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Journal of Hazardous Materials 130 (2006) 9–14

Journal of Hazardous Materials

www.elsevier.com/locate/jhazmat

Lessons learned from process incident databases and the process safety incident database (PSID) approach sponsored by the Center for Chemical Process Safety

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Available online 13 September 2005

Abstract

Learning from the experiences of others has long been recognized as a valued and relatively painless process. In the world of process safety, this learning method is an essential tool since industry has neither the time and resources nor the willingness to experience an incident before taking corrective or preventative steps.

This paper examines the need for and value of process safety incident databases that collect incidents of high learning value and structure them so that needed information can be easily and quickly extracted. It also explores how they might be used to prevent incidents by increasing awareness and by being a tool for conducting PHAs and incident investigations. The paper then discusses how the CCPS PSID meets those requirements, how PSID is structured and managed, and its attributes and features.

Keywords: CCPS PSID; Database; Incident database; Key learnings; Major incident; Precursors; Prevent incidents; Process safety incident database (PSID); PSID; Pull down menus; Query system; Reduce risk; Leading indicators; Learn from peers; Learning value; Lessons learned; Trends; Voice of experience

1. Lessons learned from process incident databases

There are two categories of unawareness or lack of knowledge. The first is knowing that you do not know; the second is not knowing that you do not know. Although both categories carry hazards, the second category is arguably worse since it eliminates the opportunity to research, identify and react appropriately. In the world of process safety incident prevention, not knowing about potential hazards can have adverse consequences. Yet, if you know that you lack specific knowledge on a particular subject, those hazards can be managed by research and diligent follow-up. However, not knowing that you do not know about potential hazards can have catastrophic consequences. Since there is no prompt to research questions in the first place, these consequences are much more likely to happen and are more difficult to manage.

Both categories of hazards can be overcome with an effective, well-designed, and user friendly incident database. For this incident database to be effective, however, it must have the proper goals, scope, and attributes. The need for goals, benefits, and attributes of an incident database that benefits both the "aware" and the "unaware" users are discussed below.

2. Basis for need

The media love to report major incidents. The headlines they generate capture our attention in print or on the television screen. We may be an interested stakeholder with a financial involvement in the company, someone who simply lives near a facility that has an incident, or just a member of the general public—regardless, we are interested. None of us are very tolerant of events we perceive might adversely affect our daily lives, health, or livelihood. We tend to have a lower opinion of a company after it experiences a major incident than before it has experienced one. The general perception is that such companies must put profit ahead of safety or a clean environment, or that they must have poor management systems or managers for this to happen to them. Stock prices can plummet based on the perceived impact of an incident on that company's profitability. A company's franchise to operate may even be adversely

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doi:10.1016/j.jhazmat.2005.07.061

affected by a major incident if the surrounding community is involved.

More often than not, the reason for a major incident is a combination of failures instead of a single event. Failures include management system breakdowns, miscommunications, and misunderstandings—all impacting the company's framework of process safety management programs. Precursors (leading indicators) are almost always there. Rarely does a catastrophic event result the very first time a system fails. We need to learn how to recognize the precursors/leading indicators early enough to resource preventative actions.

Major incidents, in addition to bringing the horror of an industrial catastrophe into our living rooms, make us keenly aware of what can happen when safety systems break down and things go terribly wrong. Immediately following the relief that a reported particular incident did not occur at one of their own facilities, process safety professionals usually turn their thoughts to how a similar event might occur in their company, even if there are slightly different prompting conditions. The astute professional recognizes that an analysis of a loss at another company's facility may help them understand what improvements to facilities, procedures, and programs are needed in their own company to prevent a similar occurrence. Their objective is to learn from previous incidents and losses, others or their own, so that they are not repeated. They also expect to learn enough so that the possibility of new incidents and losses, in some way associated with the same, though not identical, failure mechanisms is reduced. This analysis is a key tool in finding the weak spots, the un-addressed areas, and the easily misunderstood or misapplied parts of a company's process safety management program so that those areas can be strengthened. It does not replace an effective, well-managed suite of process safety programs but supplements them.

3. Goals

An effective database must have goals and then be structured to meet those goals. Key goals of a process safety incident database might include the following:

- prevent incidents;
- reduce the risk of incidents (reduce the probability of occurrence and/or the consequence severity of incidents) by making information available on known hazards and risks;
- function as a mechanism to learn from peers;
- capture and share key learnings from past incidents and near misses;
- educate today's workforce so that yesterday's failures are not repeated;
- help meet OSHA PSM requirements to share incident information, including root causes (without revealing source);
- provide information in a fashion that it can be found and extracted easily and quickly as needed.

Each of these individual goals when working together provides the framework for an effective database.

4. Uses and benefits [1]

A well-managed incident database with a sufficient number of meaningful incidents provides a multitude of information and resources for addressing hazards, both known and unknown. It is a listing of the things that went wrong, why they went wrong, what was done to correct them, and the type of process or equipment that suffered the failure. It is a chronology, a time-line, of events that, uninterrupted, led to the failures. It is also a road map of what can be done to interrupt that sequence of events and, thereby, prevent the incident. It is a textbook, open for review, of what not to do if you have this type of process or equipment. It is a leading indicator of possible failures in your company and may be a map of hidden hazards that would prevent incident free operation. Used to its fullest, it can be the "experience" your company does not have in the form of a seasoned engineer when designing a process or doing a process hazard analysis (PHA) by providing insightful and sometimes historical data relative to the hazards of a process or particular type of equipment. It can help your company meet the OSHA PSM requirement to use lessons learned from past incidents in PHAs and to share learnings with others outside of your company. Of course, it also can be effectively utilized as another investigator on an incident investigation team by providing the experience of history as well as a listing of possible causes for failures associated with similar processes or systems. A list of common and valuable uses might include:

- *Process hazards analysis*: A search of the database before the PHA or revalidation PHA is conducted may yield hazards the team would not otherwise recognize. This may be helpful in any of the stages of the various PHAs, such as the initial design PHA, the design-finalized PHA, the pre-start-up PHA or pre-start-up safety review (PSSR), or in a management of change (MOC) related PHA. In each of these cases, the incident database functions as another member of the review team—a member who has tremendous experience and a great memory!
- *Mechanical integrity improvements*: By matching listed equipment failures with similar types of equipment in another facility, predictions and alerts can be generated based on in-service time, mean time between failures (MTBF), chemicals handled, temperature and pressure ranges, etc. Trends can also be identified associated with certain types of equipment, manufacturers of equipment, and metallurgy of key components when used in certain services and under certain conditions. These trends can be the leading indicators needed to build an effective predictive or preventative maintenance program.
- *Operator training*: Investigation findings often point to operational errors caused by failures in training systems. Real life examples of how these failures resulted in significant losses can provide senior management the justification needed to allocate resources to improve training systems. Front line operators more readily believe that training has a basis and will be helpful to them when they are faced with an example of how a training failure resulted in an incident and injury to someone in a similar position as theirs.

- *New chemical screening*: By reviewing the experiences others have had with the particular chemical being considered for importation, manufacture, or use in your facility, a preview of the expected and un-expected hazards involved in its use can be understood. Risk scenarios can be developed, and training as well as engineering solutions can be implemented before the chemical is brought on site.
- *Incident investigations*: An incident database is really a listing of incident investigations and the associated findings. Each finding is a pearl waiting to be discovered and recycled, then used again. The wise database user knows how to extract those findings and how to recycle them so that they relate to potential hazards in his or her facility. Sometimes, this helps find the cause of an incident that just occurred, and sometimes it prevents an incident from occurring in the first place.
- *Emergency planning and response*: After the incident, consequences of the failures are mitigated by the emergency response plan. An analysis of what mitigation actions did and did not work for others and why provides a checklist of things to review and improve upon.
- *Identify high-risk activities, operations, and procedures*: Sometimes you just do not know the risks associated with your processes, and an incident database can provide the keys to what high-risk activities are actually present in your facility. At other times, the incident database can function as the voice of experience in convincing others that risks do, in fact, exist, and that resources need to be devoted to reducing those risks.
- *Safety alerts* [3]: When combined with a "lessons learned" communication system (such as the Center for Chemical Process Safety's *Process Safety Beacon*), incident databases function as the source for valuable lessons and make great safety meeting examples. While most of the aforementioned uses are somewhat technical in nature, one of an incident database's most exciting potentials is the ability to be used as a teacher or a learning tool. Summaries of incidents can be customized for each respective audience, technical engineer, or front line worker and then used as tools to teach the key elements of process safety management and risk reduction.

5. Database—required attributes

For process incident databases to meet these expectations and provide the needed benefits, they must possess certain attributes. How many attributes the database has and how well these attributes are endowed determine the true usefulness of the incident database.

5.1. Accessibility

The database must be accessible and easy to get to when needed. Web- or LAN-based versions are usually more accessible than PC, CD, or diskette-based versions. Hard copy versions, if they ever really existed, are rightfully things of the past. If a database is not readily accessible, potential users will migrate away from using it, and over time, it will be forgotten. Accessibility applies not only to how easy it is to get to, but also to the list of prospective users. The database should be readily available to prospective users regardless of rank—from front line worker to process engineer to design engineer to PSM and risk program managers, etc. It should be available to anyone who can use it effectively to reduce risk.

5.2. User friendly

Along with accessibility, the database must be user friendly. It must be easy for a user to both enter data into the system and extract data from it. Both a novice and an experienced user must be able to quickly access needed information without undue effort and time commitment. Frustration level must be kept low.

5.3. Accuracy

Obviously, the data entered must be accurate and pertinent. Accuracy includes comprehensiveness of the data in addition to technical validity. The database should be void of editorial comments and sensationalized conclusions. It should be a rendition of the facts and only the facts. Coloring the incident with editorial comments, technical inaccuracies, or incomplete data potentially nullifies the effectiveness of the lesson to be learned and can guide the next user to the wrong conclusion or solution for his or her particular hazard. In this case, action to mitigate a risk by using sensationalized or understated information from the database may actually increase the risk either through an inappropriate action or through inaction because of the belief that the risk has been managed or is not of sufficient concern.

5.4. Sufficient volume

Even though accuracy is important, a scant amount of extremely accurate data is almost worthless. So, there must be a lot of it if it is to have meaning and statistical validity. In the case of a database, bigger is better, but only if the data is also accurate. It is unrealistic, hopefully, that one company would generate enough process safety incidents to adequately populate a database with current and meaningful events. Information from one company will tend to be limited to a particular type or set of hazards and failures. Databases built as an industry-wide participative effort have the best chance of success since they can provide sufficient quantity of varied data. As a further refinement, databases specifically built around input from one of several broad categories of industries (such as petrochemicals, refining, chemical manufacturing, pharmaceuticals, etc.) will have more meaningful data simply because there will be some commonality in chemicals handled.

5.5. Standardization

There must be a standardization of reporting format and investigation-of-causes philosophy for the system to be workable. A template and instructions must clearly define how and where the components of an incident and the ensuing investigation findings are to be entered into the database. Pull-down menus are very helpful in standardizing the input language and minimizing the use of different words to describe the same event or equipment. This standardization enhances the query capability of the database also.

It is best if a recognized investigation approach, such as the one espoused by the Center for Chemical Process Safety (CCPS) [5] in the recently published "*Guidelines for Investigating Chemical Process Incidents, second ed.*" is used. This provides a standard approach to incident investigation (although a variety of methodologies and tools are used) and a consistent philosophy of cause determination. When all users understand the investigative approach used to populate the database, they can more easily adapt the findings to their particular situation. Further, a common investigative approach tends to have some commonality in language, thereby making searches easier and quicker.

5.6. Query system/search engine

To quickly and efficiently get information out of the database, a comprehensive query system is needed—one that not only answers the query itself, but also suggests other potential paths to failures. This second part has not yet been effectively implemented in current incident databases but may be on the horizon. Already there is some development work being done in "fuzzy logic" by graduate engineering students at Texas A&M University [4]. Potentially, this "fuzzy logic" concept could be carried over into database query logic. For instance, if the prime query target does not exist, perhaps its relative does. The person posing the initial query may not know enough to ask the right questions, but "fuzzy query" will take care of it for them.

While we wait for "fuzzy query" innovations to migrate into databases, we rely on the innovativeness and knowledge of process safety professionals to ask the right questions, or at least to ask enough questions to get the right answers. This current approach must be somewhat standardized as well if people are to be proficient in finding the answers they need. This approach should also have the flexibility to provide some basic statistical analyses. For instance, quantity lists and two-dimensional (2-D) charting capabilities are a minimum. Lists are self-explanatory—how much of what, or when, etc. Two-dimensional charting can be used to view relationships—the most common failure mode, the type of equipment involved in the most serious incidents, or the phase of the operation in which most incidents occur, relative to others in the database. Since it is impossible to do everything immediately, this type of analysis provides a key as to where a company's valuable and scarce resources should be focused.

5.7. Data security and confidentiality

Some companies are hesitant, for a variety of reasons, to have their name mentioned in an incident description. In some cases, their concern is valid; in others, it may be a hold over from a past philosophy. Either way, data in a database must be secure, and the database must provide the confidentiality the participants expect.

Secure means that the data cannot be maliciously manipulated and reinserted in the database giving an incorrect impression of the incident and the findings. Secure also means that the data cannot be extracted and misused by someone or some organization to the detriment of the database, the users, or the industry in general.

Confidential means that any validated submitter of data that chooses to remain anonymous can do so. To ensure this, a confidentiality process must be developed and implemented. The system used by CCPS in their PSID possesses the necessary requirements to meet this standard.

6. The CCPS process safety incident database approach

In 1995, the Center for Chemical Process Safety (CCPS) undertook a project to develop a database that tracked industrial incidents for the purpose of sharing "lessons learned" among members. The goal was to collect safety incidents of high learning value from participating companies without identifying the submitting company, consolidate those incidents into a searchable database, and provide the flexibility for participating companies to organize and compile the information and reports in a way most valuable to them, all the while keeping security and confidentiality high.

The project was titled process safety incident database (PSID), and a database manager was hired to manage the system. From that, small beginning, the project has grown and matured through several revisions and upgrades. In 2002, the project underwent the most significant format and usability change to date—conversion to a web-based model.

The CCPS's PSID is an example of a database that meets all but the "fuzzy query" criteria discussed above. PSID is an industry-wide project, open to manufacturing companies who are willing to support the effort. It is web-based, so it is accessible at any time by any PSID participant who can connect to the Internet [2]. The response time is short and the screen transitions seamless. The search engine is quick and comprehensive except for the lack of "fuzzy query." To protect confidentiality and ensure data quality, the PSID project employs a database manager with specific and focused responsibilities. Fig. 1 is a graphical representation of the confidentiality and quality assuredness process. By careful review, the database manager assures the completeness, accuracy, and clarity of the data submitted. If necessary, the database manager gathers additional required information from the original submitter.

The system utilizes a standard data entry template, and all data is checked and validated by the database manager for relevance, clarity, and applicability before it is migrated into the main searchable database. Participants agree to enter a specified number of incidents each year, so the database is continuously growing. Equally important, the incidents being entered are relevant to the participants because the participants themselves enter them. Root cause analysis forms the basis for the investigation philosophy, and most participants ascribe to the CCPS incident investigation approach. This provides the standardization needed in cause determination and provides a common language between contributors and those extracting data. As a web-based

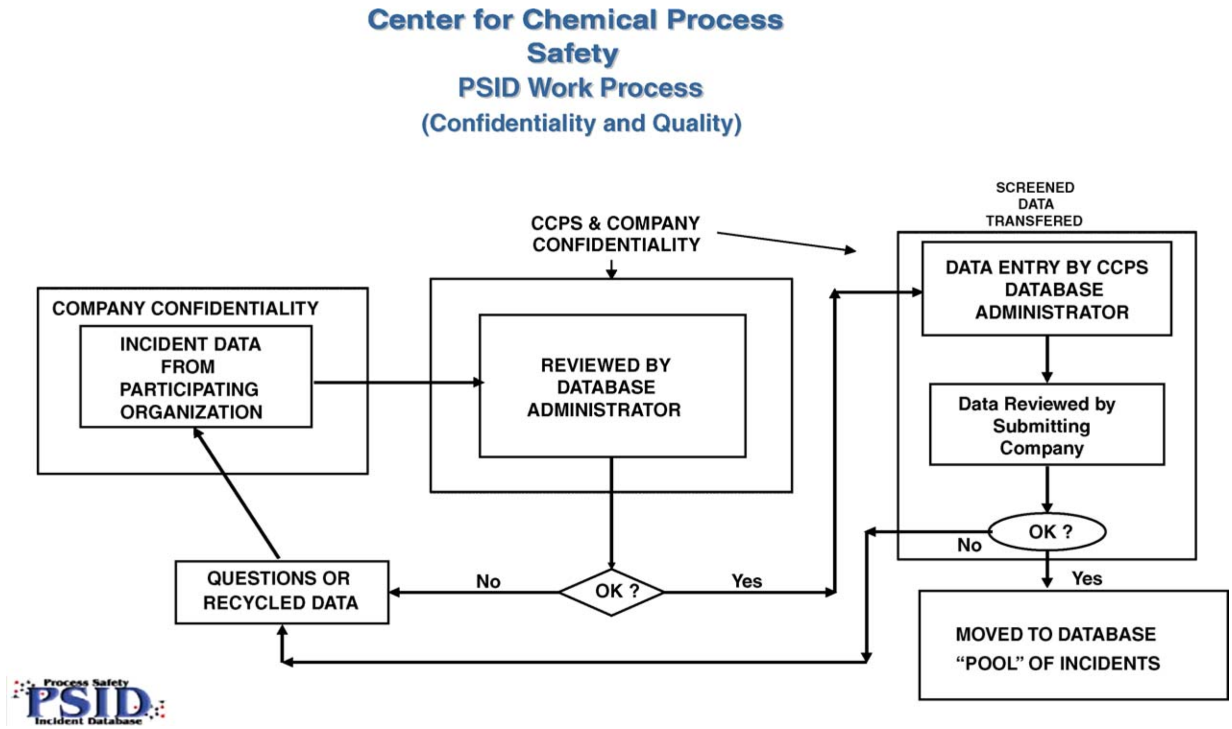

Fig. 1. Confidentiality and quality assurance work flow.

system, the data is refreshed and automatically updated every time an incident is entered into the system.

Although PSID does not have a “fuzzy query” feature, its conventional query system is well-developed and contains a few built-in models as an added enhancement. One such built-in feature is its two-dimensional cross plot of data. Fig. 2 is an illustration of this feature. By plotting the type of incident versus the total count of incidents, it is easily seen that approximately one-third of all incidents in this database involve fires and/or fireballs. The prudent process safety professional would certainly want to understand how and why these fires occurred and if there is a potential for them to occur at his or her facility. Virtually any two data fields can be plotted against each other.

Fig. 3 is a Pareto chart of contributing factors to incidents. A quick review shows that process equipment integrity issues contributed to almost 20% of all incidents in the database. Knowing this would lead practitioners to try to better understand and support the facility’s mechanical integrity programs. Process knowledge and documentation and Training issues contributed to another 13.5% each. This is evidence and support for training resources. The Pareto chart can be customized to reflect different time periods in which incidents occurred.

PSID also includes pre-programmed lists making it easy for the casual users to seek-and-find. The more experienced users can customize these pre-programmed lists or generate their own specific topic lists. And again, these lists are automatically updated every time an incident is entered, so the users have the

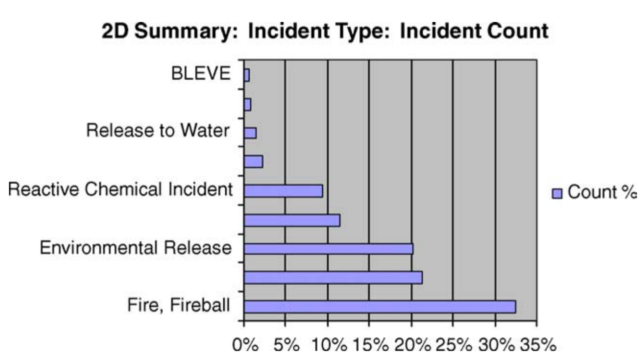

Fig. 2. Two dimensional summary.

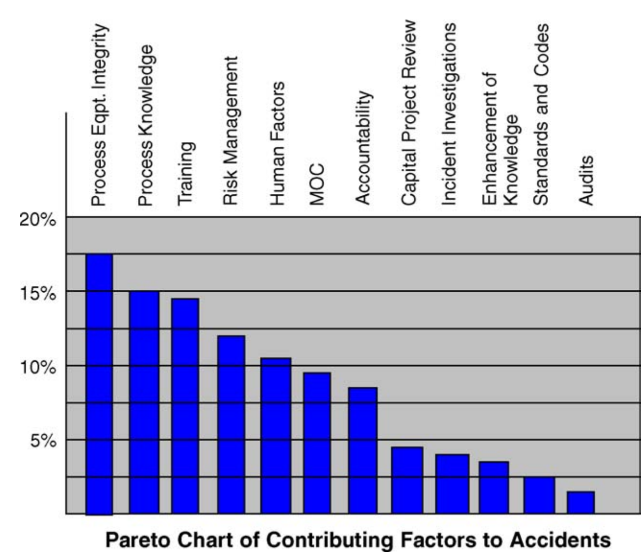

Fig. 3. Pareto chart.

- My Lists—this folder holds the customized lists the user built specific to his or her type operation and concerns.
- Type of Operation—this folder lists the various types of operations for which lists are developed.
- Chemicals—this folder lists chemicals for which lists are developed.
- Phase of Operation—this folder lists the various operation phases for which lists are developed.
- Initiating Event—this folders lists initiating events for which lists are developed.
- Incident Type—this folder lists the various types of incidents for which lists are developed.
- Root Cause—this folder lists common root causes for which lists are developed.

Fig. 4. PSID preprogrammed lists.

most up to date data and lists each time they log on. Fig. 4 shows the lists already pre-programmed in the PSID.

By simply activating any of these pre-programmed lists, a pick-list menu appears and the specific type of query for that particular listing can be entered. The user can then list and display the desired data.

Additionally, PSID contains six pre-programmed reports 2-D summary, key learnings, cross tab, incident reports, follow-up actions, and a Pareto chart of contributing factors. Results can be easily pasted into Word or Excel applications. Being web-based, it is easily updated with new incidents and is accessible from almost anywhere by any participating company representative making it extremely useful to PHA teams, incident investigators and as a training tool.

Additional information on the CCPS PSID project can be found on the web site http://www.psidnet.com [2].

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