*Analysis of the EPA RMP*Info Database*

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ABSTRACT

EPA's risk management program requires regulated facilities to submit a risk management plan, which includes the 5-year accident history of the facility. EPA has compiled the risk management plan in the RMP*Info database. This paper presents an analysis of the RMP*Info database in order to determine the most significant chemicals released and other trends. According to this analysis, 85% of the releases in the chemical industry are due to twelve chemicals. The sources of those releases and their consequences are presented. In addition, the effects of the chemical type, toxic or flammable, and the number of full time employees in the facilities are discussed.

Introduction to the RMP Database

In 1996, the United States Environmental Protection Agency promulgated the final rule for Risk Management Programs for Chemical Accident Release Prevention (40 CFR 68)[1,2]. The federal rule is mandated by section 112(r) of the Clean Air Act Amendments of 1990 and requires regulated facilities to develop and implement appropriate risk management programs to minimize the frequency and severity of chemical plant accidents. The EPA rule also requires regulated facilities to develop a Risk Management Plan (RMP), which includes a description of the hazard assessment, prevention program, and the emergency response program. The hazard assessment in turn must include worst-case scenarios, alternative release scenarios, and a five-year accident history for the regulated chemicals.

The RMP rule covers facilities that produce, process, handle, or store regulated substances at or above specified threshold quantities. Notwithstanding the RMP rule requirements, these facilities "have a general duty to identify hazards which may result from such releases using appropriate hazard assessment techniques to design and maintain a safe facility taking such steps as are necessary to prevent releases and minimize the consequences of accidental releases which do occur[3]". The regulated substances are those that if released could cause adverse effects on human health or the environment.

The hazard assessment program analyzes the consequences associated with an anticipated worst-case scenario and an alternative release scenario, which has higher probability of occurrence. The hazard assessment program also includes a five-year history of the facility's accidental releases.

The prevention program includes safety, maintenance, training, and monitoring measures to prevent accidents from happening.

The emergency response program describes emergency health care measures and the procedures for informing the public and response agencies should an accident occur.

This information about the risk management program must be submitted to EPA through the RMP*Info Database. This database is divided into nine sections as follows:

Section 1:	Identification of the facility and its process
Section 2 and 3:	Description of worst-case scenarios for toxic and flammable substances, respectively.
Section 4 and 5:	Description of alternative release scenarios for toxic and flammable substances, respectively
Section 6:	Five-year accident history
Section 7 and 8:	Prevention program description for program 3 and 2 processes
Section 9:	Emergency response program

Also included in the database is an executive summary of the nature of the facility and its safety policies.

Since different processes have different levels of risk and impact on human health or the environment, EPA has adopted three program levels to cover three types of processes. Program 1 applies to processes that have no off-site accident history and there is no danger to the public in the case of the worst-case scenarios. Program 3 applies to processes of higher risk and are already subject to OSHA's PSM standard. Program 2 is for processes that are not eligible for program 1 or 3. It should be noted that each facility may have more than one process; and each of these processes could be categorized in different program levels depending on the risk involved and the complexity of operations.

This database is, therefore, more than an accidental database. It gives a general overview of the facility's risk assessment and promotes an effective prevention of accidents. It also helps reduce chemical risk at the local level and gives response agencies the necessary information in case of an accident. The general public can benefit from this database in understanding the chemical hazards in their localities.

As noted above, this database is based on the past 5-year history of each facility. If a facility has no accident during the 5-year period, then that facility has no entry in Section 6 of the database; however, they must submit the other information.

Although this database has fewer number of accidents compared to other databases, it has gone through an extensive data review to assure its accuracy, so lessons learned and conclusions drawn from this database are more meaningful.

Analysis of the Top Twelve Chemicals

The following sections discuss an analysis of the top twelve chemicals released according to the RMP*Info database. These chemicals contributed to 85% of the releases reported in the database. Lessons learned from the releases of these chemicals can help improve the safety performance of the chemical industry. These chemicals are listed below in the order of number of releases, where ammonia has the highest number of releases.

1. Ammonia (anhydrous)
2. Chlorine
3. Flammable Mixture
4. Hydrofluoric Acid
5. Chlorine Dioxide
6. Propane
7. Sulfur Dioxide
8. Ammonia (conc. 20% or greater)
9. Hydrochloric Acid
10. Hydrogen
11. Methane
12. Butane

The EPA 5-year accident history database shows ammonia and chlorine as the top two released chemicals. The RMP*Info database includes a total of 1869 releases from mid-1994 to mid-1999. However, some releases involve more that one chemical. If each chemical is considered separately, the total number of releases would be 2004.

Number of Releases per Year

Figure 1 shows the number of accidents per year for all chemicals reported in the RMP*info database. It should be noted here that the 1994 and 1999 numbers are lower because these years were only partly within the reporting window[4]. However, there is a general upward trend in the number of accidents during the period 1995 to 1998. The same trend is followed if we looked at the number of releases for each chemical per year. Ammonia and chlorine are shown in Figure 2 as examples.

Release Sources

Looking at the release sources, Figure 3, we see that approximately 50% of all-chemical releases are associated with failures in valves and piping. More than one-third of the ammonia releases are associated with valves, whereas piping is the largest source of releases for chlorine, as shown in Table 1.

Furthermore, if we investigate the initiating event of the ammonia releases due to valves, we find that 57% of them are due to equipment failure compared to 36% due to human error as shown in Table 2. This result suggests that ammonia facilities should give higher priority to the maintenance and inspection of valves in ammonia services. This fact is further emphasized by the knowledge that valves and piping are the sources of most of the ammonia release deaths, 88% of which is due to valves, as shown in Table 3.

Although the higher number of chlorine releases was due to piping, all chlorine deaths were due to failures in valves, as shown in Table 3. However, the initiating event of the valve releases was distributed between equipment failure and human error, 50% compared to 44%, respectively, as shown in Table 2.

Piping and valves were responsible for more than 70% of the ammonia injuries. However, process vessels in addition to piping and valves are responsible for 66% of the chlorine injuries, as shown in Table 5.

If we examine the hydrofluoric releases, we find a similar trend: 50% of the hydrofluoric acid releases are due to valves (21%) and piping (31%), as shown in Table 1. However, unlike ammonia and chlorine, 67% of the valve releases were due to human error and the remainder was due to equipment failure, as shown in Table 2. Although there were no deaths as a result of hydrofluoric acid releases, 57% of the injuries are due to piping and valve releases, as shown in Table 5.

The other chemicals have generally similar trends with regard to the importance of proper maintenance and operation of valves and piping. Therefore, facilities should give more emphasis to adequate maintenance and operating procedures for valves and piping.

For the top twelve chemical releases, the category "other," in the release sources section, ranges from 11-33% depending on the chemical, as shown in Table 1. This indicates that the multiple choices given for the source of the release works better for some chemicals than others. For example, 28% of the hydrogen releases fall under the category "other". Upon investigation, we see that 50% of the releases under that category "other" are associated with compressors. Therefore, for hydrogen, the category compressor is more important than storage vessel, transfer hose, or pump. This suggests that the choices given should be revised to reflect the wide range of chemicals and facilities involved. Although the database was designed to include a wide range of facilities, the choices given are more tailored toward manufacturing plants.

Initiating Event and Contributing Factors

More than 90% of the initiating events for each chemical of the top twelve was either due to equipment failure or human error, which agrees with the general trend of all chemicals, as shown in Table 6. Equipment failure was the primary cause of most releases. According to this database, equipment failure resulted in 52 – 77% of the releases, depending on the chemical released. Mannan et al.[5] reported a similar conclusion from an analysis of the EPA's Accidental Release Information Program database.

Equipment failure and human error are listed as an initiating event and contributing factor. This may lead to confusion for the reporter because of the inability to differentiate between the initiating event and contributing factor. In fact if we look at Table 7, we find that the highest percentage occurred where the contributing factor was the same as the initiating event.

Toxic vs. Flammable Chemicals

The RMP*info database has 77 toxic chemicals and 63 flammables. 81% of the releases reported to RMP*Info database are from toxic substances. Although most of the releases reported are toxic, the probability that a toxic release will result in a fatality is 3.7%. However, this percentage increases to 4.5% for the case of a flammable release, as shown in Table 8.

Looking at the subject chemicals, we find that all flammable chemicals, except butane, have fatalities; however, three of the toxic chemicals released resulted in no deaths. These chemicals are hydrofluoric acid, chlorine dioxide and hydrochloric acid, as shown in Table 9. It is also interesting to note that all fatalities and almost all injuries due to flammable substance releases affected on-site workers or contractors, as shown in Table 4.

Number of Releases per Facility Size

Table 10 shows the relationship between the size of the facility and the number of releases in which for eleven out of the twelve chemicals, the highest number of releases were in large facilities, where the number of full time employees was greater than one hundred.

Conclusions

1. Analysis of the EPA RMP*Info database indicates that 85% of the releases were caused by twelve chemicals.
2. 49% of the releases reported in the database are failures associated with valves and piping. Valves are responsible for most of the fatalities in the ammonia environment and all fatalities in the chlorine environment.
3. The category "other" has a high number of releases, because it is believed that the database did not reflect the wide range of chemicals reported and facilities reporting.
4. The primary initiating event for valve and piping releases is either equipment failure or human error depending on the chemical released. For example, equipment failure was the primary initiating event for ammonia and chlorine releases. On the other hand, human error is the primary initiating event for hydrofluoric acid releases, which were associated with piping and valves.
5. Although most of the releases reported in the database are toxic, flammable substances showed a higher probability that a release would result in a fatality. All of these fatalities were on-site workers and contractors.
6. Most releases reported in the database occurred in facilities where the number of full time employees was 100 – 1000.

References Cited

1. *Risk Management Programs for Chemical Accidental Release Prevention; Final Rule*; 40 CFR Part 68, Environmental Protection Agency, Washington, DC, June 20, 1996, Federal Register, volume 61, no. 120, pp. 31667-31732.
2. List of Regulated Substances and Thresholds for Accidental Release Prevention and Risk Management Programs for chemical Accidental Release Prevention; Final Rule and Notice; 40 CFR Parts 9 and 68, Environmental Protection Agency, Washington, DC, January 31, 1994, Federal Register, volume 59, no. 20, pp. 4478-4501.
3. Clean Air Act, title III-section 112(r); Hazardous Air Pollutants, Prevention of Accidental Releases.
4. Kleindorfer, P. R.; Feldman, H.; Lowe, R. A.: "Accident Epidemiology and U.S. Chemical Industry: Preliminary results from RMP*Info", Working Paper 00-01-Univerity of Pennsylvania, March 6, 2000.
5. Mannan, M. S.; O'Connor, M.; West, H. H.: "Accidental History Databases : An Opportunity", Environmental Progress (Vol. 18, No. 1), Spring 1999.