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Review of Selected Chemical Accident Report Sites Regarding Major Accident Investigation and Lessons Learned Needs

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The aim of this review is to support and accelerate experts and commissioners work during the major chemical accident investigation process within the Czech Republic in the future using information technologies, and sharing the lessons learned. Investigator should always look for lessons learned from historical accidents including evidence left, involving dangerous chemicals, another evidence such as accident precursors and near misses, root causes and different types of damage. The purpose of the existing Czech database of major chemical accidents called “MAPIS” already is to share existing lessons learned, causal information and to enable classification according to the EU Gravity Scale based on human health, environment, community and economic impacts. Regarding to new potential requirements of accident investigators, it´s purpose should also be to provide as much root causes, typical clues and other indicators as well. In the introductory part of the article, description of current investigation state of the art within the Czech Republic has been briefly described. In the following part of the article, current needs analysis of investigating police officers and experts has been identified and discussed. As a part of project recherche activities, sometimes more deep and comparative analysis and critical review of available chemical accident sites been done and also briefly summarized for this topic. On the basis of upper mentioned activities, development of specific recommendations for improvements of Czech database MAPIS was done and approved for realisation in late 2021 and early 2022.

1. Introduction

Approximately until the end of the year, the expert opinions of experts in the Czech Republic in the field of serious industrial accidents, OHS and O&M were solved on the basis of evolving good practice, available knowledge in the field of safety and risk analysis and with great help of knowledge from many established scientific disciplines - physics, chemistry, mathematics, sociology, psychology (specifically recommended in Jefferson et al., 1997). The structure of the expert report has gradually evolved, in discussion with the representatives of the investigating commissioners. In cases of major industrial accidents and lesser incidents, the commissioners are usually investigators from the Police, Fire Brigade, Labour Inspectorate, etc. Until the end of 2020, there was no fixed mandatory structure of expert reports in the Czech Republic.
Based on good practice and knowledge available from abroad (for example in correlation with Sklet, 2004) and from investigated Czech cases of industrial accidents, the authors of this article proposed and used the following structure of the report for the expert institute of VSB - Technical University of Ostrava, FSE:

1. Introduction (the role of the institute of experts, purpose of the expertise).
2. The basis for the expert report (documents supplied by the client – the Police, the Fire brigade, documents provided by the expert institute).

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3. Finding part (evidence received, witness statements and explanations given, simplified description of the technology, the findings obtained by the expert institute, records on the previous near misses and potential accident precursors).
4. Assessment section (risk and safety analysis of described technology, discussion of the observed and assessed scenario of the accident, discussion of the potential and probable root causes of the accident, other circumstances affecting the course of the accident, other relevant communications from the expert).
5. Annexes.
6. Expert´s clause.

The situation has changed with the amendment to the Czech Act No. 254/2019 Coll., on experts, which came into force on 1 January 2021. The structure of an expert investigation report prepared in the Czech Republic must now comply with the following new structure according to § 28 of the Act:

a) Title page.
b) Assignment - for example an arrangement for bringing in an expert from the Police of the Czech Republic, including specific questions to be answered.
c) List of documents - for example an evidence and typical traces found, both by investigators from the police and fire brigade and by representatives of the expert institute.
d) Finding.
e) Opinion.
f) Justification to the extent that the expert opinion can be reviewed.
g) Conclusion.
h) If possible, the annexes needed to ensure the verifiability of the expert opinion.
i) An expert clause.
j) Imprint of the expert seal.

Last but not least the report must also meet other requirements like completeness, truthfulness and reviewability.

Investigating officers from the Czech Police and Fire brigade always establish and maintain their own records, they have their own investigation report structure and case file structure. They also develop their own proposals of investigative versions, which are understanded as initial hypotheses to how the specific accident or crash could have probably occurred. Finally, with the help of evidence, witness interviews, expert reports and using the basic principles of resilience (mentioned in Vairo et al., 2020), proposed investigation versions are always gradually refused, until the hypothesis or several hypotheses are found that cannot be refused in whole context. In terms of historical practice, many of the investigating Czech police commissioners have been very lacking in more specialized training in risk analysis, the principles of chemical technology, physical chemistry, and other scientific disciplines (specifically recommended in Jacobsson et al., 2010). With the help of available training courses and university education and self-education (especially with books: Hyatt, 2006; McKinnon, 2012) the investigators tried to supplement their education to the best of their ability.

In addition to the commonly used investigative police questions (what, who, how, why, …), logical reasoning and proof, the good old scientific method and all types of classic philosophical logical reasoning can find their use in determining the causes and most likely scenario of a realized industrial accident:

- Occam's razor: Principle - "Pluralitas non est ponenda sine necessitate" (plurality is not to be proved unless it is necessary). Later definition - "Entia non sunt multiplicanda praeter necessitate" (Entities are not to be multiplied more than is necessary). Explanation: if there are multiple explanations for a phenomenon, it is preferable (more correct) to prefer the least complicated one. A narrower definition of Occam's Razor: If some part of the theory is not necessary to achieve the results, it does not belong in the theory.
- Popper's Razor: A theory that cannot be disproved is worthless. It expresses the condition of testability and falsifiability of hypotheses (imitation or falsification of something) and theories. Principle: Scientific theories are testable. Verifiable theories can be rejected (and replaced by other theories) on the basis of a verification procedure. Popper's Razor also expresses that there is no point in dealing with theories that cannot be disproved.
- Hume's Razor: The principle of bringing rationality to faith and miracles. "That no testimony is sufficient to establish a miracle, unless the testimony be of such a kind, that its falsity would be more miraculous, than the fact, which it endeavours to establish." A narrower definition of Hume's razor: any witness can be deceived, therefore a miracle (in this case the origin and root causes of the crash) is difficult to prove.

A partial problem or obstacle in the investigation of accidents in the Czech Republic about 10 years ago was also the "fight for evidence" and a kind of investigative competition at the scene, including problems with the competence of investigators from the police and firefighters (who will investigate what, who found the evidence earlier - who secured it and did not want to provide it to the second or third investigating party). The problems with this undesirable rivalry and competition, within the competence of the rescue services, which together fall under one Czech Ministry of the Interior, were fortunately mitigated or eliminated after several years with the help of regional agreements on cooperation in the investigation of fires, accidents and incidents between the police and the fire brigades.

The problem has also long been the fact that accidents with truly serious consequences (with consequences for the lives and health of people, their property, infrastructure and environmental components) and with leaks of hazardous chemicals, toxic dispersion scenarios, fires, explosions or environmental contamination have "fortunately" not happened and do not happen often enough to create a separate position of "commissioner - investigator of serious accidents" within the Police of the Czech Republic (as reported in Sanders, 2015). The common practice in the Czech Republic is that the Police Commissioner is in charge of investigating traffic accidents and accidents as well as other selected potential crimes and offences (including industrial accidents and serious accidents). According to the possibilities, needs and increased frequency of occurrences of industrial accidents in the jurisdiction of individual Czech police directorates (e. g. in the Central Bohemia Region, Moravian-Silesian Region), some commissioners have become more profiled for industrial accident investigations over time and with increasing experience. However, despite all the progress in police and fire investigation work (both of these components of the integrated rescue system in the Czech Republic have their own specialised technical institutes for the investigation of evidence traces, causes and possible development of accidents), each complex serious industrial accident is still considered a unique case, requiring the investigator to proceed from point "0", not infrequently also requiring external expert opinion (see Miranda, 2015). To some extent, shared databases of historical industrial and other accidents, type scenarios of major accidents and possibly databases of root causes, typical traces and typical accident manifestations may help (as reported in CCPS, 2003) investigating commissioners, officers and external experts and expert institutes.

2. Consecutive needs analysis of investigating police officers and experts for lessons learned

Interviewed Czech Police officers and experts, who participated recently in the investigation process of selected major chemical accidents responded that they still struggle a bit with the lack of good practice, specific knowledge regarding the involved industrial technology and chemicals, and the lack of Czech national lessons learned (in correlation with Kletz and Amyotte, 2019). And because major accidents are not happening every day, rather the opposite – they tend to occur just several times per decade. Up to these days, there exists at least one classified police database of investigated accident cases (mostly fires, explosions, and few toxic chemical releases) and one Czech chemical accident report site (Occupational Safety Research Institute, Prague, MAPIS). Police officers would appreciate another useful resource of information on the root causes, typical evidence left and real accidental scenarios (in correlations with Sklet, 2002 and Sklet, 2004). Investigating police officers shared their doubts about the possibility to develop or update such kind of lesson learning system, because within each major chemical accident they started again from the scratch, calling for every available expertise. By such a statement, they mean that every major accident is unique (Hollnagel, 2002), which requires a specific approach and a lot of fantasy during the process of postulating of all possible crime versions (hypotheses on possible scenarios of accident development).

3. Comparative analysis and critical review of available chemical accident report sites

Each of the reviewed chemical accident report sites (eMARS, SOZOGAKU, ARIA, MAPIS and few others) has been developed probably for slightly different needs and purposes (serving from managers of industrial facilities to state bodies – ministries).

Practical investigation of major accidents can be difficult in many ways and its nearly always complicated and complex, taking a lot of time and energy from the involved stakeholders (DNV, 1996). Still, its essential way to gather and verify new data (Aven and Zio, 2014), new evidence (Aven, 2016), possible accident scenarios (Jefferson et al., 1997), and root causes (Goldberg, 1996) for so-called risk analysis science or if you want to – for the safety science (Aven, 2012). It is crucial also for never-ending risk prevention, mitigation, and adaptation within the management of not only industrial facilities (RoSPA, 2015).

Table 1: Comparison of selected chemical accident databases (source: author´s findings).

No.	DBF Abbr.	Link (Full name) / Data on impacts	Purpose	No. of events	Access/ Language	Time span	Update
1	ARIA	http://www.aria.developpement-durable.gouv.fr/ (Analysis, Research and Information on Accidents) / Each incident is classified according to the EU Gravity Scale based on human health, environment, community and economic impacts.	Lessons learned	>50 000	Open Access. In French and in English.	> 1970	>1000 records added/ year
2	eMARS	https://emars.jrc.ec.europa.eu (The Major Accident Reporting System, established by the EU's Seveso Directive 82/501/EEC in 1982) / Quantitative data on human health impacts. Inconsistent data in all other categories. Economic impacts not collected.	To facilitate lessons learned and causal and impact statistics.	>1100	Open Access. The public has access to all data upon registration with the EU ECAS authorisation system. In English.	>1984	Reported EU/OECD major accidents. Updated.
3	SOZO-GAKU	www.sozogaku.com/fkd/en/ (JST Failure Knowledge Database, Japan) / Information on human health impacts, physical damage and costs incurred.	To share lessons learned and causal analysis.	Nearly 600	Free, public. Unlimited through webpage. In English and Japanese. Records, divided according to fields of industry	> 1970 (> 1940)	Mainly accidents from Japan
4	IOGP	www.iogp.org / IOGP Safety Performance Indicators and Process Safety Events (International Association of Oil and Gas Producers-IOGP) / Each incident is classified as Tier 1 or Tier 2 severity based on human health, environment, community and economic impacts	Lessons learned and causal and impact statistics	>6000	Limited access after registration. Full access to the restricted areas of this website is for IOGP Member Companies only.	2015	Accident data reported by IOGP participating member companies.
5	PSID	www.aiche.org/ccps/resources/psid-process-safety-incident-database / https://us.core.resolver.com/#/session (Process safety incidents reported by member companies of the AICHE CCPS) / Specific numbers provided on deaths and injuries. Limited detail on other types of impacts.	Lessons learned, with detailed explanation and adequate details.	>800	Limited access. Registration (access after login and password), in English. Major improvement in last years.	>2000 (not given)	AICHE.
6	Pro-cess Net	https://processnet.org/en/ incident_db.html[en], https://processnet.org/ ereignisdb.html [de] / Process Net (German industry) / Data impact: Very limited if available at all. Concise technical summaries of chemical accidents.	Lessons learned and causal information	>100	Free access, online. In English and German. With possibility to propose new record for further verification.	>2000	Managed jointly by DECHEMA and VCI.
7	ZEMA	http://www.infosis.uba.de/index.php /de/site/12981/zema/index.html / (Zentrale Melde- und Auswertestelle für Störfälle und Störungen inverfahrenstechnischen Anlagen – ZEMA) / Quantitative data on human health impacts. Inconsistent data in all other categories. Economic impacts not collected	Lessons learned and causal and impact statistics	>750	Open access. In German language.	>1980	Managed by the German FEA / UBA of hazardous incidents.
8	MAPIS	https://mapis.vubp.cz/Portal/ (Major Accident Prevention Information System) / Each incident is classified according to the EU Gravity Scale based on human health, environment, community and economic impacts (same as ARIA DBF).	Lessons learned and causal information	>600	Limited access. Registration (access after login and password), in Czech.	>2000	Managed by Czech OSRI (VUBP). Irregular update.

4. Results: Development of recommendations for improvements of existing Czech chemical accident database MAPIS

On the basis of upper mentioned activities and detailed structure analysis of MAPIS, development of specific recommendations for improvements of Czech on-line database MAPIS was done and approved for realisation (by Czech T-Soft private company) in late 2021 and early 2022. In overall, it could be concluded, that after minor changes and extensions of functionalities, the Czech information system MAPIS (managed by Czech Occupational Safety Research Institute) could meet present additional requirements of police and expert investigators very well (in correlations with Sklet, 2002). It is possible also due to very detailed and advanced structure of database, which includes a lot of specific tables and attributes. It is only up to the employee of OSRI or up to the dedicated and approved volunteering expert, how detailed and well verified data he or she fill into the on-line form. Also, it depends heavily on the availability of real investigation report (or case lessons learned). Implementation of EU Gravity Scale for the classification of major industrial accidents - regarding SEVESO II (European Commission, 1996) and SEVESO III (European Commission, 2012), based on human health, environment, community and economic impacts (same as ARIA DBF), is also very valuable, because it enables possibility of different kinds of losses.
Approved extensions of functionalities of MAPIS database in 2021/ 2022 were as following:

- Updating the application to a new version of the .NET framework and updating the used components.
- New entry "Typical accidental clues / evidence" in event detail (recommended in Vallée et al., 2020).
- Importing new entries into the involved hazardous chemicals database (increasing the number of involved chemicals from about 100 up to more than 350, searching based on CAS number).
- Possibility of user editing of involved chemicals database. Editing should allow to add a new record, editing an existing record and deleting or terminating an existing record (an unused record is deleted, a used record is only terminated).
- Improvement of the User´s Help, for each item within the on-line form. The help will be in the format of static text, which will always be placed next to the respective item. The text will be displayed on mouse click or hover. The help text will not change according to the currently entered data.
- Further testing of “search” functions and implementation. Consideration of possible export of whole (or at least simplified record) into the PDF format.

5. Conclusions

Practical investigation of major accidents can be difficult in many ways and its nearly always complicated and complex, taking a lot of time and energy from the involved stakeholders. Still, its essential way to gather and verify new data, new evidence, possible accident scenarios, and root causes for so-called risk analysis science or if you want to – for the safety science. It is crucial also for never-ending risk prevention, mitigation, and adaptation within the management of not only industrial facilities.
As for the conclusion, the following common issues regarding existing chemical accident report sites, presented particularly by their authors or guaranteed institutions, have been recognized. In many chemical major accident cases investigated by the police, many details which could pose valuable lessons learned (like potential typical visual or less visual clues (evidence), results of root cause analysis, damage description, etc.), could not be published and shared publicly, because they remained secret until the end of court proceedings. This kind of information should not be also free accessible because of the state security issues (prevention of potential terrorist acts, sabotages). Therefore, at least personal access for authentication and authorization to the on-line report site should be required. Information shared this way should be critically evaluated and verified by the public institution.
Beware of – lessons learned sharing information systems could be developed for different purposes (like for police investigation, practice risk analysis expert needs risk analysis science / safety, science etc.). Each of these cases could be focused on different needs.

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