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# IPICA_Lite—Improvements to root cause analysis

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ABSTRACT

A few modifications can significantly improve root cause analysis using predefined trees. These modifications are based on adopting four ideas: (1) Causes represent deficiencies in processes. (2) Processes connected to causes are grouped into a hierarchy. Superior processes shape the subordinate ones. (3) The same safety management system can be applied to all processes in the hierarchy. (4) The structure described in the CCPS Guidelines for Risk Based Process Safety represents a universally applicable safety management system. Simultaneously, it can be transformed into a universal RBPS Root Cause Map.

The resulting IPICA_Lite procedure described in this paper can serve as a tool that identifies underlying causes, including the problems inherent in a safety culture, and promotes corrective recommendations including the third layer recommendations, enforcement of which is often difficult.


## 1. Introduction

Kletz's book [1] established what is now considered to be a self-evident truth: Causes of undesirable events are analyzed in order to identify recommendations on how to prevent the recurrence of events or the occurrence of similar events. Kletz states that we need to look in our analysis beyond the immediate causes for the underlying causes. Three layers of recommendation should be identified:

(1) First layer recommendations: preventing the accident, (2) second layer recommendations: avoiding the hazard, and (3) third layer recommendations: improving the management system.

Moreover, book [1] anticipates the themes which came to the forefront later, especially the importance of attitudes to safety (in other words safety culture) for the prevention and remedy of incidents. E.g. the relatively well-known Kletz's sentence: 'It often seems that managers must not be human because incident investigation reports rarely indicate that they make mistakes.' Indubitably refers to the management's attitudes.

The term 'root causes' became the usual term for Kletz's underlying causes. Engineers in various industries use Root Cause Analysis (RCA) to identify three levels of recommendations. Various ways in which Root Cause Analysis (RCA) could be performed in chemical industry are described in both first and second editions of the CCPS guidelines on incident investigation [2,3]. The second edition [3] brings a further division of RCA approaches where, in Chapter 9, two different methods of root cause determination are described. RCA using logic trees is called method A and RCA using predefined trees is called method B.

The author presumes that RCA method B is applied to incident investigations in chemical and energy sectors relatively frequently. Nevertheless, it is difficult to verify this presumption by exploring relevant literature. Ten articles, [4–13], which mention root causes and refer to the CCPS guidelines on incident investigation have been published in Process Safety Progress (PSP, journal published on behalf of the publisher of guidelines) since 2003. Eight of these articles are case studies or summaries of results of accident investigations. Mostly they refer to the guidelines [2], but not [3], and do not indicate the method of root cause determination. Only one article, [7], clearly indicates that the method A from [3] was used. Surprisingly, no article indicates the use of method B. Two of 10 listed articles, [9] and [13], deal with the difficulties of incident investigation and the RCA method. Both of them reflect on the role senior managers play in shaping the culture of an organization; and at the same time the papers motivate the authors of recommendations to focus on tackling problems in the field of safety culture.

The absence of RCA method B in recent PSP articles does not mean that method B is not used in real-life investigations. Rather it implies that method B is so simple and obvious that it is generally not considered worth discussing in the journal chosen for investigation. On the contrary, the important position of RCA method B in industrial practice seems to be confirmed by the existence of numerous literature sources which polemize with RCA or which search for alternative approaches. So e.g. in his handbook [14], mainly in Chapter 10, Johnson thoroughly describes the application of RCA, and identifies its deficiencies

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and limitations. Leveson [15] is a leading figure among those academicians who are deeply skeptical about the suitability of RCA, and especially RCA using predefined trees, for trustworthy analysis of incidents. Her two most important objections may be summarized as subjectivity (e.g. in the selection of an initiating point of causal chart) and shallowness (e.g. the tendency to concentrate on events immediately preceding the loss). In order to improve the RCA, ESReDA guidelines [16] recommend the application of organizational analysis which is – according to paper [17] – based on the identification of pathogenic and resilient organizational factors. Article [18] compares three incident analysis methods alternative to the RCA.

Although the author of this article agrees that these reservations are legitimate, he does not think that subjectivity and shallowness disappear as soon as the RCA is abandoned. He is well aware that causal charts and predefined trees are not only the most criticized, but also the most popular features of the RCA. Rooney and Vanden Heuvel [19] give a good example which illustrates the charms of the application of RCA method B. The Summary Root Cause Table in [19] is especially noteworthy, since it connects each of the multiple root causes with the three layers of recommendations mentioned above.

The author attempts to improve the RCA method B without spoiling these charms. After becoming acquainted with its limitations, he suggested a method named IPICA (Integrated Procedure for Incident Cause Analysis), which incorporates tools originating from the STAMP method (described e.g. in [15]) into the framework of RCA. The IPICA procedure and its use are explained in Refs. [20,21].

Nevertheless, IPICA combines two very different approaches, thus making the resulting method rather complicated. In the current article the author wants to show that a few modifications created within the development process of IPICA can significantly improve the RCA method B. The resulting simplified IPICA method can even serve as a tool that helps identify the problems in a safety culture, and promotes the third layer recommendations addressing such problems. In such a way, coping even with the no-mistakes-making managers may be much easier. The simplified IPICA method that fulfills these practical requirements without the use of tools derived from the STAMP method is called here IPICA_Lite. The results of IPICA_Lite analysis are organized into a summary table which attempts to reflect Benner's [22] ideas regarding data documentation.

Improvements chosen to be used with the IPICA_Lite shift the RCA method substantially closer to "system safety as a control problem" as it is described in review article [23]. The improvements make incident cause analysis procedure more complicated than when conducting an analysis according to RCA method B, but, hopefully, more suitable for everyday practice in process safety than e.g. the methods applied in articles [24–26] within this journal.

The explanation is organized into eight sections. Basic rules of RCA method B are summarized, and practical definitions are introduced in Section 2. Section 3 provides an illustrative example which is used in illustrative Sections 4 and 7. Section 5 summarizes the ideas for improvements that are implemented by creating an improved procedure IPICA_Lite in Section 6. Section 8 compares the results from Sections 4 and 7.

## 2. Root cause analysis—Method B

### 2.1. First step

Root Cause Analysis follows the collection of data, and precedes the recommendations. It can be divided into two steps. In the first step, the course of the accident is reconstructed, known data about the accident are organized and, finally, causal factors are identified. An events and causal factors chart (E&CFC) documents the implementation of all these activities.

An E&CFC is created step by step, beginning at the end of the incident sequence and moving backwards in time. Rectangles (occurrences) connected by arrows describe the timeline i.e. the chronology of the development of the incident. The description of conditions/circumstances in which occurrences have occurred are connected to rectangles. Conditions/circumstances are represented by ovals. All ovals connected to a rectangle describe the context of an individual occurrence in the timeline. Detailed recommendations on how an E&CFC should be created are described in Ref. [3]. Although [3] aims to provide a very accurate and detailed guidance for the creation of an E&CFC it still leaves considerable room for different individual approaches. Quite different charts may arise. It is therefore desirable to make the procedure for further processing of the chart so robust that similar determination of root causes will result even from different charts.

Causal factors constitute necessary and sufficient conditions for the development of an incident. Guidelines [3] recommend to identify them as major, unplanned, unintended contributors to the incident that, if eliminated, would have either prevented the incident, or reduced its severity or frequency. The word 'contributor' in this definition may represent both a negative occurrence, and an undesirable condition.

Conditions are associated with occurrences. Thus (negative) occurrences including their (undesirable) context can also be described as contributors. In this case, context determines whether a non-negative occurrence is a causal factor or not. The author considers this definition of contributors to be more advantageous because it unifies the approach to causal factors, and allows searching for them strictly chronologically. A chronological search facilitates the exclusion of dependencies since a candidate causal factor, which is the inevitable consequence of a causal factor cannot itself be a causal factor.

### 2.2. Second step

In the second step, the root causes are gradually assigned to individual causal factors. A Summary Root Cause Table (SRCT, see [19]) documents an aggregation of all causes of causal factors which are considered to be the multiple causes of the accident. It is also advisable to include in the table all the recommendations that have been proposed based on determining the multiple causes. The recommendations are meant to address the deficiencies revealed by the root causes. The resulting summary table then perfectly supports the incident investigation feedback.

Root causes are identified in method B using predefined trees that attempt to represent a list of all possible types of deficiencies in the safety management system. The most respected and probably the oldest predefined tree is the MORT tree (see e.g. [27]). A MORT tree however is very complicated, mainly because both OR and AND logic gates are present in its structure. Other trees have been created for determining the root causes in which AND gates are not explicitly present. Root Cause Map ABS Consulting, which is published in both [3] and in [19], represents an example of such a tree. Following the example of this map we call Root Cause Maps all those trees without explicit AND gates. The map can be regarded as a hierarchy of checklists. As is usual for checklists, the map represents the accumulated experience of a group of professionals.

A root cause is defined differently in [2,3]. According to [3], it is a fundamental, underlying, system-related reason why an incident occurred that identifies a correctable failure(s) in the management system. Article [9] notes that many more attempts to define a root