KIGAS Vol. 15, No. 1, February, 2011
(Journal of the Korean Institute of Gas)

Analysis of Recent Accidents and Regulating Activities for the Hazardous Materials in Korea

†**Kyungok Kwon · Youngeun Kim**
Department of Fire Safety Engineering, School of Engineering, The University of Jeonju
(Received October 21, 2010; Revised February 25, 2011; Accepted February 26, 2011)

요 약

Abstract - The systems in Korea regarding manufacture, storage, transport and use of hazardous materials are regulated by the related laws and ordinances. The number of accident from hazardous materials has recently decreased but the size of accident has increased according to the hazardous substances are greatly consumed and delivered. The results of analysis showed that most of accidents are caused by human problems and occurred frequently at unauthorized facilities. It is suggested that workers should be trained more and the strict regulation on unauthorized facilities is needed to reduce the accidents caused by hazardous materials.

Key words : korean hazardous materials regulation, accidents of hazardous materials

1. INTRODUCTION

A potential hazard from hazardous materials has recently increased[1-7] as a lot of hazardous substances are greatly, made, consumed and delivered, which results from the needs to build large buildings or facilities for strengthening national competitiveness and expanding social infrastructure, due to the improvement of production technology, the development of new products, and technological innovations for conversion of raw materials. The chemical industry, which is one of the national key industries, has relatively lower frequency of accidents than other industries in Korea, but it holds and deals with various kinds of noxious substances and hazardous materials. It is a process industry which operates at the high temperature, high-pressure and flow rate successively. Even a small leakage from dangerous materials in the process of reaction and decomposition may lead to large fires, explosions, and disintegrations. If any great accident occurs in a chemical factory, it can affect not only its employees but also the residents in the nearby factory, and, what is worse, it can destruct our ecosystem and environment, which costs us tremendous time and labor in restoring them over the country.

The hazardous materials defined by Korean Hazardous Materials Safety Management Law are no more than about 3,000 kinds, but there are hundreds of thousands of the compounds or mixtures from chemicals [8-10]. We have shown that the status of regulation of hazardous materials and analysis of recent accidents : the frequency, the causes and loss properties of accidents in Korea.

2. HAZARDOUS MATERIALS SAFETY REGULATIONS

2.1. Classification

Under the Hazardous Materials Safety Management Regulations, hazardous materials are designated, divided, and classified in accordance with their properties. The Korean Hazardous Materials Safety Management Law plays a role as a safety regulation against fires and explosions in manufacture, transport, storage and use of hazardous materials, which was made in May 2004, modifying the Fire Service Law. As the materials are liable to be ignitable or flammable, and facilitate combus-

†주저자:kokwon@jj.ac.kr

tion when mixed with other substances, there are great possibilities of fire occurrences and expansions. Accordingly, if a certain substance is included among the items regulated under the Hazardous Materials Safety Management Law, it is considered as hazardous materials, and, if it is not, it is classified into the non-hazardous materials. The hazardous materials are classified into six kinds of substances from Class 1 to Class 6 on the basis of their physical properties (Table 1) that is different from the classification of GHS, UN and 49 CFR in USA.

2.2 Regulation of hazardous materials

Uniquely in the world except Japan, the designate amounts are defined and regulated in accordance with the risk of hazardous materials. The regulation of hazardous materials under the Hazardous Materials Safety Management Law is divided into three categories, such as storage, handling and manufacture. If the substances in storage and handling are more than designated amounts, the regulation by hazardous facilities and interim regulations by temporary storage and handling are imposed on them. If they are less than designated amounts, the local governments regulate them in accordance with the storage and handling of small amounts of hazardous substances. So these substances are controlled by their amounts in consideration of dangers like fires and explosions. Recently, with the increasing demands from domestic and international organizations like WTO, the regulations on the handling of hazardous materials are extensively relieved. For example, the gas stations which deal in hazardous substances receive deregulation measures as the regulation on the distance between the gas stations is lifted up[8]. In the past, they could only install the oiling facilities with small office, but now they can have not only car-washing facilities and auto-repair shops but also small stores for car accessories and self-service gas station is available.

Currently idea of GHS is introduced in the Korean regulations. And it is also revised by the performance based design systems according to the increasing of specific environment.

Table 1. Classifications of hazardous materials in Korea

Class	Properties	Examples
1	oxidizing substances	ammonium nitrate sodium peroxide
2	flammable solids	sulfur, red phosphorus, metal powder
3	pyropholic substances or water reactive chemicals	sodium, potassium yellow phosphorus, calcium carbide
4	flammable substances	gasoline, kerosene, diesel, crude oil
5	self-reaction substances	organic peroxide, hydroxylamine
6	oxidative liquids	hydrogen peroxide nitric acid

Table 2. The facilities dealing with hazardous materials in Korea

Year	Total	Manu-facturer	Handling				Storage						
			Oil station	Sales	Trans-port	Generals	indoor	Outdoor	Outdoor-Tank	Indoor-Tank	Under-ground	Trans-port	others
2007	129,980	1,368	14,720	303	294	10,969	4,991	3,580	25,535	18,569	15,897	33,649	18
2008	127,491	1,448	15,291	288	308	10,463	5,134	3,597	25,608	17,592	14,747	32,910	24
2009	124,150	1,513	15,623	248	292	10,032	5,229	3,495	25,369	16,759	13,641	31,883	24

Table 3. Large hazardous facilities

Year	Total	Factories			Oil storage facilities	Power plant	Keep Storage	Others
		Refineries	Chemical Factories	others				
2007	2,757	824	862	37	695	172	95	72
2008	3,604	1,123	1,135	35	779	252	128	152
2009	2,904	922	763	37	701	171	112	198

Note: The facilities above have over three thousand times the designated amounts of hazardous substances for storage and handling

Table 4. Number of firms or facilities in classified by hazardous materials

Category / Total	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6
130,641 (2007)	370	386	611	128,628	353	293
127,491 (2008)	432	433	502	125,421	384	319
124,150 (2009)	538	646	283	122,814	928	301

*: Unauthorized facilities included.

2.3. Current status of hazardous facilities

The hazardous facilities in Korea approximately reach 125,000, as shown in Table 2. The large hazardous facilities among them have hazardous substances capacity over three thousand times of designated amounts as shown in Table 3. Number of firms is decreasing from 130,641 in 2007 to 125,150 in 2009. Table 4 has shown the number of facilities classified by harzardous materials.

2.4. Major hazardous materials safety control system

The Hazardous Materials Safety Law defines the license storing and handling hazardous substances by the one to installation of hazardous facilities. The performance tests on the safety and installation of oil tank are done by the Korea Fire Equipment Inspection Corporation (KFI), private businesses, and fire stations. The completion tests are done by the fire stations. Maintenance of the facilities is regularly inspected, and general inspections are done by the owners of facilities for the record (once a year). Regarding safety examinations and inspections of the structures of the facilities, the outdoor tanks of 1 million l or more are put to detailed examination by KFI and organizations inspecting the tanks every eleven years. The selection of the person in charge of safety control is defined, and the methods of prevention regulations for making the plans of fire prevention and emergency measures are defined. The fire protection inspections in their manufacturers like the types of inspections or questions are defined.

3. STASTICS ON DAMAGES FROM HAZARDOUS SUBSTANCES

The damages from hazardous materials in Korea are decreased. In the year of 2008, it has two big fires so that the cost of the damages reported is about 7.8 billion Won (Table 5).

3.1. Analysis of recent fires and accidents

The hazardous facilities are usually under safety control through the license, safety inspection of oil tank at installation, and completion inspection after the installation. Nevertheless, the process problems during operations or the non-observance of safety rules cause large fires in the chemical factories. In most cases, materials belong to class 4 (Table 6).

Here, examples of recent accidents with hazardous materials in Korea;

- June 30, 2006: A fire of uncertain flammable mate-

Table 5. Damages from hazardous materials

Year	Properties Loss		Fire Casualties	
	Number of Accidents	Loss Amount (Unit:10,000 Won)	Deaths	Injuries
2007	164	770,500	9	113
2008	121	778,600	11	77
2009	89	269,680	11	88

Table 6. Number of accidents of hazardous materials classified by hazardous materials

Year	Total	Class1	Class2	Class3	Class4	Class5	Class6
2007	164	4	6	0	147	1	2
2008	121	0	2	1	115	2	1
2009	89	2	3	0	80	2	2

rials like gasoline explosion (Four people dead and five people injured and property loss to 92.5 million Won)

- July 25, 2006: A fire of used vegetable oil at outdoor storage tank (Three people dead and property loss to 98 million Won)
- May 26, 2007: An explosion of ethane gas in manufacture (Seven people injured and 742.340 million Won)
- June 5, 2007: A fire of thinner by spike in the car crash (No person dead and injured and 911.530 million Won)
- December 6, 2007: A fire of magnesium products in manufacture (No person dead and injured and 1,751.177 million Won)
- March 1, 2008: A fire of phenol resin in manufacture (Two people dead and fourteen people injured and 2,282 million Won)
- June 12, 2008: A fire of stearic acid and oleic acid in manufacture (No person dead and injured and 3,700 million Won)

3.2. Characteristics and problems of accidents in Korea

Most of large fires of the chemical factories in Korea break out at the old facilities aged twenty-years or more over. The chemical factories are designed to operate for twenty years, but most of them have been forced to operate from twenty years up to forty years, so they are in desperate need of safety control. And the operator's lack of expertise about the process also brings on insufficient response in the early stage and leads to accidents.

The other main causes of accidents of hazardous materials are as follows: when transporting of hazardous materials, the truck drivers make over speed that cause of accidents, the accidents from unauthorized facilities by manufacturing variation oils and the accidents from facilities handling small amounts of hazardous materials that less than designated amounts. Among the 89 number of accidents of hazardous materials in 2009, the fire from facilities handling less designated amounts is 19% and the next is 16% from manufacturer and oil station, and 14% from unauthorized facilities and movable tank storage. The accidents of movable tank fire are caused by reckless drive of truck (Table 7).

Old chemical factories especially in the large petrochemical complex should be identified and put to special control so that it is needed to prepare the new fire act to control systematically to prevent fire disaster. Currently the new fire act is preparing under the consideration of manufacturers. In order to prevent the fire from facilities handling less designated amounts, the guidance and supervision for safety control should be planned to guide the workers to change processes of the facility or the operation by fully reviewing safety technology from the design level. If necessary, the order of facilities less des-

Table 7. Number of accidents in the site of facilities dealing in Hazardous materials

Year	Total	Manu-facturer	Oil Station	Generals Handling	Indoor Facilities	Movable Tank	Outdoor Tank	Indoor Tank	Unauthorized Facilities	Transport	Less than designated amounts of Facilities
2007	160	12	10	8	2	13	4	10	17	7	77
2008	121	13	12	8	2	16	10	1	9	16	41
2009	89	15	15	8	0	12	4	5	12	12	17

Table 8. Possibility, P

year	Accident rate
2007	1.2×10^{-3}
2008	0.9×10^{-3}
2009	0.7×10^{-3}

Table 9. Type of accidents in hazardous materials.

Type	Fire	Explosion	Leakage	Total
2008	105	1	15	121
2009	63	16	10	89

Table 10. Cause of accidents in hazardous materials

Type	Cause of fire			
	person	Physical	Others	Not certain
2008	76	12	28	5
2009	58	14	14	3

ignated amounts controlled by city fire station should be raised to ordinance in the fire law that will be controlled by central government. Regarding the accidents from unauthorized facilities, the more strict supervision is needed not to make variation oil.

3.3. Accident probability

Accident (including fire) probability, P, is calculated with the equation; P = Number of accidents / Total number of facilities. Results are shown in Table 8. P is 1.2×10^{-3} in 2007 and 0.7×10^{-3} in 2009, so that facilities dealing with hazardous materials in Korea might be slightly safer than those in other year[8].

Detail information of accidents is reported by the National Emergency Management Agency (NEMA) [Table 9, 10] that mentioned human errors are as one of the most important keys for accidents.

4. CONCLUSIONS

The analysis of recent of accidents for hazardous materials in Korea was conducted for three years from 2007 to 2009. Regulations are revised continuously by the recommendation of international regulation like GHS, etc. Most accidents are caused with human problems. Regarding the accidents of unauthorized facilities increased, it may need that more strict regulation to reduce the accidents. Human errors are one of the keys to cause accidents, and to teach workers in such facilities is important.

REFERENCES

[1] M-A. Kordek, Toulouse Accident, OECD-IGUS-EOS meeting, France, March 2002
[2] R.J.A. Kersten, A.C. van der Steen, A.F.L. Creemers, G. Opschoor, The Ammonium Nitrate Explosion in Toulouse, France-The Incident and its Conse-

quences for Industrial Activities, CCPS, AIChE, 17th Annual International Conference and Workshop, USA, October 2002
[3] The United Nations, Recommendations on the Transport of Dangerous Goods, Manual of Tests and Criteria, second revised edition, 1995.
[4] M-A. Kordek, Update of Seveso II Directive Relating to Ammonium Nitrate, OECD-IGUS-EOS meeting, Germany, March 2003
[5] Wim Mak, Definition of AN Entries with respect to Definition of Organic Contents OECD-IGUS-EOS meeting, Germany, March 2003
[6] A.K. Brown, New UK Ammonium Nitrate regulations, OECD-IGUS-EOS meeting, Germany, March 2003
[7] A.K. Brown, Rationalisation of Ammonium Nitrate Entries in ADR, OECD-IGUS-EOS meeting, Germany, March 2003
[8] Hazardous Materials Safety Management Law of Korea (2009)
[9] The annual statistics of Fire accidents in Korea reported by NEMA (1997 – 2009)
[10] Related Web Address – www.nema.go.kr
[11] The annual statistics of Fire accidents in Japan reported by FDMA (2006 – 2009)
[12] Related Web Address – www.fdma.go.jp