been 3 failures of the same additive pump and 8 failures of 5 other similar pumps in different services. Based on the number of failures and cumulative losses, the company performs an RCA of the 11 failures, resulting in findings which when applied to all similar pumps and services, greatly reduces the production/quality impacts. The RCA of the grouping of incidents proved very cost effective.*

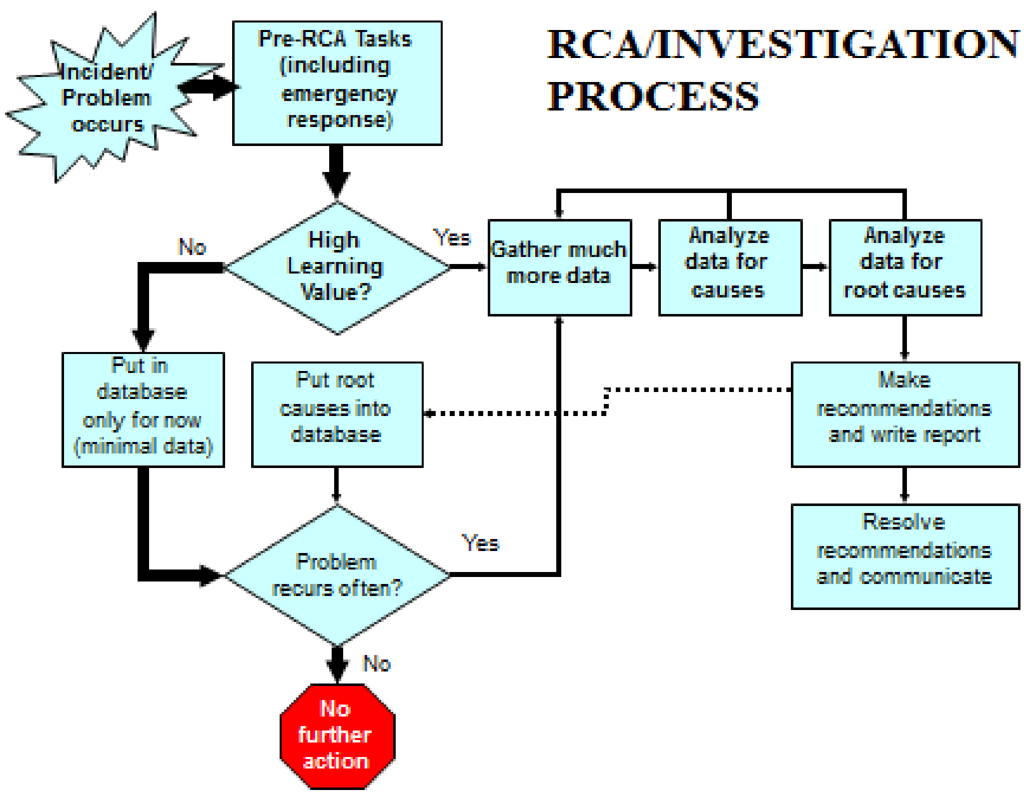

Figure 2: RCA/Investigation Flow Process

Figure 2 illustrates the process flow for an investigation system than can handle a large volume of near misses and losses/accidents. For this process to work:

- Be prepared for investigations by having enough staff trained in root cause analysis methods (or to help in the analysis, such as being able to interview peers).

- When the near miss, etc., is first noticed or reported by staff, let the frontline supervisor or foreman decide if it has high learning value.
- For high learning value incidents, investigate now. For low learning value incidents, put in the database now, along with the little data you have and any obvious causes. Do not investigate yet!
- Query the database every one to six months and perform Pareto or similar analysis to help decide which recurring events need to be analyzed in more detail.
- Take the root causes from investigations/RCAs and put in the database as well.
- Query the database every one to six month

4.2 Barrier 8. Not knowing which accident investigation system to use

One consideration that is not related to any of the barriers mentioned above, except marginally to Barrier 3 (lack of understanding of what a near miss is), is the scope of the investigation program. Some companies have one investigation system for occupational safety incidents, another one for process safety incidents, another for environmental releases, another for reliability issues, and yet another for quality and customer services issues. We have found that the same investigation approach and investigator training works well for incidents in any facet of a business. We believe there is merit in combining the systems and, in particular, in combining the incident databases. Combining the incident systems will require more work on defining near misses and in determining success in reporting near misses.

Consider having ONE incident reporting system with ONE approach for teaching employees the definition of a near miss and with ONE approach for doing incident investigations (including one approach for root cause analysis).

5. Effective and Efficient Incident Investigation and Root Cause Analysis

The incident investigation and root cause analysis (II/RCA) process should enhance organizational learning, reduce accidental losses, invest wisely in protective and mitigative systems, better protect people and equipment from harm, and continuously improve EHSS performance. An efficient and effective process ensures that scarce organizational resources are used appropriately in activities that matter.

The overall II/RCA process consists of the following steps:

- Data collection
- Causal factor analysis
- Root cause analysis
- Develop recommendations
- Reporting and follow through

5.1 Data collection

Every investigation begins by collecting, organizing, and preserving all relevant data as quickly as possible after the incident has been stabilized. Data comes in the form of personnel interviews, physical evidence, and documentation. All data is fragile and susceptible to loss or damage if it is not properly collected and preserved in a timely manner. All front line supervisors should be trained in the II/RCA process with particular emphasis on initiating the investigation, interviewing people, and collecting the physical evidence. Provide front line supervisors with an investigation tool kit containing a camera, barrier tape, collection bags and bottles, and appropriate forms and checklists.

5.2 Causal factor analysis

Once collected, data must be organized and analyzed to determine what happened – the chain of events (causal factors) that led to an undesirable occurrence. The most effective and proven methods for analyzing data are Event and Causal Factor Charting (ECFC) supplemented, if needed, with a Simplified Fault Tree Analysis for complex, chronic, or acute events. These are only effective when the rules are followed for their use – but with training and practice most people can be taught to identify causal factors using these basic tools for most of the incidents they will encounter.

Event and Causal Factor Charting: When an investigation team begins a root cause analysis (investigation), the first step is to prepare an Event and Causal Factors Chart (ECFC).

- Arranges event building blocks (sticky notes) to graphically depict cause-effect relationships between known events
- Allows for testing of "necessity" and "sufficiency"
- Best method when timing of events is important

Events make up the backbone of the ECFC. Event statements describe specific occurrences (e.g., "4-12 shift operator filled Tank 123," or "Control room operator acknowledged level alarm for Tank 123"). Conditions usually provide descriptive information (e.g., "Pressure was 1000 psig" or "The operator did not have hands-on training in this task") as opposed to stating action (e.g., "Operator placed Valve ABC into open position"). Primary events form the basic sequence in the diagram. Secondary events are actions that impact the primary events, but which are not directly involved in the situation. Figure 3[3] provides the steps for developing a casual factor chart.

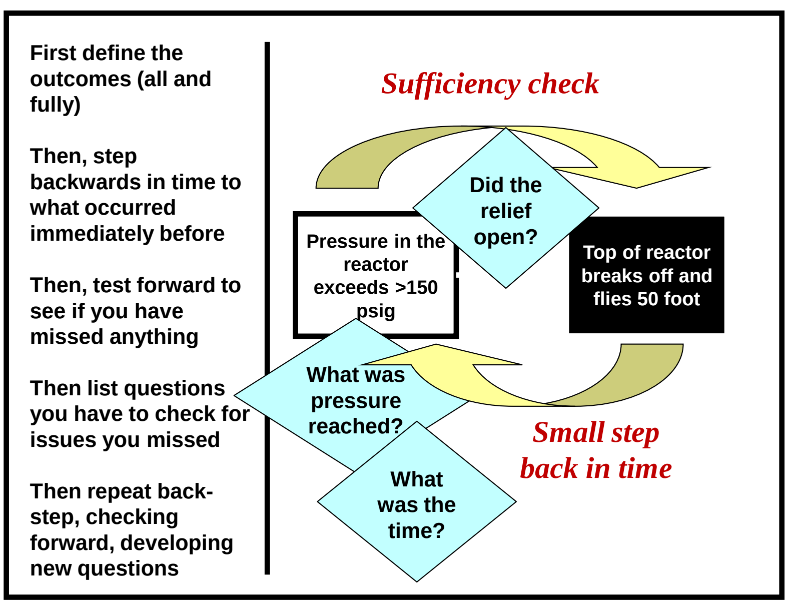

Figure 3: Steps for Casual Factor Charting

If applied correctly, ECFC will aid the investigators in generating a great many new questions. These will lead to more data gathering. Above are a couple of examples of how we show these questions on an ECFC. The answers to the questions sometimes become new events or conditions on the ECFC, as illustrated in Figure 4[3]:

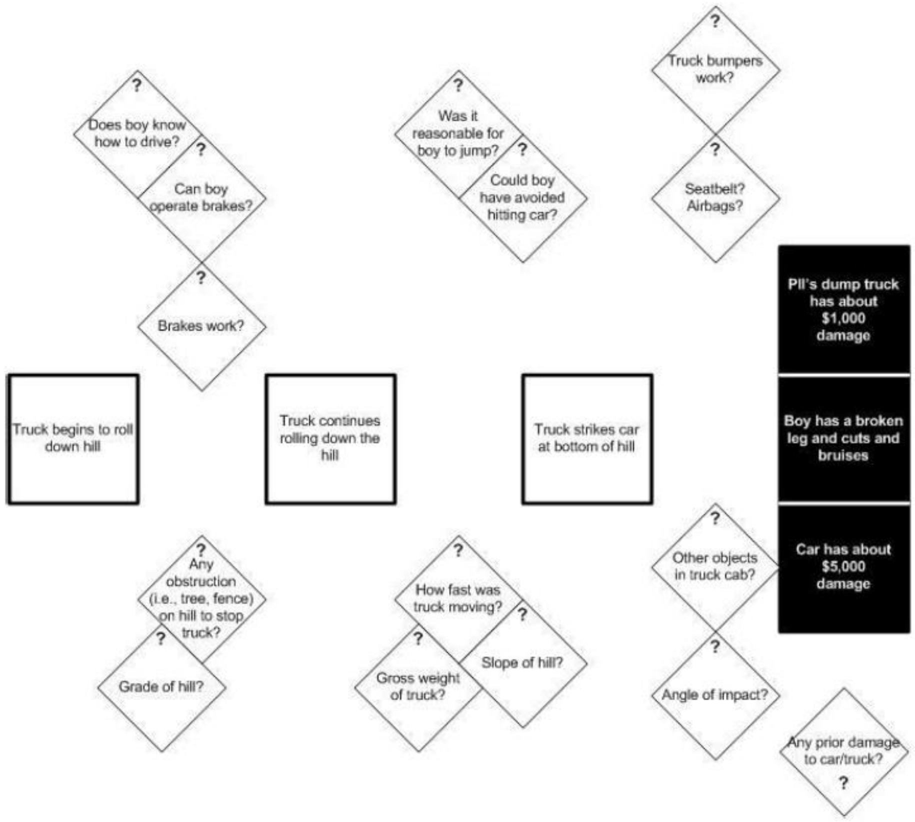

Figure 4: Example of a Partial Casual Factor Chart

The investigators will go back and forth between doing the ECFC, generating new questions, getting new data to answer the questions, and taking more steps backwards in time and sequence. This process continues until all of the data is exhausted and/or the investigators fully understand the sequence of the events and all of the mistakes and failures that led to the final ending condition or loss.

After the ECFC has been completed, the investigators are in a good position to identify the negative factors that influenced the course of events. These components are labeled causal factors. Causal factors, which may be in the form of events or conditions, are those items that are considered to be major contributors to the incident and as defined earlier, are either component failures or human errors or severe environmental problems.

The logic rules for constructing an ECFC are critical to success. These govern how small of step backwards the investigators take backwards in time and how many questions they generate as they test to ensure they understand each pair of building blocks.

5.3 Root cause analysis

When all the causal factors have been identified, the investigation team should begin asking "Why?" each causal factor occurred. Using a combination of the "5 Whys" and a Root Cause Chart™ (derived from the management oversight and risk tree process developed for US DOE's Savannah River Laboratory) shown in Figure 5, step down each of the root cause paths by:

- Select a causal factor from the causal factor chart or fault tree
- Work through the map for each causal factor
- Ask Why to help gathering the right data to get to the lowest level (root causes)
- Step down paths, identifying:
    - causal factor type (equipment, personnel, other)
    - root cause category
    - near root cause
    - root cause
- Record results on forms, at each step (see next page)

The Root Cause Chart™ structures the reasoning process for identifying root causes, identifies detailed root causes for each causal factor, facilitates consistency across all investigations, supports trending of "root causes" and "categories", and gives more thorough coverage of root causes by reminding investigator of all possible root causes.

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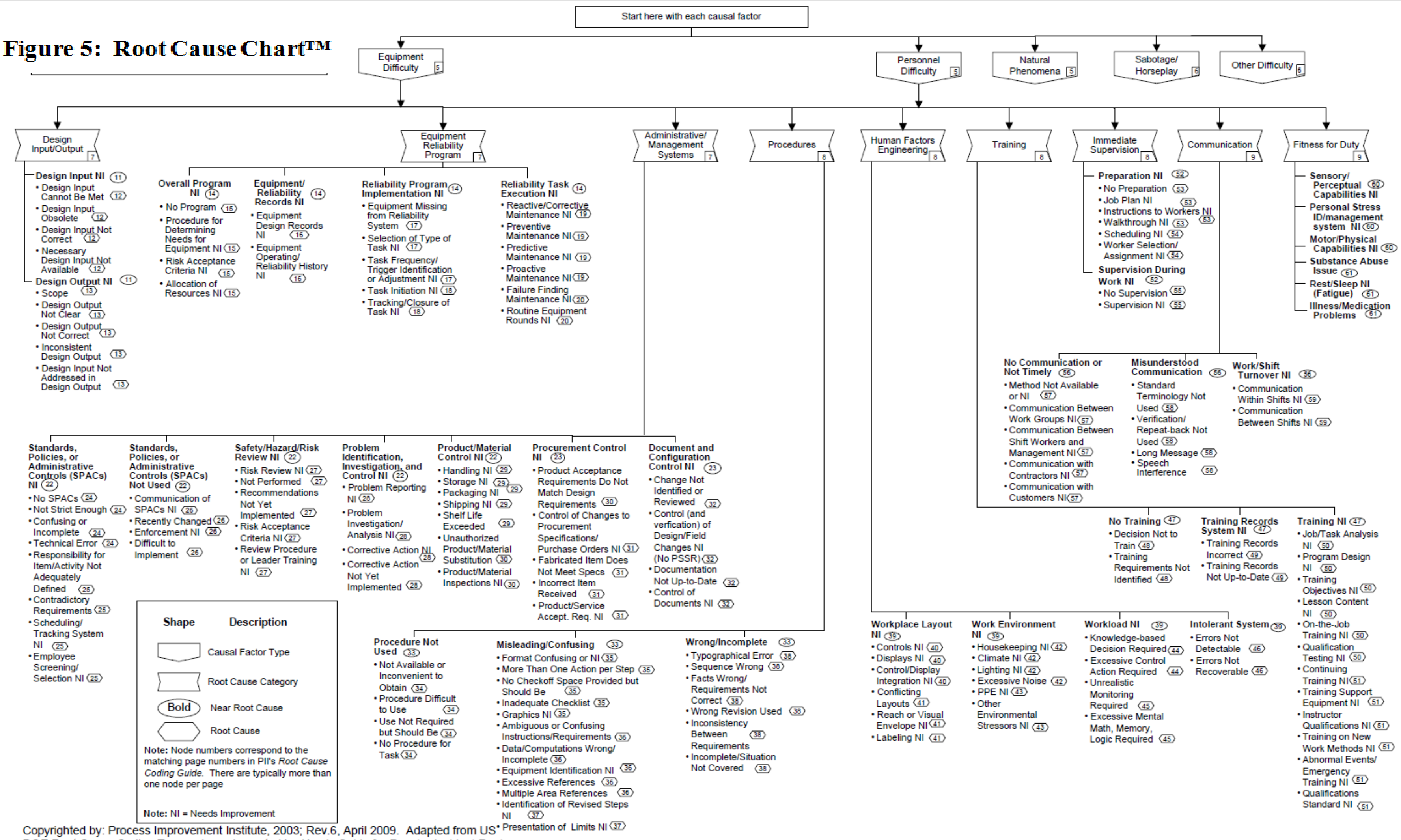
Figure 5: Root Cause Chart™



 Adapted from US DOE Root Cause Coding Tree and supplemented by *User's Guide for Reactor Incident Root Cause Coding Tree*, revision five, DPST-87-209, E.I. duPont de Nemours, Savannah River Laboratory, 1986.

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5.4 Develop recommendations

The investigation team should develop recommendations to remedy each root cause of each causal factor. Recommendations should describe the general objective to be accomplished and the consequences if not completed. Recommendations can also include possible solutions considered by the team and an example of how this could be accomplished.

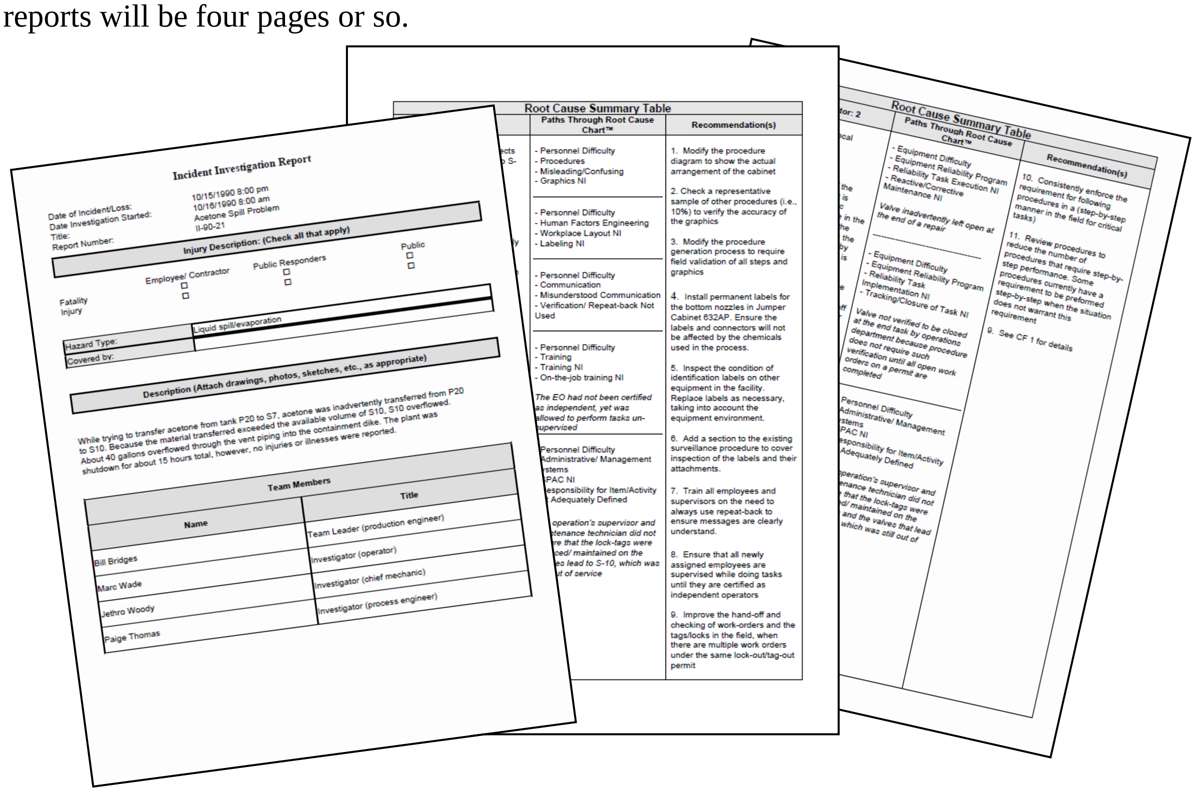
5.5 Reporting and Follow Through

5.5.1 Simplify the reporting of the investigation/RCA results to the bare minimum needed

Part of the reason for the belief that it is impossible to investigate large numbers of near misses stems from the large reports currently required by the company for investigating incidents. Some companies insist on producing what they call "professional" reports of accidents, and these grow to 50 or 100 pages (half of the pages are attachments). Why produce such a large report? What is the use of that large of a report? What makes "size" of a report equivalent to "professionalism" of a report? Think about every aspect of the report and make sure it is needed. Normally, all that is needed is a:

- Cover sheet that includes the date, time, location, one or two sentence description of the near miss or incident, and a title that summarizes the incident at a glance. The cover sheet should also list the team members.
- Forms that have the causal factors filled in and the root causes filled in, with perhaps one or two sentences that explain the root cause. These forms can also contain the recommendations necessary to correct the root causes.
- That's It!

So, most near miss investigation results will be two pages or so and most loss/accident reports will be four pages or so.



The complexity of results reporting has grown from the legacy of only investigating losses/accidents. When an organization gets a large ratio of near misses report and therefore a large number of investigations going on, the reports must shrink. This is a good thing. However, if you still have a major accident (which you won't have if you get a large number of near misses reported and investigated), then add more documentation to meet the needs related to litigation, regulatory interface, etc.

5.5.2 Deciding which incidents should be investigated

All near miss incidents should be reported and cataloged with basic information and apparent causes, but not all near miss incidents will warrant a full investigation. Only those incidents with either high potential impact or high learning value should be investigated using the II/RCA process. This is an excellent opportunity to engage staff and give them control over the process by granting front line supervisors the authority to decide which incidents have high learning value. For example, establish a shift target of investigating 15-20% of the near miss incidents reported and then let them decide which ones they want to investigate to meet their goal.

6. CASE STUDY: One Company's Experience with II/RCA

A large pharmaceutical company (more than 50,000 employees) initiated a drive to report and analyze large numbers of near misses. Before this initiative, they had about 3 near misses reported per loss event. Their loss categories included quality impacts, reliability issues, safety mishaps, and environmental issues. Also before the initiative, they had five incident reporting systems, investigation protocols, and databases. One of the first steps the company took towards the stated goal was to consolidate the five reporting and investigation systems into one system. They tried to use one of the existing database systems for this consolidation, but decided that all were deficient for this purpose. So, they modified the reliability incident database to make it suitable for all types of incidents. This took several months of effort (not full time though).

In parallel, they adopted a new investigation approach, which is the one described in this paper. This involved changing the database structure to provide pull-down menus for each branch on the Root Cause Chart. The chart was not modified. Next, a training course for lead investigators was customized to meet their new needs and to use their examples in the exercises and case studies. Then, this course was presented seven times in the USA and UK, thereby training an initial group of 200 investigators but more importantly training 7 instructors within the company. The eventual goal was to train 15% of the operating staff how to perform root cause analysis (RCA) of near misses and losses. The new database and consolidation of reporting and analysis systems (developed in parallel with the development of the customized training materials), was rolled out at the same time as the initial training courses. The reporting system was incorporated into their Lotus Notes e-mail system. The reporting forms were very simple and any worker could report a near miss or incident. Initial reports were routed automatically by the e-mail system to the worker's supervisor and viewable by any qualified investigator. A lead investigator on the same shift rotation and from the site (but not from the same group) was assigned to each incident; investigations typically began within one hour and on average were completed within the next hour.

These initial efforts were extremely successful and within about one year, the company achieved a ratio of more than 100 misses being reported per loss event. All near misses and loss events were captured in the database of incidents and about 20% were high value and immediately investigated. Typical reports were 2-3 pages. After the first year, the sites performed queries of the databases and based on Pareto analysis, performed RCA on the highest number of repeated "similar" incidents. In subsequent years, the queries were performed every three months.

This new system was much more productive in reducing losses than the previous collection of five systems. Overall, production and quality losses were reduced about 95% with little or no increase in time spent in RCAs (because the number and magnitude of losses decreased dramatically and so there was much less time spent on fire-fighting and major investigations).

7. Conclusions

Near miss reporting and investigation has been very effective in reducing losses due to process safety incidents. However, implementation has proven difficult for many companies due to several implementation barriers. The proven methods described will improve both the efficiency and the effectiveness of the II/RCA process. Consistently applying these methods will enable near miss reporting, providing early detection and correction of process safety warning signals, thereby reducing losses and improving process safety performance.

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