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ABSTRACT

For long with the objective of improving the protection of environment and the avoidance of accidents, plant managers, insurers, authorities, consultants, research organisations are dealing with learning from investigations of accidents with chemicals.

Many databases on chemical accidents are in existence and sharing data is initiated by database developers and end users.

Since 1993, a working group of European Safety, Reliability and Data Association (ESReDA) is dealing with data collection, quality and dependability of data and networking of databases..

This work will be described, pointing out the possible use of data, the requirements as seen by the end users and the issue of a directory on existing databases. The emphasis will also be given on the minimal requirements for data collecting including some evaluation of data and the need of investigations of accidents by multidiscipliniary teams. On this last aspect, lessons drawn from French experience on accident investigations with flammable and toxic gas and liquids in plants, storages and transport will be explained.

INTRODUCTION

For long, very large accidents occurred in plants where chemicals were processed and stored. Further, transportation and use of chemicals were at the origin of very severe accidents. The manufacture of explosives was certainly the first industry manufacturing chemicals in which very strict safety precautions were taken. More recently in Europe, everybody kept in mind the large variety of possible accidents such as those in Flixborough (explosion with 29 fatalities) in 1974, Sandoz Bâle (fire with release of chemicals in water without fatality) in 1986, La Mède

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refinery (unconfined explosion with six fatalities) in 1992, Los Alfaques (explosion from a road tank of propylene with 216 fatalities) in 1976.

Accidents considered are defined as any occurrence involving a hazardous substance such as a major emission, fire or explosion leading to serious damage to human health or the environment including property.

The above mentioned accidents involved very severe damage and are fortunately rather rare. In France, every year, chemical accidents statistics are established by Bureau d'Analyses des Risques et des Pollutions Industrielles (BARPI).

For example, from July 1993 to June 1994, 683 accidents occurred in plants or during transportation : 49.20 % dangerous releases, 45.10 % fires, 6 % near misses and 5.70 % explosions. Chemical industry is implied in 6.40 % of all accidents and transport in 21.80 %. As regards the human consequences, water and air pollution, one fourth arose in transportation.

All these accidents involved detailed investigation of their root causes and the development of the sequence of events in order to reassess safety measures for the prevention of the occurrence and the protection against the effects.

In this paper, as regards chemicals, an overview of the different means of collecting data and analysis on accidents, the improvement of data reliability and the attempts for sharing data and networking of databases will be given *.

COLLECTION AND ANALYSIS OF DATA ON ACCIDENTS

Press dispatches and general newspapers give immediately information but without detailed analysis and with large uncertainties.

On the contrary, administrative inquiries emphasize detailed information but, in many countries such as France, are not publically available.

Open databases could be considered as an interesting mean to have detailed information when reliable data are included. On the basis of an inquiry performed at European Safety, Reliability and Data Association, it was proved that three databases are largely used in Europe :

. ARIA, developed by Bureau d'Analyse des Risques et Pollutions Industrielles including French and abroad accidents

. FACTS, which was developed and is still managed by TNO, Department of Industrial Safety, Apeldoorn, NL.

* The ideas and opinions expressed in this document are these of the authors at the time of the meeting and do neither commit the French authorities concerned, nor the ESReDA "Accident Analysis" working group.

. MHIDAS, which was originally developed for Health and Safety Executive purposes in UK.

Open litterature information is included in FACTS and MHIDAS.

For ARIA, as regards the French accidents, only disclosable informations from administrative reports are publically available.

Note : MARS database developed by Joint Research Center, Ispra, for DG XII of the Commission of the European Communities, is a confidential database.

All this information allows the preliminary analysis of risks and the getting of statistical data. But, for a detailed analysis of the sequence of events and the development of phenomena, more information is needed .

DIRECT INVESTIGATION OF ACCIDENTS

It is the reason why direct detailed investigation of accidents are always necessary. At many occasions, we were involved in such field investigations and the summary of our findings will be explained.

Recent field investigations dealt with :

. an unconfined vapour cloud explosion (UVCE) in a fire depot at St Herblain, October 7, 1991 (J.F. Lechaudel et al., 1995) with one fatality and extensive damages outside the depot premises

. another major UVCE in the TOTAL refinery's fluid catalyting cracking unit at La Mède (November 9, 1992) (P. Michaelis et al., 1995) with 6 fatalities and 2 billion francs damage

. a fire in a fuel depot at St Ouen, June 1991 with 15 fire fighters injured and the evacuation of 1.000 persons

. ammoniac accident release in a chemical plant at Mazingarbe when unloading a railtank (December 16, 1994). About 30 tons were released

. fire and explosion following derailment of unleaded fuel railtanks on August 13, 1993 in La Voulte. 1.000 persons evacuated

. fire in a NPK ternary fertilizer storage, Nantes in 1987, 30.000 persons evacuated.

Most of these investigations were carried out at the request of French competent authorities, the rest directly for industrial firms.

Further details on other accidents investigated, either in chemical industries or in other industries are given elsewhere (J.P. Pineau et al., 1993).

Methodological approach to be used

It must be emphasized that the methodological approach is to be carefully defined especially when the investigation team is a multidisciplinary one.

Such an approach is described for La Mède's accident (P. Michaelis et al., 1993) and implies four main steps, with explanation related to this particular case :

. gathering evidence with a search for information (records, chronology, videotapes, snapshots, witnesses interviews, missiles mapping, seismic waves records ...)

. defining potential scenarios (flammable gas mass involved and explosion epicentre, identification of ignition sources, numbering of ruptured equipment, mainly the one from which the primary release and the explosion occurred)

. investigating the possible scenarios (four systems remained selected)

. performing the validation of the assumption (2D modelling of dispersion simulation, wind tunnel simulation, dynamic process modelling, use of metallurgical and mechanical data ...).

Lessons learnt from these various accidents

From the cases in which all the above mentioned steps were used, it was possible to draw some general assumptions.

The accidents at St Herblain and La Mède pointed out the influence of the location of ignition sources when flammable gases can be released and the absolute requisite of the definition of dangerous areas for choosing the adapted equipment.

The accident in the St Ouen fuel depot emphasized the role of repair and maintenance works and some difficulties for closing valves during fire fighting, mainly in relationship with the design.

The emission of toxic gases as in Mazingarbe could be considered as an illustration of a post Seveso accident. A safety system to avoid releases was installed but with a poor reliability implying failures to closing systems.

The case of Nantes accident is an illustration of a dangerous release of toxic fumes from a fire and the necessary emphasis to be paid to proper distribution of goods in storages and use of adapted fire fighting methods.

The railtank accident in La Voulte is dealing with a transportation accident for which the geographical location of the occurrence can play a major role : explosion in a sewage system and pollution of the drinking water system.

The previous comments are only given as evidence and examples of the variety of root causes and sequences of events to be considered.

A number of other aspects drawn from our experience may be pointed out like enough knowledge of the phenomena (by modelling or experimentation) and possible effects of explosion and fire fumes, the reliability of safety related systems, the safe operating envelope of a given process, enough consideration of the distribution of adapted equipment in endangered areas and of the topography of the site.

A case study is always necessary and implies multi-disciplinary experts (fluids mechanics, detonics, mechanics, electricity, metallurgy, industrial risk analysis and assessment, process control).

All these remarks must be kept in mind when considering the use of databases on accidents and the collection of data.

EXISTING DATABASES ON ACCIDENTS

A database on accidents could be defined as any collection of accident data independent from the storage media (paper, CD-ROM ...).

It is a common experience at a company level that files are existing on past accidents and incidents for the purpose of learning from the occurrences to avoid their coming back and to mitigate the consequences. The sharing of data in a large company or between companies could be difficult by reference to different safety cultures or to differences in chemicals processed.

End-users of data could also be other organizations such as engineering companies, competent authorities, consultants, insurers, research organisations and universities.

Objectives

Objectives are various (J.P. PINEAU et al., 1995) :

. to identify accident scenarios

. to identify deficiencies of potentially hazardous plants, buildings and transportation systems (in design and operation)

. to help to identify whether current emergency procedures are appropriate

. to assist national and international competent authorities, financial and insurance companies to formulate proactive policies

. to assist consultants in their tasks dealing with safety cases and experts in accident investigations

. to develop quality aspects for data and software

. to improve total quality management of safety and training of operators and managers

. to collect reliability data and failure rates

. to look at compliance with regulations, codes of practice and standards

. to develop research project for understanding involved hazardous phenomena, hazardous situations and initiating events

. to encourage the incorporation and use of databases in the curricula of universities and other academic courses

. to improve the right to know of large public.

Inquiry on existing databases

A working group "Accident Analysis" of European Safety, Reliability and Data Association was initiated in January 1993 to deal with all these aspects. It decided first to prepare a questionnaire for assessing strengths and weaknesses of existing databases.

This questionnaire was distributed by AA group members in 13 different countries. 93 questionnaires, valid for analysis, were returned and analysed (A.Z. KELLER, 1994).

From this investigation, about 85 databases, either dedicated in house or generic, were identified.

As a conclusion, it was emphasized in a recommendation :

"Consideration be given to the future convergence of current accident databases and the development of a future European or international network accident database. Immediate consideration be given to producing an ESReDA Directory of Accident Databases".

The ESReDA Executive Committee accepted and supported by partial funding the preparation of the above mentioned Directory.

Directory of existing databases

The basis of the Directory (to be issued end of 1996) will be a description in four sections : identification, technical aspects, access conditions and use, database details.

The inquiry phase was launched in 1995 and the form addressed to the previously known database operators. An extension of contacts with other database managers was carried out.

Answers were received for 47 database operators. Very surprisingly, only 13 previously identified databases operators sent an answer on the basis of the description form.

A first conclusion is to be drawn, the interest of sharing experience is rather limited mainly of the basis of confidentiality of processes.

As regards especially chemicals (table 1), about one third of existing databases is strictly devoted to chemicals, but really the vast majority are dealing with chemicals (refinery, offshore, pesticides, water pollution).

Industrial areas and activities	Number of quotations
offshore	12
nuclear	4
refining	16
chemical	18
transport	31
pesticides in agriculture	1
water pollution	5
explosives	2
fires	3
mines	1

Table 1 : Information in the future ESReDA Directory on accident databases (multiple answers possible)

We are also aware of the work performed at European Process Safety Center - EPSC - level on the sharing of experience from accident between chemical firms. A report was published recently under the title "Use of data on past incidents including, in particular, use to aid hazard identification and control".

WHICH TYPES OF DATABASES ARE NEEDED ?

When analyzing the findings of detailed field investigations and the data from existing databases, it should be fair to say that the objectives are so various that it is rather impossible that even a very extended database can cover all the fields mentioned in table 1.

It implies that specialization with experts in the field to be covered is the only mean to improve the confidence on stored data.

One of the most interesting conclusion drawn from the investigation of existing databases is the very large number of accident reports mentioned in each database (about 12.000). In order to avoid multiple analysis which is time consuming, an important task should be for example the avoidance of entry of the same incident or accident in various databases.

Another requirement is related to the reliability and dependability of data. Questions arose on this aspect at 1994 Autumn ESReDA seminar.

It was proved that the input of the same accident in various databases leads to uncertainties in the data included and induces loss of confidence for the users. Such a drawback should only be avoided by networking of databases dealing with the same field.

Generally speaking, the dependability of data must be improved by using a method in which both the chemicals and process or systems involved should be checked. Efforts should be devoted to develop a well accepted accident report form.

As a common collection form, the basis could be the one used for the MARS database.

The minimum requirements for inclusion are under consideration at ESReDA "AA" working group and could as a minimum deal with facts and analysis.

Facts

. date, time of occurrence, location and establishment (or part of it involved, with field of activity)

. immediate effects (consequences) : deaths, injuries, evacuations, material damage

. ecological components : inland, freshwater, shore, offshore, other

. mid term and long term effects

. emergency measures : internal, external, sheltering, evacuation, decontamination, restoration, other

. specific process, equipment and substances (and their amounts)

. accident type : release, fire, explosion, other

5. CONCLUSION

In front of the permanent difficulty in Rock Mechanics, to collect the complete data necessary to solve a problem, and particularly to know the actual geometry of a jointed rock mass, we can now be helped by specialised software and by statistical methods.

Then the same difficulty appears when we try to understand and to predict the behaviour of this jointed rock-mass after reinforcement. Simulations of the mechanical behaviour can be helpfully undertaken using a numerical model.

Different methodology have been elaborated and tested in two mines (Sotiel and Brusada mines) corresponding to two different geomechanical conditions (hard rock and relatively soft-rock) and mining methods.

In the first situation (Sotiel mine), the geomodel is based upon a statistical reconstitution of the block distribution, coming from some direct structural statements. The coherence of this model has been established by comparing a volume of blocks fallen in the site. The mechanical behaviour is studied by the way of a static analysis of stability for single rigid blocks, identified by the geomodel in the vicinity of the excavation. This method proved that it is possible to optimise a roof bolting pattern by testing the influence of several essential parameters.

In the second situation (Brusada mine), the geomodel is reconstituted by grouping together the points of the cables which seems to behave statistically in a similar way, and by verifying the coherence of this division in blocks with the structural statements. The mechanical behaviour of cables is approximated by the use the Distinct Element Method (code UDEC).

The quantitave adjustement between calculated and measured variables representative of the behaviour of the reinforced rock mass is not excellent. The inaccuracy or the uncertainty of some essential data, as well as the assumptions used in the models have been pointed out.

In the other hand, a qualitative comparison between the theoretical and actual behaviour is not so bad, so that we can be encouraged to improve and develop this approach.

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