|  |  |
| --- | --- |
| cetlogo ***CHEMICAL ENGINEERING TRANSACTIONS***  ***VOL. xxx, 2025*** | A publication of  aidiclogo_grande |
| The Italian Association  of Chemical Engineering  Online at www.cetjournal.it |
| Guest Editors: Bruno Fabiano, Valerio Cozzani  Copyright © 2025, AIDIC Servizi S.r.l. **ISBN** 979-12-81206-xx-y; **ISSN** 2283-9216 | |

The 2nd Loop Project – Learning from small incidents

Mats Lindgren

The Swedish Process Safety Association, Rönngatan 12, 426 77 Västra Fröliunda, Sweden

mats@ips.se

The 2nd Loop Project was an analysis of approximately 200 process safety events at six companies, conducted by The Swedish Process Safety Association (IPS) during 2023. The objective was to evaluate the scope and quality of investigations, and to draw conclusions about the lessons learned. At each participating company, records from 30-40 process safety events from recent years were reviewed by a small group of safety specialists from the participating companies, led by the IPS director (this author). Most of the events were relatively minor LOPC's (loss of primary containment), challenges to barriers or malfunctioning barriers.

The main conclusion was that the process of learning from small incidents and near misses could be improved significantly. Regular reviews of incident reports, investigation results and resulting actions by process safety specialists and production staff together should be implemented or reinforced. Regarding common causal factors, it was concluded that poor design/construction often leads to cumbersome procedures and thereby invites human error, and that poor maintenance in aging plants often leads to leaks and malfunctioning equipment. It is proposed that these conclusions can be generalized to many companies in the process industry.

* 1. Introduction

The 2nd Loop Project was a qualitative analysis of approximately 200 process safety events at six companies, conducted by The Swedish Process Safety Association (IPS) during 2023.

The project was inspired by a doctoral thesis about learning from incidents in the process industries (Jacobsson, 2011). This is a quote from a subsequent book on the same topic, written by the same author (MSB, 2012, p. 11):

*There are many small incidents, and few major ones. Correctly handled the small incidents are a source of many lessons to learn from. Even deep-seated weaknesses in an organization and its systems can be identified by good handling of the small incidents. By taking good care of the small incidents, one can learn lessons in nearly all areas that matter for safety. The major accident should not have to occur!*

The specific objective of the project was to evaluate the scope and quality of investigations and to draw conclusions about the lessons learned and the process of learning from incidents. The wider objective was to promote improved learning from incidents among IPS member companies by dissemination of the project results. This paper is a summary of the project report (IPS, 2024).

* 1. Method

A project proposal was developed by the IPS director (this author) in cooperation with the IPS program committee and sent to all the member companies who operate process plants. As a result, six companies who operate chemical or petrochemical plants covered by the Seveso Act in Sweden decided to participate:

* Borealis
* IneosInovyn
* Kemira
* Nynas
* Perstorp
* SEKAB

A project group was formed, consisting of the IPS director and 1-2 safety specialists from each company. This group developed a project plan and conducted the project together.

* + 1. Selection of events

It was decided to use the definition of Process Safety Events (PSE:s) described in the API Recommended Practice 754 (API, 2021) as the basis for selection of events. Parts of API 754 were already used for event classification by several of the participating companies. A PSE is “an unplanned or uncontrolled release of any material, including non-toxic and non-flammable materials…or an undesired event or condition that under slightly different circumstances could have resulted in a release of material” (API, 2021). PSE:s can be divided into Tier 1-4 according to API 754. That was not done in the project due to frequent lack of sufficient detail in the data, but the definitions of Tier 1-3 were used broadly for the selection of relevant events.

* Tier 1: Loss of Primary Containment (LOPC) of Greater Consequence.
* Tier 2: LOPC of Lesser Consequence.
* Tier 3: LOPC below Tier 1 or 2 or challenges to Safety Systems, e.g. safe operating limit excursions, inspection or testing results outside acceptable limits, or demands on safety systems.
  + 1. Review of events

Each team member scanned the incident database at his/her company, working backwards in time until 30-40 events had been identified. The number was agreed by the team to get a manageable scope, considering the time and resources available. Typically, the events had occurred in the previous 1-3 years. At one company, events at sites both in Sweden and abroad were considered. At the remaining five companies, only events at the site where the project team member was based were considered.

The database records for each event were reviewed and classified in two-day meetings at each company. The IPS director and the project team member from the company in question participated in person, and one of the other team members participated via Microsoft Teams. At times, other staff from the company in question also participated. Generally, only the information available in each company’s incident database was considered. In a few cases, additional information about a particular event was also made available.

* + 1. Classification

During the review meetings, each event was classified with the following parameters:

* Mode of operation according to API 754.
* Point of release according to API 754.
* Causal factors according to API 754. There are 13 primary causal factors in the model, and each has several sub-categories. For each event, three primary categories and sub-categories were selected.
* Actual severity according to the IPS 5x5 risk matrix (IPS, 2012) where severity 1 means negligible effects on people, the environment and finances, and 5 means multiple fatalities, severe environmental effects or major financial impact.
* Potential severity and risk according to the IPS 5x5 risk matrix (IPS, 2012), where frequency 1 is less than 0,001 per year and 5 is more than once per year.
* Amount and quality of the information available in the database on a scale from 1 (very limited) to 3 (comprehensive).
  + 1. Review of results and conclusions

During the preparation of the report, there were meetings with the project group to review and calibrate the results and agree on conclusions.

* 1. Results

Key aggregated results of the classifications are shown in the diagrams below. Additional diagrams are included in the project report (IPS, 2024).

There were some differences between the participating companies, but the overall results and conclusions are valid for all the participating companies, with only slight variations. Detailed results were kept by each company for internal use.

* + 1. Actual severity

Most of the events had negligible or minor consequences. That is an indication that the reporting of near-misses and anomalies is working, even if there is some under-reporting.

Diagram 1: The total number of Process Safety Events in each severity category

* + 1. Amount and quality of information

In most cases the information in the database was limited, as shown in the diagram below. Still, since the number of events with comprehensive information is greater than the number of events in severity category 3 and 4, it seems that the participating companies do handle some near-misses and anomalies more rigorously. The time and effort spent on a particular event should be based on consideration of the potential risk and the potential for organisational learning, but that was not always obvious from the database records.

Diagram 2: The total number of Process Safety Events in each category of information amount/quality

* + 1. Causal factors

Both primary causal factors and sub-categories are shown in the full project report, but for the purpose of this paper, only the primary causal factors are shown in the diagram below.



Diagram 3: The number of events where a certain primary causal factor was considered relevant

The most common sub-categories among the three dominant primary categories were:

* Design/construction: “Engineering less than adequate”.
* Human performance: “Other”, which was selected when operator actions were involved, and more specific sub-categories related to human performance did not seem applicable, or the available information was not enough to select one of those.
* Equipment reliability: “Pre-mature failure” closely followed by “Preventive maintenance/testing less than adequate” (often the selection of one or the other was somewhat arbitrary, as they can be “two sides of the same coin” and the available information was limited).
  + 1. Mode of operation and point of release

Typically, 72% of the total number of PSE:s were either gas or vapour releases to atmosphere, or liquid releases to concrete surfaces with drains to effluent treatment facilities. The most common mode of operation at the time of a release was “equipment preparation for maintenance”, closely followed by “start-up” (19 and 18 events, respectively). The most common point of release was, by far, “piping systems with diameter < 50 mm”, with 43 events. In addition, flange leaks were counted separately and there were 17 of those (irrespective of diameter).

The diagrams for mode of operation and point of release are not included here, due to limited space, but they are available in the full project report.

* 1. Discussion

Two events are discussed here, to briefly illustrate the reasoning behind some of the overall conclusions, especially regarding common causal factors.

* + 1. Leaking heat exchanger due to corrosion

A heat exchanger started to leak shortly after start-up, following maintenance work where the tube bundle had been removed for inspection. It turned out that the internal rubber lining on the bonnet was damaged, most likely due to a combination of aging and awkward handling during the maintenance work. After startup, the corrosive liquid came in direct contact with the carbon steel, which led to rapid corrosion. The following causal factors were considered relevant:

* Primary: Design/Construction; Secondary: Fabrication or installation less than adequate.
* Primary: Equipment reliability; Secondary: Preventive maintenance/testing frequency less than adequate.
* Primary: Human performance; Secondary: Ergonomics less than adequate.
  + 1. Leakage from temporary hose connection

A hose had been connected to a vent valve to enable flushing of a system, an infrequent operation. The vent was located high up in a pipe rack with no permanent access way. Hence a ladder had been used. When the system was taken into normal operation after completion of the flushing, the hose was left in place with the vent valve still in the open position. No non-return valve had been installed, which was a deviation from standard design for hose connection points and standard operating procedures. The following causal factors were considered relevant:

* Primary: Operating procedures; Secondary: Procedure available but not used/followed.
* Primary: Design/construction; Secondary: Construction not consistent with design.
* Primary: Human performance; Secondary: Other.
  + 1. Human error is not a cause

In the so called “New View of Safety” it is stressed that workers at the “sharp end” of an organization (e.g. plant operators and maintenance technicians) often have to deal with complexities and goal conflicts (Dekker, 2014). After a process safety event, it should be investigated thoroughly why people acted as they did and why it made sense to them at the time (“local rationality”). That was often difficult in this project due to the limited information available in most cases, and the fact that we did not have any possibilities to interview people involved in the events. However, we did our best with the information available. When “human performance” was selected as one of the primary causal factors, two organizational or technical cause categories were also added for that event.

* + 1. Organisational learning

Based on the information in the data bases, it seemed that the resulting organisational learning was limited for most events. Described in terms of the six-stage model for assessment of the level of learning from incidents developed by Jacobsson (2011), most actions would correspond to:

* Level 0: Essentially no learning, e.g. simply repairing damaged equipment.
* Level I: Limited local level learning, e.g. communication with the most affected personnel about the event and what to keep in mind to prevent recurrence.
* Level II: Limited organisational learning, e.g. changes in a local procedure and providing some information or training. Alternatively, changing the material of construction in the affected part of the system.

Responsible engineers and managers may have made well-grounded decisions not to prioritize time-consuming and expensive actions in many cases, but it appeared that many worthwhile opportunities for organisational learning and risk reduction had been missed.

* 1. Conclusions and recommendations

Classification of process safety events is inherently subjective and dependent on the underlying accident model, especially when it comes to causal factors (Lundberg et al., 2009). Furthermore, in this project the information in the data bases was limited for most of the events. Hence, the statistics must be interpreted with caution. However, in combination with tacit insights gained during discussions with the project participants, the results were interpreted towards the following conclusions and recommendations. It is proposed that they can be generalized to many companies in the process industry.

* + 1. Conclusions regarding common causal factors
* Human performance (“error”) is a common factor but it should always be a starting point for further investigation.
* Less than adequate design/construction leads to cumbersome procedures and invites human error.
* Less than adequate maintenance (including inspection) in aging plants leads to increased risk of both small and large leaks.
  + 1. Conclusions regarding the process of learning from incidents
* More efforts are needed to improve the handling of process safety event reports and check the outcome of recommendations.
* Process safety specialists should be involved in the investigation of all process safety events.
* Regular reviews of all process safety event reports, and the resulting investigations and actions, should be conducted by process safety specialists and production staff together.

Acknowledgments

I would like to thank the participating companies, especially the project team members, Christina Bas, Emelie Forss, Richard Forss, Björn Lindberg, Alba Soto, Anne-Louise Thäng and Richard Widell. Without their great support, this project would not have been possible.

References

Dekker, S., 2014, The field guide to understanding ‘human error’, CRC Press, Boca Raton, Florida, USA.

API, 2021, Process Safety Performance Indicators for the Petroleum and Petrochemical Industries, ANSI/API Recommended Practice 754, 3rd edition, American Petroleum Institute, 2021.

IPS, 2024, Learning from Incidents – A Second Loop, Analysis of approximately 200 incidents at six member companies (in Swedish), The Swedish Process Safety Association.

Jacobsson A., 2011, Methodology for Assessing Learning from Incidents – a Process Industry Perspective, Doctoral thesis, Lund University, Sweden.

Lundberg J., Rollenhagen C., Hollnagel E., 2009, What-You-Look-For-Is-What-You-Find – The consequence of underlying accident models in eight accident investigation manuals, Safety Science 47 (2009) 1297-1311

MSB, 2012, Learning Big from Small Incidents – a Guideline for Evaluation of the Efficiency of Learning (in Swedish), The Swedish Civil Contingencies Agency.