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Incident Cause Pattern Analysis at Bayer

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A detailed investigation of each occurred LoPC incident is essential for Bayer to improve safety, avoid future incidents and to strengthen safety awareness. But to look only at each incident individually is not enough as potential cause patterns cannot be found. The identification of common “leaks” and “flaws” is of utmost importance to identify weak points and to decide where to place effort for improvement measures. During the last years different systematic approaches for the analysis of incident patterns have been established at Bayer with different key objectives. The used “SIEVES” method which was developed in the end nineties at Bayer determines the underlying causes with a focus on more general aspects to facilitate an evaluation of the corporate safety strategy.
The objective of incident pattern analysis which was established during the last years is to identify potential underlying patterns which may have contributed to repeating incidents through identification of repeating causes and conditions in the incident process. This systematic approach is also implemented in the corporate incident reporting system at Bayer.
The pattern analyses show that the different causes and contributing factors are mainly related to the lack of competence and awareness of the people involved and less to pure technical reasons.

1. Introduction

It is a key objective of Bayer that Process & Plant Safety is regarded as a matter of highest priority and that a strong common safety culture is assured which is essential for the safe design and operation of processes and plants. In order to build and maintain a strong safety culture an in-depth knowledge and understanding of the process and plant safety principles must be embedded in the organization and lived by all employees.
The process safety contribution towards a sound safety culture is the implementation and maintenance of the overall safety concept of our installations. This includes:

- A robust iterative safety review process
- Implementation of safe installations and life cycle management for the entire plant incl. safety measures
- A thorough and comprehensive safety and process documentation
- Robust Management of Change and Work Permit processes
- Ensuring process knowledge and competency by education and training including lifelong learning
- Clear rules, regulations and procedures to promote adherence and an understanding of “what” and “why”
- Open communication and dialogue top down and bottom up based on trust
- Performance monitoring achieved through leading and lagging performance indicators and audits
- Investigation of and learning from incidents and near hits

Therefore, to achieve the safe design and operation of processes and plants and to continuously improve the safety culture and overall safety concept the investigation and learning from incidents is an important factor.
The investigation of and learning from all incidents is not helpful and a clear focus has to be put on relevant indicators for process and plant safety. After the Texas City incident in 2005 process safety indicators have been established by the industry to monitor the performance of process safety. In this context a definition for a process safety relevant incident was defined, the so called **L**oss **o**f **P**rimary **C**ontainment (LoPC).

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A LoPC incident is defined as an unintended release of a substance or energy from a primary containment (i.e., vessel or pipe) which is located in production, distribution, storage, utilities, pilot plants or laboratories of a facility meeting at least one of the following 3 criteria:

- Resulting in a lost time injury (≥1day) or fatality with an employee or contractor lost time injury (≥1d) and/or fatality or hospital admission and/or fatality of a third party (non- employees/contractor)

  or
- Direct cost ≥ € 20,000 caused by fires or explosions (thermal decomposition, bursting) resulting ≥ € 20,000 of direct cost to the company

  or
- Exceeding one of the following threshold limits
  a) GHS Toxic Cat. 1 + 2 (or T+, T) > 5 kg
  b) Any other hazardous substance > 100 kg
  c) All other substances > 2000 kg

Figure 1 illustrates the Loss of Primary Containment incident reporting workflow.

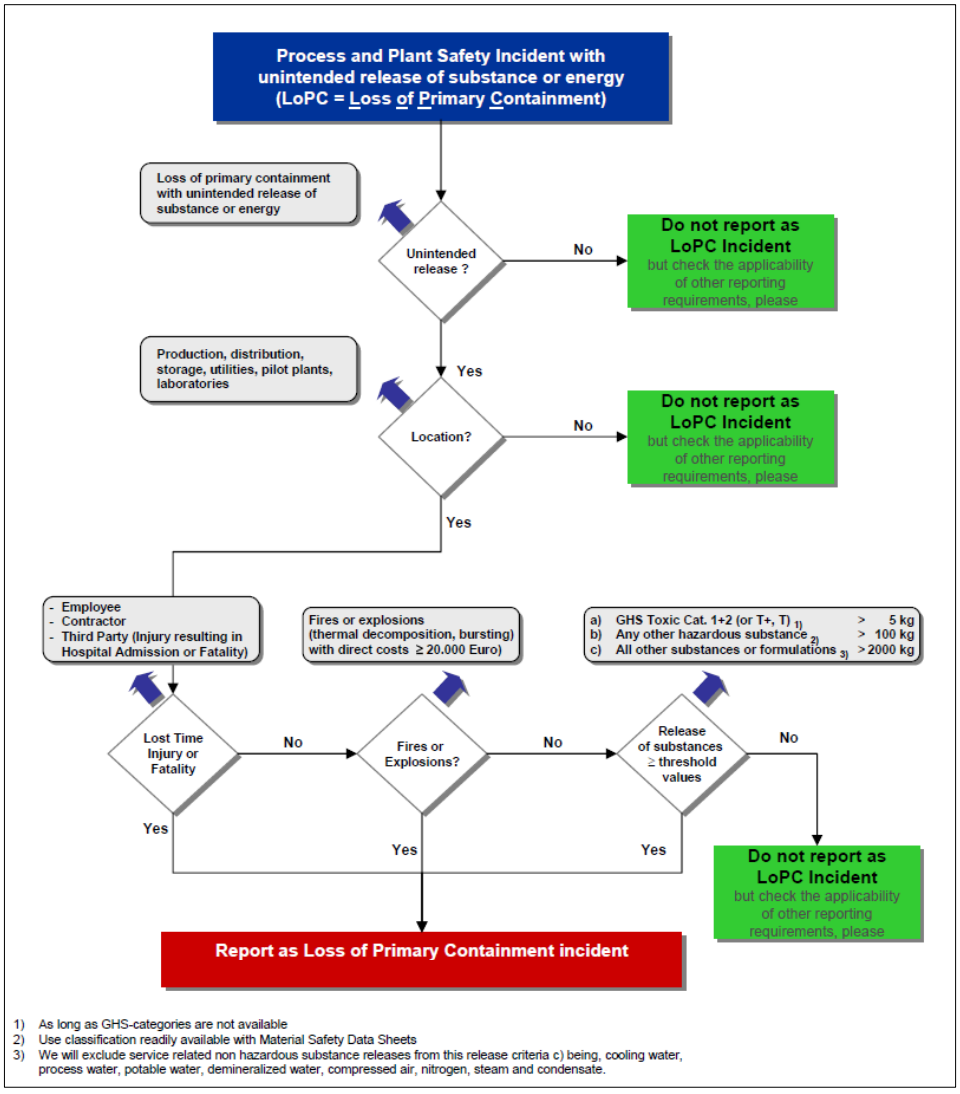

Figure 1: Loss of Primary Containment Reporting Flow Diagram

The reported LoPC incidents in a specific period are also used as basis for the incident cause pattern analysis at Bayer which is described in chapter 3.

2. Learning from incidents at Bayer

As an integral part of Bayer's commitment to sustainability it is our goal to ensure that the operations do not pose any inappropriate risks to employees, the environment and community. Therefore a consistently high level of safety has to be achieved in all processes and plants within the Bayer Group and process and plant safety has to be continually improved. Applying this principle to an incident means striving seriously to achieve the improvements necessary for preventing the recurrence of incidents with similar causes. This implies a systematic investigation of incidents with the following steps:

- Identification of the causes
- Determination of the recommendations necessary to prevent a recurrence
- Ensuring that action is taken on these recommendation

Thereby we expect to find any information necessary to avoid future incidents in our plants, to collect knowledge about any new scenario to perform better and more efficient safety reviews and to strengthen awareness and competence of the employees. The investigation and analysis of each incident individually is mandatory and has to be carried out to determine the root causes of the respective event. However, the investigation of each incident individually is not enough from a company perspective. To identify potential cause patterns and common "leaks" and "flaws" which are relevant for the whole organization further analysis are required.

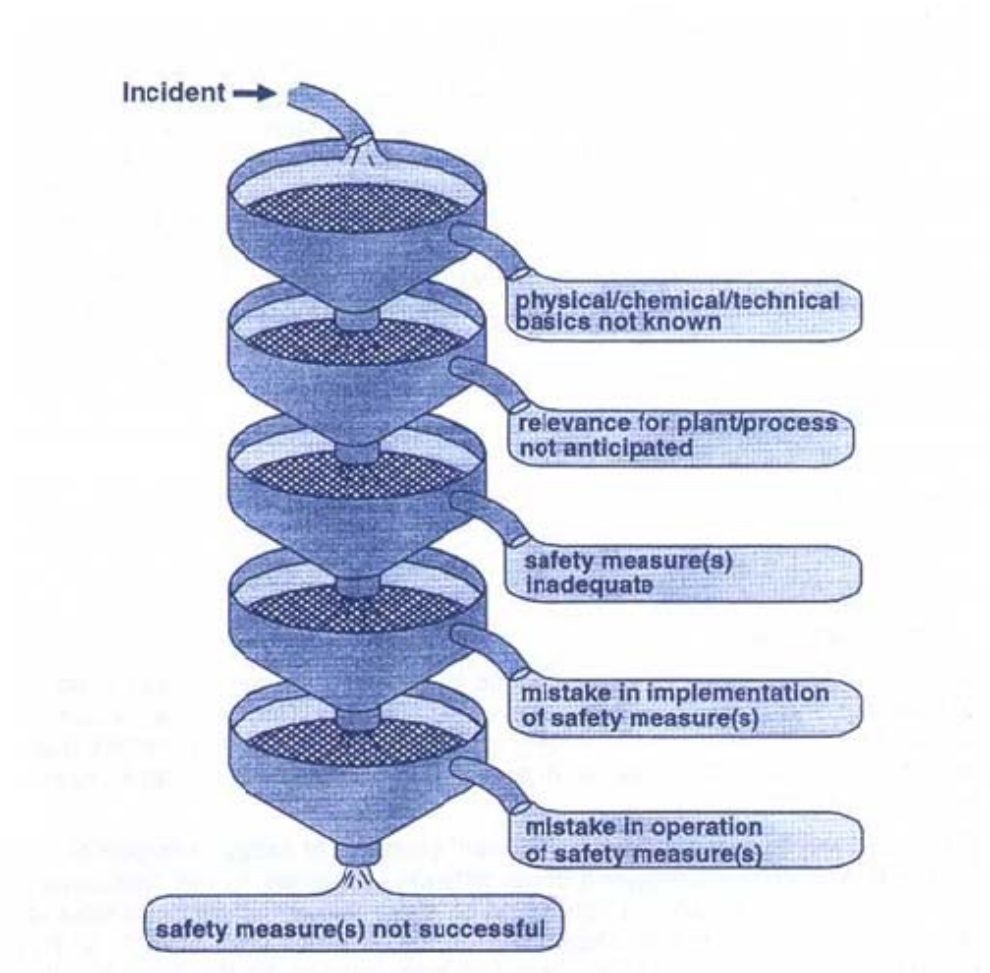

Figure 2: Bayer "SIEVES-Model" to evaluate underlying causes of an incident

End of the nineties Bayer has developed a method which determines the underlying causes with a focus on more general aspects to facilitate an evaluation of the corporate safety strategy. In this statistical analysis the incidents are treated in a kind of "sieve shaker" (Figure 2) where each sieve is characterized by a question such as "Have the physical/chemical basics been known before the incidents?" or "Has the relevance of the failure which leads to the incident been considered before the incident?". Depending upon the answer ("yes"

or “no”) to the corresponding question either the considered incident remains on the sieve or falls through to the subsequent sieve where the next question has to be answered. The distribution obtained gives specific information about particular weaknesses in the safety management system.
The general results of the classification of 200 incidents with the proposed systematics (according to the “Sieves-model”) are shown in Figure 3. Failures during implementation and operation of safety relevant equipment and procedure were the root cause of about 40% of process incidents. But in the majority (about 60%) of the cases the root causes of the incidents were found in the elements of process safety management hazard knowledge, hazard identification, risk assessment and risk reduction. This fact confirmed Bayer’s position that the failure of technical measures itself is not the main issue but that continuous effort should be put in the development and improvement of the competence of all manufacturing personnel at Bayer.

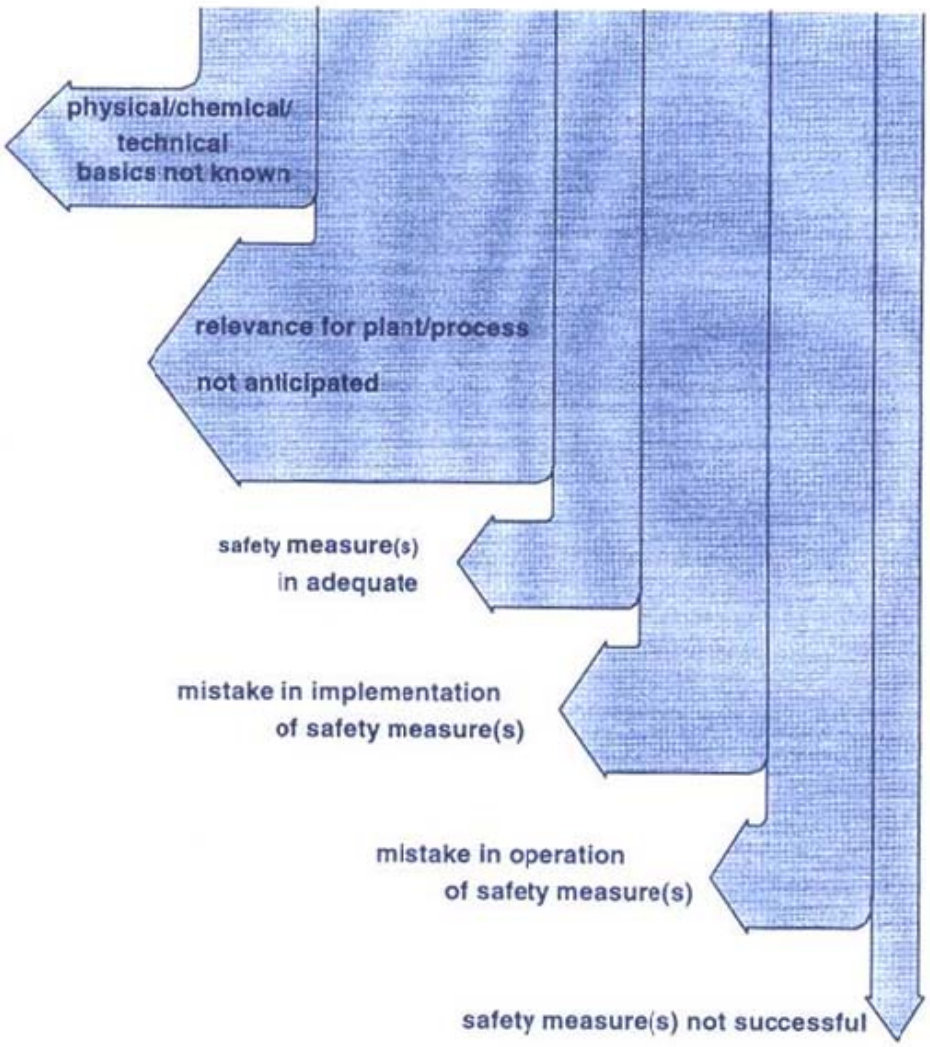

Figure 3: Results of the classification of root cause according to “SIEVES-Model”

To promote this, Bayer started a world-wide initiative with the slogan “TOPPS —Top Performance in Process and Plant Safety” appealing to employees worldwide to regularly examine and further develop the safety of their plants, laboratories and work processes.
As a result of this “TOPPS”-initiative one of the important measures to achieve the desired high level of safety was reconfirmed to be the qualification of both

- the personnel operating the production facilities and laboratories as well as
- the PPS - experts moderating and facilitating process hazard analyses and risk assessments.

This extensive process safety training program was developed and rolled out worldwide to in total 26.000 employees. The training curricula and courses were tailored to five different target groups ranging from PPS experts to technicians and craftspeople in the plants. At the mandatory seminars the participants of all levels learn how to identify the specific process hazards of their work environment and how to tackle them with appropriate safety measures. The training also increased safety awareness and fostered team building and networking improving problem solving techniques.

Name of category	Choice box
Region	EMEA
	North-America
	LATAM
	Asia-Pacific
Plant part affected	Static equipment
	Equipment with rotating parts
	Piping/flange
	Others
Product name	Product or chemical involved
	Product or material name
Substance release class	>5kg very toxic / toxic substance
	>100kg of any other hazardous substance
	>2000kg of any other hazardous substance
Effects	Environmental damage
	Fire
	Explosion
	Formation of explosive atmosphere
	Injury
	Material damage
	No significant effect

Name of category	Choice box
Operation mode	Production mode
	Non-production mode
	Multi-purpose operation
	Maintenance
	Shut-down
	Start-up
	Cleaning
	Sampling
	Stand-by
	Laboratory work
	Others
Involved party	internal operational staff
	External party (no inhouse staff)
Contributing factors (Level 1)	Technical
	Organizational
Contributing factors (submenu Level 2.1)	if technical - instrumentation
	if technical - construction
Contributing factors (submenu Level 3.1)	if instrumentation - software
	if instrumentation - hardware
	if construction - material
	if construction - design
	if construction - interface
Contributing factors (Level 2.2)	if organizational - process / work flow
	if organizational - qualification
	if organizational - discipline
	if organizational - communication

Figure 4: Incident categories LoPC pattern analysis"

3. Incident cause pattern analysis

The implementation of the TOPPS initiative and the corresponding training program was a milestone to a sustainable safety culture which was also demonstrated by a decreasing number of LoPC incidents. However, Bayer decided in 2012 to start an additional incident analysis to determine potential underlying patterns. As the analysis of incident causes using the "Sieves-model" had the focus on general aspects to facilitate an evaluation of the corporate safety strategy it was decided to use a different approach to identify obvious underlying patterns with regard to technical and/or organizational contributing factors.

Therefore, Bayer has conducted a subsequent analysis to determine the reported LoPC incidents. Main objective was to identify potential underlying patterns which may have contributed to repeating incidents through identification of repeating causes and conditions in the incident process. By this focal points and "hot spots" should be identified which help in the decision-making process to decide where further detailed actions are required. In this context a pattern was defined as a cluster of similar or congeneric causes and conditions.

As any additional tool means also a lot of effort for each user a second objective was to minimize the required effort to a minimum and to use existing tools within Bayer.

To achieve the objectives of the analysis a simple systematic approach was developed to assign contributing LoPC incident causes and similar conditions to predefined incident categories (*see Figure 4*) without looking only at the identified root causes. Furthermore the new information request has been implemented in the overall incident reporting system at Bayer to ensure an easy and less time consuming application. This allows a continuously analysis on a yearly basis which can be generated automatically from the Bayer incident reporting system.
After the individual investigation of each LoPC incident is finished and if the causes and contributing factors are identified the information is entered in the Bayer incident reporting system. Based on the detailed investigation results the given options in the choice boxes of each category are activated and the classification of contributing incident causes and similar conditions in the incident process is possible.
By performing this approach some patterns have been identified which have been derived from the analysis of Bayer's LoPC incidents from 2011 to 2013:

- Regional differences in the frequency of LoPC incidents with a clear focus on certain regions
- Focal point of a normal operating modes (which includes all operational tasks and condition from production mode and multi-purpose operations)
- Typical locations of releases are leakages at piping components and substance releases through inadvertently open valves or vents

Also these results are not surprising and new learnings have not been derived they still give important information where to place more effort e.g. in qualification of people or maintenance of plants.
The following categories have been implemented in the Bayer incident reporting system and will be analyzed on a yearly basis.

4. Conclusion

Different approaches for incident investigation and pattern analysis have been established at Bayer and important information and knowledge about common leaks and flaws have been derived. The analysis with "SIEVES" identified very clearly that the major driving underlying cause is the competence of the people involved in the manufacturing and operation of the plants. The pattern analysis which was established during the last years at Bayer identified some "hot spots" and focal points where a more detailed investigation about common causes might be required and where to place more effort. However, both analysis approaches show that the different causes and contributing factors are mainly related to the competence and awareness of the people involved and less pure technically driven. Therefore, the main effort in the future is to further strengthen the competence and to increase the awareness of the people.

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