

INCIDENT INVESTIGATION AND ROOT CAUSE ANALYSIS



January 2012

2nd Edition



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Incident Investigation and Root Cause Analysis

Published and distributed by Sutton Technical Books, Houston, Texas

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THE AUTHOR'S APOLOGY FOR HIS EBOOK



Over the course of the many years that I have been working in the process industries I have written a number of books and ebooks — mostly to do with risk management and process safety management. Titles that I have published include *Process Safety Management*, *Prestartup Safety Reviews*, *Management of Change*, *Procedures and Training in the Process Industries*, *Process Reliability and Safety*, *Y2K and the Process Industries* (sales of which are not what they were), *Process Risk Management* and *Fault Tree Analysis*. For a list of currently available publications please visit www.stb07.com. Worked examples that illustrate many of the concepts discussed in this ebook series are available as a free download from www.stb07.com/process-industry-examples.html. Reference materials for all the publications are provided at www.stb07.com/citations.html.

The ebook you currently have in your hand (or on your computer screen) is one in a series that attempts to show how process plant operations can be managed so as to achieve high levels of safety, environmental performance and profitability. The goal of the ebooks is to blend empirical practice with theoretical concepts to create publications that are useful to a wide range of technical professionals and managers in the process industries. My intent is that the publications help you, the reader, develop and manage your long-range plans. At the same time, I also hope that what I write is immediately useful at 8 o'clock on Monday morning.

The purpose of this particular ebook is to help managers, engineers and professional investigators with the investigation and analysis of incidents — ranging from near misses all the way to catastrophic events. Information about updates to this ebook can be found at www.stb07.com/process-safety-management/incident-investigation.html.

As always when I write, my greatest difficulty is in knowing when to stop. At least I can take comfort in the knowledge that I am not the only one to have experienced this difficulty. In his Apology (Preface) to his book *Pilgrim's Progress* the great 17th century Puritan author John Bunyan said, with far greater eloquence than ever I can hope to achieve,

*In more than twenty things, which I set down;
This done, I twenty more had in my crown,
And they began to multiply,
Like sparks that from the coals of fire do fly.
Nay then, thought I, if that you breed so fast,
I'll put you by yourselves, lest you at last
Should prove ad infinitum, and eat out
The Book that I already am about. . .*

Engineering companies express the same concept with the phrase, 'shoot the engineers'. It means that there comes a time when design must stop and construction must start. Project managers use the term 'scope creep' to express the same notion. Projects have an inexorable tendency to grow 'all by themselves' unless someone throws a yellow flag. When I first arrived in New York in the

year 1974 I was taught the phrase, 'Enough is enough already'. There's a good time to stop writing — and that time is now.

Finally, in every publication that I have written so far I have concluded the preface with the words Edmund Spenser used in the introduction to his poem *Faerie Queene*, 'Goe little book: thy selfe present'. So it is with this book — it is now in your hands gentle reader. I hope you find it useful.

Ian Sutton

Houston, Texas
2011

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CHAPTER 1 — INCIDENT INVESTIGATION AND ANALYSIS



Les gens heureux n'ont pas d'histoire.

(Happy people don't make history)

INTRODUCTION

The thorough investigation and analysis of incidents (both actual events and near misses), along with the appropriate follow-up, provides one of the most effective means of improving the safety and reliability of process facilities. Other risk management programs, such as hazards analysis and management of change, are directed toward anticipating problems so that corrective actions can be taken before an event occurs. Yet, in spite of their undoubted value, these predictive techniques do have the following limitations:

1. The analyses are, of necessity, theoretical and speculative; there can be no assurance that all plausible events have actually been identified. Indeed, it is more than likely that important failure mechanisms will be overlooked.
2. It is difficult to predict the true level of risk associated with each identified event because estimated values of both consequence and likelihood are usually very approximate. In particular, predictions as to what might happen are invariably colored by the personal experiences of the persons carrying out the analysis.
3. Most serious events have multiple causes, some of which appear to be totally implausible or even weird ahead of time (which is why serious accidents so often seem to come out of the blue). Even the best qualified hazards analysis team will have trouble identifying such multiple-contingency events.
4. It is very difficult to predict and quantify human error — yet most events involve such error.

Actual incidents, on the other hand, provide hard information as to how things can go wrong, thus helping to cut through wishful thinking, prejudice, ignorance and misunderstandings. The root cause analysis that follows an incident investigation will help identify weaknesses and limitations in a facility's management system, thereby reducing the chance of recurrence of similar incidents.

Another reason for emphasizing the importance of incident investigation in the process industries is that process safety management (PSM) systems — of which Incident Investigation and Analysis constitutes one element — have been in place in many cases for more than fifteen years. Many of these facilities have made good progress in meeting regulatory requirements. However, the fact that such systems can 'survive an audit' and are working well on paper does not mean that they are as effective at actually improving safety as they might be. Incident investigations

help identify how the elements of PSM really are functioning, and can provide management with insights as to how the systems can be improved.

INCIDENT INVESTIGATION AND ANALYSIS PHILOSOPHY

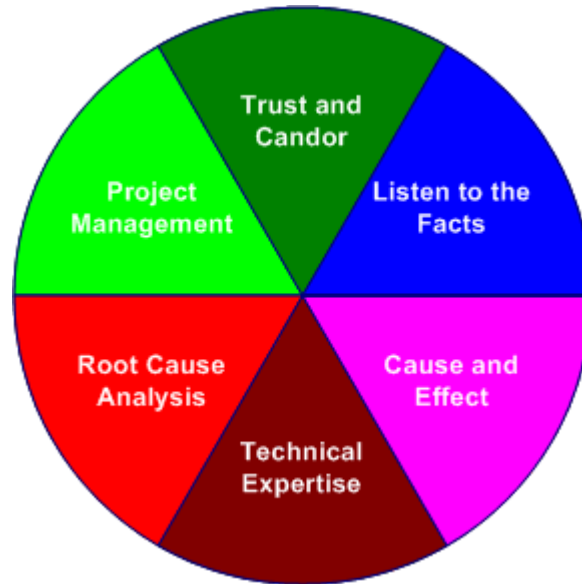
Publications in the field of incident investigation and analysis often promote a particular methodology with the implicit claim that their approach is better than the methods promulgated by other organizations. Such publications are often commercial in their approach, thus tending to create a concern in the mind of the reader as to the objectivity of the materials that are presented.

This particular ebook does not advocate or promote any particular methodology. Indeed, it is suggested here that an effective incident investigation and analysis requires much more than the mere application of a particular investigation technique. Equally important — maybe more so — is the ability on the part of the investigators to inculcate an atmosphere of trust and confidence with everyone with whom they work — not only those involved in the incident itself, but also the managers who will be charged with taking appropriate corrective actions. Each analytical technique has its strengths and weaknesses — an effective investigation will use a judicious mix of approaches as circumstances dictate.

Therefore, rather than stress the use of just one particular analytical method this ebook suggests that a successful investigation should be conducted through use of the six strategies and techniques listed below and also shown in Figure 1.

1. Establish trust, and thereby encourage candid discourse from those involved in the event and also from the managers responsible for follow-up.
2. Listen to what people actually say, base all findings on verifiable facts, and be thorough in all phases of the investigation.
3. Establish a clear cause and effect chart — backed up with solid evidence — integrated into a timeline.
4. Use technical experts to assist with understanding specialized issues.
5. Develop an understanding of root causes and systemic issues at different management levels.
6. Manage an incident investigation and analysis as a project with its own schedule, budget and deliverables.

Figure 1
Elements of Successful Incident Investigation and Analysis



Trust and Candor

The most important feature of a successful investigation is the establishment of trust between the investigators — who are *not* interrogators — and the persons involved in the incident itself. In one instance a technician whose actions had contributed to the occurrence of an injury event approached his boss twenty four hours after the interviews had been concluded; he voluntarily reported that a valve that should have been open at the time of the incident was actually closed. Without that information it is unlikely that the investigating team would have ever have fully understood what happened. The technician was not the only person who was candid. His boss, who had twenty five years of experience with the equipment involved, took the initiative to successfully work out the complex sequence of events that led to the incident, even though the upshot was to make his own company and he himself look more accountable for the event. The integrity and candor displayed by these two persons showed that the investigation process had gone well.

It is also important to establish trust with the managers of the facility where the incident occurred. This can be done by ensuring that the investigation team keeps management and other directly affected parties fully informed at each stage in the investigation process. Thus the project becomes “our investigation”, not “their investigation”.

Listen to the Facts

Many incident investigators are intelligent, highly experienced, and are not lacking in self-confidence. Although these attributes are important they can get in the way of simply listening to the facts. For example, during one investigation, the team members noted that a piece of equipment was damaged. By assuming that the damage occurred immediately prior to the event a plausible explanation as to what happened was developed. Unfortunately for the credibility of the team members who had jumped to the (incorrect) conclusion as to what had happened, a manager who arrived at the site a few hours after the incident noted that the

equipment had not been damaged at that time; therefore the damage must have occurred when the affected equipment item was being removed for inspection and repair. This inconvenient fact overturned the investigators' elegant and satisfying analysis.

An investigator must always be thorough — particularly when he or she thinks that the investigation is complete, and no more fact finding work is needed. For example, on one investigation the equipment involved in the event was moved from its location in the field to the vendor's yard. The lead investigator felt that there was really no point in going to the site of the incident because there would be nothing to be learned. Nevertheless, he did visit the site as a matter of duty. When he did so he uncovered some new information that led to a basic reassessment as to how serious the event could have been.

Cause and Effect

Virtually all investigations include the development of a timeline (*see* Chapter 5 for a detailed explanation of this topic). By ordering the events sequentially it becomes possible to determine their causes, and then the causes of those causes.

Technical Expertise

One engineering company had as its motto, "There's no substitute for knowing what you're doing". In many investigations it is found that a real expert is needed in order to establish the technical details as to what happened. As already noted in the example provided above, a senior manager who had twenty five years experience to do with the equipment involved took it upon himself to determine what happened. Without his insight, knowledge and experience the investigation team would have taken much longer to determine what happened — indeed they might never have done so.

Root Cause Analysis

Once the facts have been established and an understanding of the event has been established, a root cause analysis can be carried out in order to apply lessons learned to a broader set of circumstances. Chapter 6 outlines four types of root cause analysis. They are:

1. Argument by analogy (story-telling);
2. Barrier analysis;
3. Categorization; and
4. Systems analysis.

Each of these approaches can be of value — to purposely exclude any of them, particularly for commercial reasons, is short-sighted.

With regard to the incident cited on page 3 the root cause was shown to be the lack of proper management of change. Many years prior to the incident a block valve was inserted into the system; this valve had the effect of allowing one part of a depressurized system to retain pressure. In order to demonstrate the dangers associated with having this valve in the system the lead investigators visited a factory where brand new units are made, and found that the valve in question is never installed in the factory, moreover the factory superintendent gave it as his opinion that the installation of such a valve was an unacceptable practice.

Project Management

One of the difficulties associated with many investigations is that they tend to suffer from “scope creep”. They grow and grow and grow with root causes being piled upon root causes, without any clear idea as to when the end point has been reached. As one manager once sarcastically observed, “The team seems to be trying to solve world poverty.” It must be understood by all the team members that an investigation is a project, just like any other project. As such it needs a budget, a schedule, a clear scope of work and a contingency plan for when things go awry. Project management issues are discussed in Chapter 8.

A particularly common project management difficulty is that an investigation proceeds well until the root causes of the incident have been established, at which time the investigators are often given other assignments because they really need to get on with their ‘real work’. Therefore the ‘danger point’ to watch for with respect to project management is that time between completion of the analysis and the writing of the report.

COMMUNICATIONS

An effective incident investigation and analysis program generally contains two major components: technical and human. The technical side of the investigation is what most publications in this area focus on, particularly with regard to root cause analysis. However, what does not always receive the same degree of attention is the human aspect of incident investigation work. An effective investigator understands how people think and behave. Consequently he or she must be able to communicate with a wide range of people, particularly those listed below.

- *Technicians*

Most incidents involve front-line technicians (operators and maintenance workers), some of whom may have been injured or emotionally shaken. These people will often be feeling defensive and upset. They may also be feeling guilty if any of their colleagues were injured or died.

Technicians often may not understand what caused the incident, but they are worried that they will be blamed anyway. An effective investigator encourages these front-line technicians to be open and candid — primarily by simply shutting up and letting them talk. Unfortunately, many investigators — who often possess years of experience — are much too quick to interrupt the technician’s narrative flow with questions, war stories or snap judgments as to what happened. An investigator should also make it clear to the technicians that the goal of the investigation is to find out what happened — not to apportion blame or to demonstrate how smart the investigator is.

- *Mid-Level Managers*

Most investigations find that changes are needed at the facility’s mid-level management systems. Examples of such changes include an increased emphasis on equipment inspection, upgraded operating procedures and beefed-up training for the technicians. The implementation of such changes requires that the facility managers commit scarce resources that they would prefer to spend on achieving other goals. An effective investigator will empathize with these mid-level managers, and will understand the demands that are being placed on the organization by the investigation and its follow-up.