The whole accidents concerning on the chemicals of PDS', were 615 cases in Japan for six years from 1999 to 2004. These accidents were distributed over a variety of business as shown in Figure 1. And, Figure 2 and Figure 3 are given the breakdowns of the manufacture and the transportation respectively of which the sum accounts for 66 percent of all poisonous material accidents.

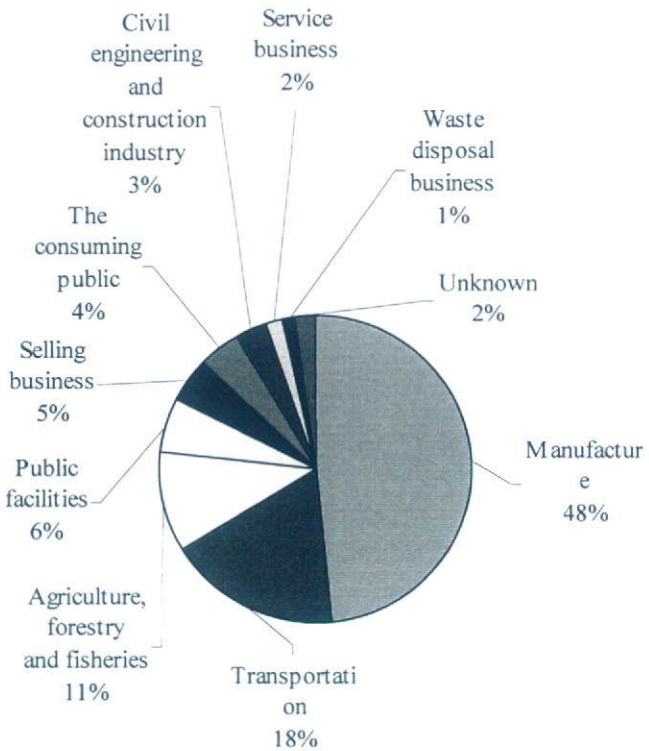

Figure 1. A category of business

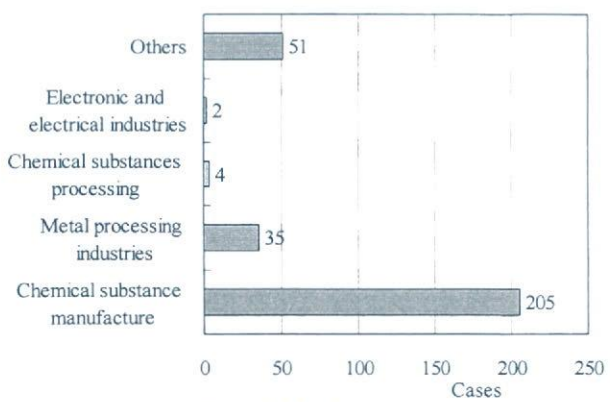

Figure 2. Manufacture

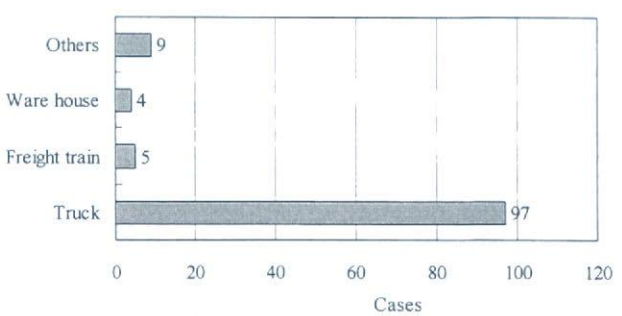

Figure 3. Transportation

Concerned Chemicals

The substances concerned in the 615accidents extended to a wide variety of 118 chemicals as shown in Figure 4.

Strongly basic compounds and strongly acidic compounds rank high in many chemicals. Ammonia, which is used as refrigerant, is also very high. Chloropicrin, which is a soil fumigant of agricultural chemicals, is remarkable. The 15 cases of cyanides (approximately 2 percent) and the 6 cases of phosgene (approximately 1 percent), which are highly poisonous, are predominant. The states of these substances are divided into 64 percent liquid, 25 percent gas, 10 percent solid and others.

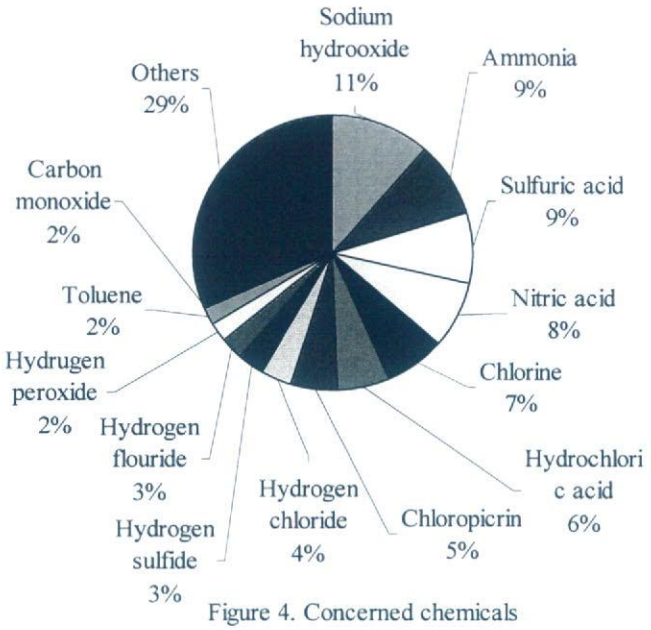

Figure 4. Concerned chemicals

Technical Factors of Causes

Properties: The factor analysis of the causes was performed for the all 615 cases with regard to the technical factors as shown in Table 1, firstly. The accidents due to the property of substance result in the injury and poisoning and the damages, whose approximately equal shares in the all accidents are shown in Figure 5. Others/unknown contain the accidents on theft and loss mostly.

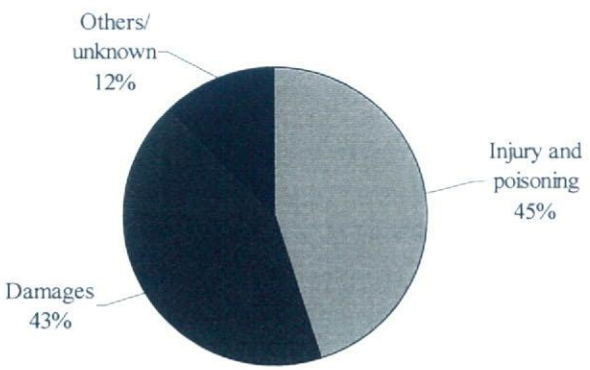

Figure 5. Technical factors on the proprty of substance

The properties caused to the injury and poisoning and to the damages are two of the corrosion/irritation to skin/eye and the toxicity and one of the corrosion/erosion as the principal factors respectively, as shown in figure 6 and Figure 7. Therefore, these three are recognized to be key factors to the safety measures regarding the properties.

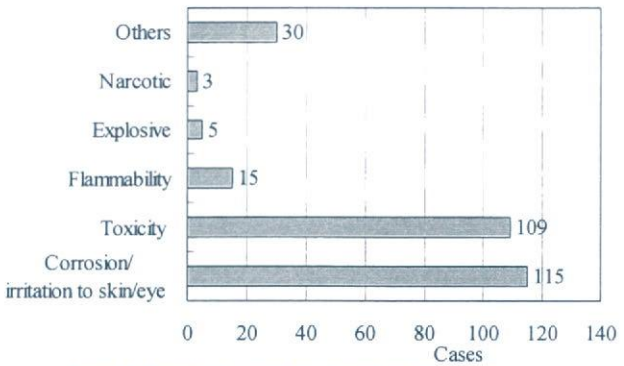

Figure 6. Properties caused to the injury and poisoning

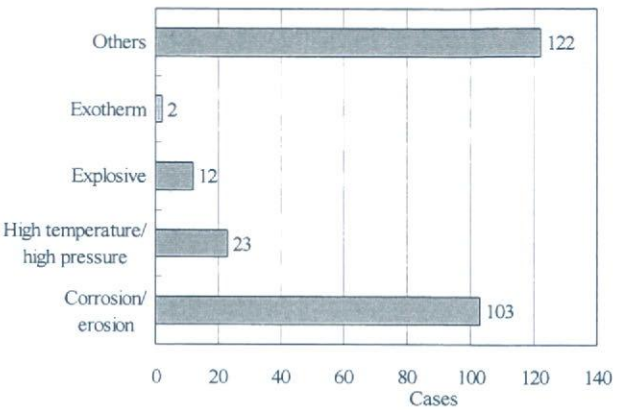

Figure 7. Properties caused to the damages

Installation: Secondly, if there is a problem in the installation as a technical factor, an accident may occur and its damages will expand occasionally. As shown in Figure 8, the problems concerned in the installation are poor maintenance, improper/faulty design, shoddy workmanship/trouble in execution, and so on in order. However, others/unknown accounts for more than 50 percent of all accidents. This means that it is difficult to identify the cause of an accident as the problem concerned in the installation.

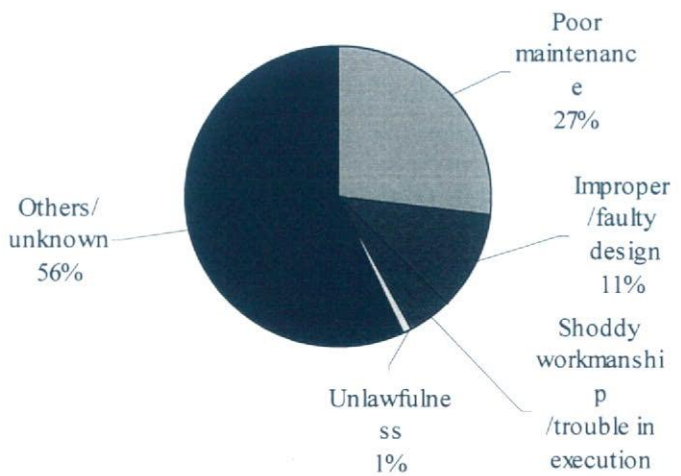

Figure 8. Problems in installation

The detail of poor maintenance has not been elucidated, but a breakdown of improper/faulty design was figured out as shown in figure 9. The factor analysis concerning the technical factors indicates to bring into basic questions on technical safety such as poor maintenance and installation-safing design.

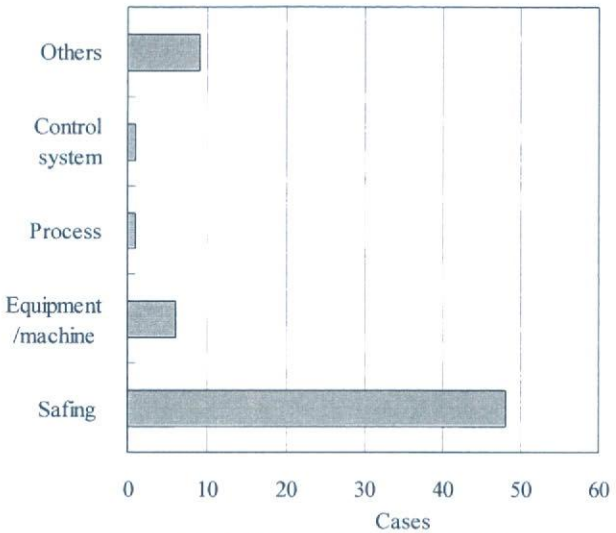

Figure 9. A breakdown of improper/faulty design

Organization Factors of Causes

Human: The organization factors were divided into two of the human problems and the inferior management as the major factors as shown in Table 2. Firstly, through the analysis of all 615 cases, the human problems are established as shown in Figure 10. Doing in a state of unconsciousness leads largely you to an accident and the states of unconsciousness are desultoriness, lazy/slipshod and lack of knowledge in descending order of the occurrences of the accidents as shown in Figure 11.

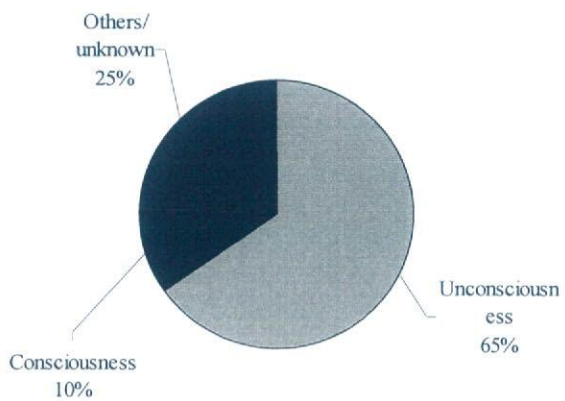

Figure 10. Organization factors on the human problems

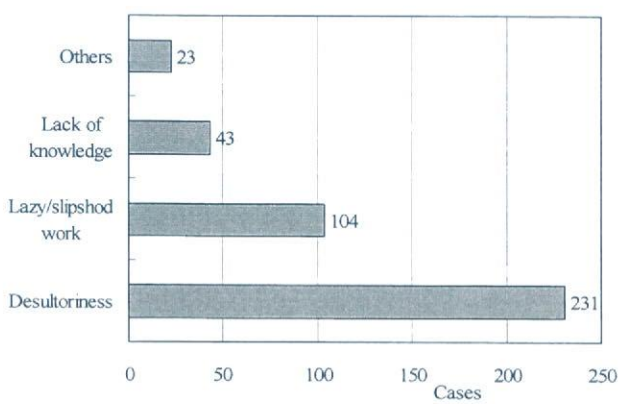

Figure 11. Problems in unconsciousness

Management: Secondly, from the view point of the management in the organization, many kinds of inferior management are found over the causes of all 615 accidents as shown in Figure 12. It seems that there are many problems in the middle-level and the daily management rather than in the professional management. Contrastively, the accidents in the hazardous material facilities, of which manufactures the flammable and the explosive substances are handled in, are chiefly caused by the professional management such as the identification and evaluation of hazards[1]. As a general speaking, it is needed that the rational and scientific management

must be introduced and the upper level management to be stable and seasoned will be grown in the middle management level under the strong top management.

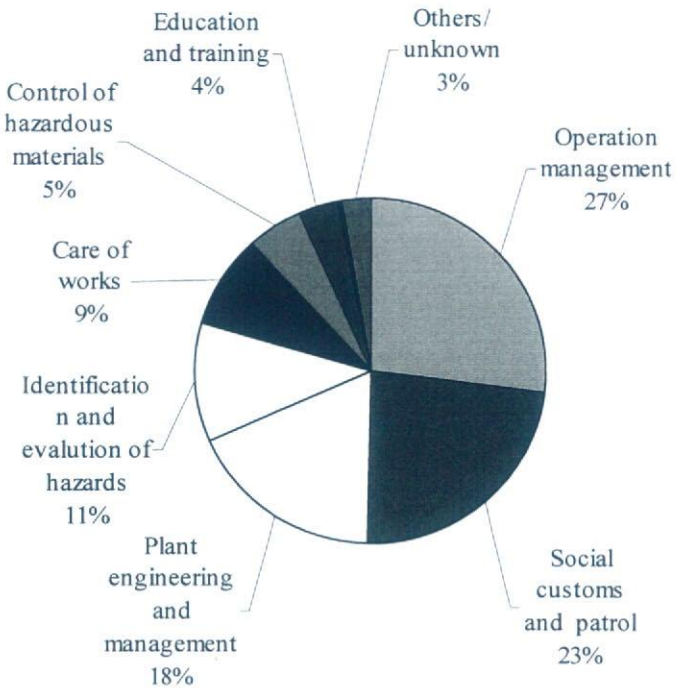

Figure 12. Organization factors on inferior management

DEDUCED SAFETY MEASURES

On the basis of the results of factor analysis, the practically effective measures can be deduced from the predominant factors as follows:

1. It is necessary to step up the measures for safety in the manufacture of chemical substances and the truck transportation.

2. The safety measures applied to strongly basic compounds, strongly acidic compounds, ammonia, chloropicrin, cyanides and phosgene should be specified and intensified.

3. From the point of view of the corrosion/irritation to skin/eye, the toxicity and the corrosion/erosion, the safety measures for the human-beings and the protective measures for the installations must be strengthened concretely.

4. There are a variety of problems in regard to the installation. To carry out not only the proper and strict maintenance but also the friendly and safer design are more important than anything else.

5. In view of most cases caused by the unsafe act in a state of unconsciousness as a human factor, to be diligent in your own work is a matter of the highest priority and to make thoroughly a confirmation of your act is demanded.

6. It is absolutely necessary to keep the fundamental matters of management rather than the higher level management. Especially, this shall be urgently required of the middle management level under their following the top management.

CONCLUSIONS

This work gives obviously the main backgrounds and the major causes to the accidents in regard to the PDS'. As the countermeasures of dealing with this, the essential items which are related to the fundamentals on safety and the basis of management are deductively devised. Namely, it is need to step up the standards of safety and risk management.

The above is the gist of this article. Conclusively, the systematic methodology of deriving the rational measures from the accidents is established.

ACKNOWLEDGMENTS

The authors wish to thank the Ministry of Health, Labor and Welfare of Japan for the Health and Labor Sciences Research Grant to the Research on Risk of Chemical Substances.

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論文（3）

Strategic Safety Measures for the Toxic and/or Corrosive Materials-handling manufacturing industries

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Abstract: The authors have analyzed the accidents of the poisonous and deleterious substances, amounting to 615 cases, reported to the Ministry of Health, Labor and Welfare (MHLW) and the Fire and Disaster Management Agency (FDMA) by the local public authorities in Japan for six years until 2004. In this paper, the accidents are limited to the poisonous and deleterious substances-handling manufacturing industries, whose accidents amount to 205 cases. The accidents reports were analyzed from the many points of view, that is, chemicals, facilities, phenomena, causes, and physical factors and human factors concerning the accidents. A variety of chemicals were involved in the accidents, such as sulfuric acid, sodium hydroxide, chlorine, hydrogen chloride, ammonia, hydrochloric acid, nitric acid, hydrogen sulfide and so on. From the points of view of the organization factors and the technical factors, an accident causes were investigated and analyzed into the detailed factors. The accidents resulted repeatedly from similar causes and in similar events, namely, characterized typically by the technical factors of the poor maintenance and the improper and/or faulty design chiefly, and by such organization factors as the unconsciousness of failing to make sure and the inferior managements of the operation, the plant engineering mainly. In order to prevent the accident due to the major causes from repeating itself, the strategic safety measures were deductively found by devising the means so that the causes ranking higher risk, based on the statistical analysis for the cause factors, can be avoided and/or eliminated. Conclusively, this calls not only the middle management into question who manages the design, the workmanship of plant formation and the maintenance, but also the operators and the laborers. The risk assessment and the awareness of the hazard are hardly enough to fulfill their duties on the fundamentals of safety.

Keywords: poisonous, deleterious, safety-measures, accidents, factor-analysis, causes

INTRODUCTION

This work is conducted as part of the research project to build the database of the accidents in regard to the chemical substances having the poisonous and deleterious property for the purposes of decreasing the accidents and promoting safety. There are several databases on the accidents of hazardous materials having the properties of flammability and reactivity but no database on the accidents of the poisonous and deleterious substances in Japan [1]. If there were no systematic data of the accidents, it would be impossible to assess the risk properly. The safety measures must be a wide variety of the methods to reduce the risk and to avoid the risk. Without an accurate risk assessment, the practicably effective measures against the risk would be never thought out.

The purpose of this work is to invent the methodology to find out the effective measures against the risk and to confirm whether it is true or not by applying it to the real cases. Firstly, the case histories of the accidents, related to the poisonous and deleterious substances, are collected all-inclusively in Japan for the limited years and they are systematically arranged in a suitable format for a factor analysis. It is just basic data for the accident database. Secondly, what is the major cause of an accident connected with the chemical substances having the poisonous and deleterious property, what kind of chemicals it occurs chiefly to, where

it happens, and how it develops from and into will be made clear with a comprehensive survey. The factor analysis, which is applied to the accident data, must be useful. The risk will also become evident semi-quantitatively. And thirdly, on the basis of the results of factor analysis, the measures can be thought out so as to reduce the risk and to avoid the risk. Practical data and authors' experiences are essential for conducting this process.

BACKGROUND

Chemical substances having the poisonous and deleterious property are controlled by Poisonous and Deleterious Substances Control Law, falling under the jurisdiction of the Ministry of Health, Labor and Welfare (MHLW) in Japan. The chemicals under the control of the law, hereinafter called PDS', are divided into three categories of poisonous substances, deleterious substances and specified poisonous substances. The 101 chemicals having strong toxic property such as sodium cyanide, arsenic and phosgene are designated the poisonous substances. The 358 chemicals weak toxic property such as sodium hydroxide, sulfuric acid and chloropicrin are done the deleterious substances. And, the 13 chemicals very strong toxic property such as tetraethyl lead, tetra-alkyl lead and phosphates are done the specified poisonous substances, at present.

If an accident should occur, it is reported to the local authority. The accidents concerning on dispersion, leakage and spill are investigated by the public health department, the district police station and/or the local fire department. The accidents on theft and loss are done by the district police station. The accidents on fire and explosions are done by the local fire department. The investigation reports from the public health departments and the district police stations are submitted to the MHLW and ones from the local fire departments to the Fire and Disaster Management Agency (FDMA) through their own prefectural government, respectively. And then, the MHLW and the FDMA compile the investigation reports from the prefectural governments into the annual reports severally and publish them one by one officially.

PROCEDURES

The procedures of this work are schematically shown in Figure 1 and described as follows:

Collection of Case History

The whole accidents of Japan were collected concerning on the chemicals of PDS' by quoted from the annual reports of the MHLW and the FDMA for the limited period of recent six years from 1999 to 2004. The accidents amount to 615 cases.

Case Analysis

The accident reports are mostly described in the sentence style unsuitable for the factor analysis. As a general rule, an accident is composed of a cause-and-effect sequence of events. Various factors combine to produce the sequence of the accident. The case analysis is to consider seriously the sequence of the accident and to determine carefully its own factors, based on its accident report, in order to arrange every accident into a prearranged format.

The causes shall come entirely to two divisions of the technical factors and the organization factors. The technical factors shall result in two factors of the property of substance and the installation, which seem to be equivalent to a viewpoint of hardware in material safety and process safety respectively. The organization factors shall contain the human problems and the inferior management. Furthermore, these major four factors, 1st factors, are divided into the many detailed factors, 2nd and 3rd factors, as shown in Table 1 and Table 2.

Judging an accident from a standpoint of these major four factors, a factor corresponding to its causes will be chosen from the detailed factors belonging to each major factor. Namely, four detailed factors concerning on the causes will be selected for every accident. The case analysis was performed on the whole accidents.

Factor Analysis

The case history of an accident combines not only the factors of causes but also other factors, a category of business, a kind of the concerned chemicals, its state, a course of the event and so on. All the accidents are analyzed into the factors and are indicated with the factors what the accident is. And then, in order to evaluate the percentages of every factor in the total, the statistical treatment is applied to the whole accidents, that is, the factor analysis.

Safety Measures

Based on the result of factor analysis, it is easy to find out the predominant factors which appear frequently among the cases. If these factors are concerned in the causes of the accident, the safety measures could be extracted from the meanings of the factors as the measures to avoid, escape and seal the causes in principle, referring to the concerned accidents. These safety measures will prove to be effective in practice and must be strategic.

RESULT OF FACTOR ANALYSIS

A Category of Business

The whole accidents concerning on the chemicals of PDS', were 615 cases in Japan for six years from 1999 to 2004. These accidents were distributed over a variety of business as shown in Figure 2. And, Figure 3 gives the breakdown of the manufacture accounting for 48 percents of all PDS' accidents. Chemical substance manufacture is particularly prominent among the manufacture, counting for 205 cases. Consequently, in this paper, an argument is limited to the chemical substance manufacture, that is, the PDS'-handling manufacturing industries hereafter.

Concerned Chemicals

The substances concerned in the 205 accidents extended to such a wide variety of chemicals as sulfuric acid, sodium hydroxide, chlorine, hydrogen chloride, ammonia, hydrochloric acid, nitric acid, hydrogen sulfide and so on, as shown in Figure 4. Strongly acidic compounds and strongly basic compounds rank high in many chemicals. The 6 cases of phosgene (approximately 3 percents), which is highly poisonous, are predominant. The states of these substances are divided into 60 percents liquid, 35 percents gas, 3 percents solid and others.

Technical Factors of Causes

Properties: The factor analysis of the causes was performed for the all 205 cases with regard to the technical factors as shown in Table 1, firstly. The accidents due to the property of substance result in the harms and the damages, whose approximately equal shares in the all accidents are shown in Figure 5.

Others/unknown contain the accidents on theft and loss mostly.

The properties caused to the harms and to the damages are two terms of the corrosion/irritation to skin/eye and the toxicity and also two terms of the corrosion/erosion and the high temperature/high pressure, causing physical damage and/or burst, respectively as the principal factors, as shown in Figure 6 and Figure 7. Therefore, these four are recognized to be key factors to the safety measures regarding the properties.

Installation: Secondly, if there is a problem in the installation as a technical factor, an accident may occur and its damages will expand occasionally. As shown in Figure 8, the problems concerned in the installation are poor maintenance, improper/faulty design, shoddy workmanship/trouble in execution, and so on in order. However, others/unknown accounts for approximately 50 percents of all accidents. This means that it is difficult to identify the cause of an accident as the problem concerned in the installation.

The detail of poor maintenance has not been elucidated, but a breakdown of improper/faulty design was figured out as shown in Figure 9. The factor analysis concerning the technical factors indicates to bring into basic questions on technical safety such as poor maintenance and installation-safing design.

Organization Factors of Causes

Human: The organization factors were divided into two of the human problems and the inferior management as the major factors as shown in Table 2. Firstly, through the analysis of all 205 cases, the human problems are established as shown in Figure 10. Doing in a state of unconsciousness leads largely you to an accident and the states of unconsciousness are desultoriness, that is, failing to make sure, and lazy/slipshod as shown in Figure 11. The failing to make sure is notable for the unconsciousness.

Management: Secondly, from the view point of the management in the organization, many kinds of inferior management are found over the causes of all 205 accidents as shown in Figure 12. It seems that there are many problems in the middle-level and the daily management rather than in the professional management. Contrastively, the accidents in the hazardous material facilities, of which manufactures the flammable and the explosive substances are handled in, are chiefly caused by the professional management such as the identification and evaluation of hazards[2]. As a general speaking, it is needed that the rational and scientific management must be introduced and the upper level management to be stable and seasoned will be grown in the middle management level under the strong top management.

DEDUCED SAFETY MEASURES

On the basis of the results of factor analysis, the practically effective measures for the chemical substance manufacture, that is, the PDS'-handling manufacturing industries can be deduced from the predominant factors as the measures to avoid, escape and seal the causes in principle, referring to the concerned accidents as follows:

1. The safety provisions for the PDS' shall be revised for the more suitable to the actual situation. It is necessary to step up the measures for safety in the manufacture of chemical substances.

2. The safety measures applied to strongly basic compounds, strongly acidic compounds, chlorine, ammonia, hydrogen sulfide and phosgene should be specified and intensified.

3. From the point of view of the corrosion/irritation to skin/eye, the toxicity and the corrosion/erosion, the safety measures for the human-beings and the protective measures for the installations must be strengthened concretely.

4. There are a variety of problems in regard to the installation. To carry out not only the proper and strict maintenance but also the friendly and safer design are more important than anything else.

5. In view of most cases caused by the unsafe act in a state of unconsciousness as a human factor, to be diligent in your own work is a matter of the highest priority and to make thoroughly a confirmation of your act is demanded. Furthermore, the technical support such as fail-safe must be introduced and the tolerance for an unsafe act is essential to be designed in advance.

6. It is absolutely necessary to keep the fundamental matters of management rather than the higher level management. Especially, this shall be urgently required of the middle management level under their following the top management.

CONCLUSIONS

This work gives obviously the main backgrounds and the major causes to the accidents in regard to the Poisonous and Deleterious Substances. The risk circumstances to the PDS'–handling facilities must be elucidated. Consequently, the essential items which are related to the fundamentals on safety and the basis of management are deductively devised as the countermeasures of dealing with them. Namely, it is need to step up the standards of safety and risk management.

The above is the gist of this article. Conclusively, the systematic methodology of deriving the rational measures from the accidents is established.

ACKNOWLEDGMENTS

The authors wish to thank the Ministry of Health, Labor and Welfare of Japan for the Health and Labor Sciences Research Grant to the Research on Risk of Chemical Substances.

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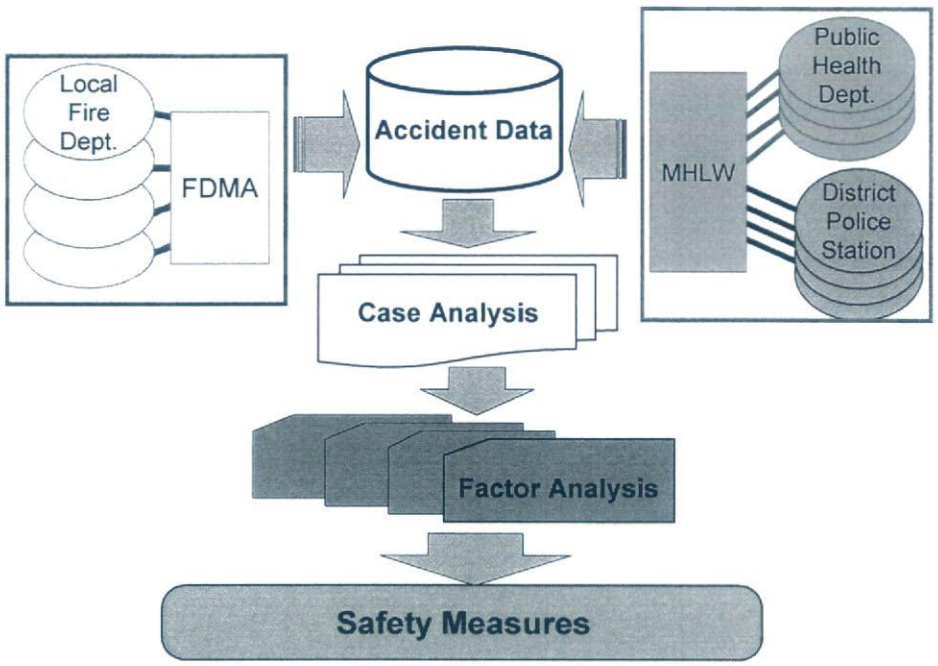

Figure 1 Principle procedures

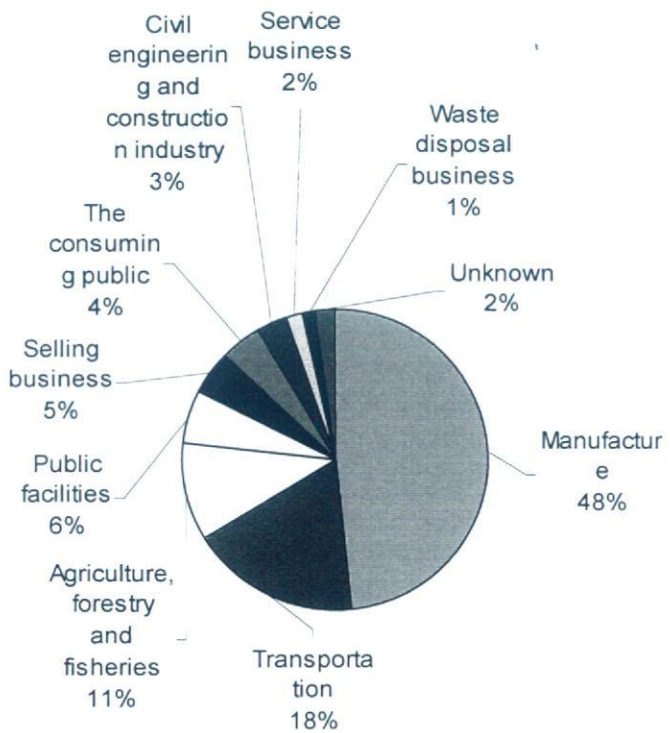

Figure 2 A category of business

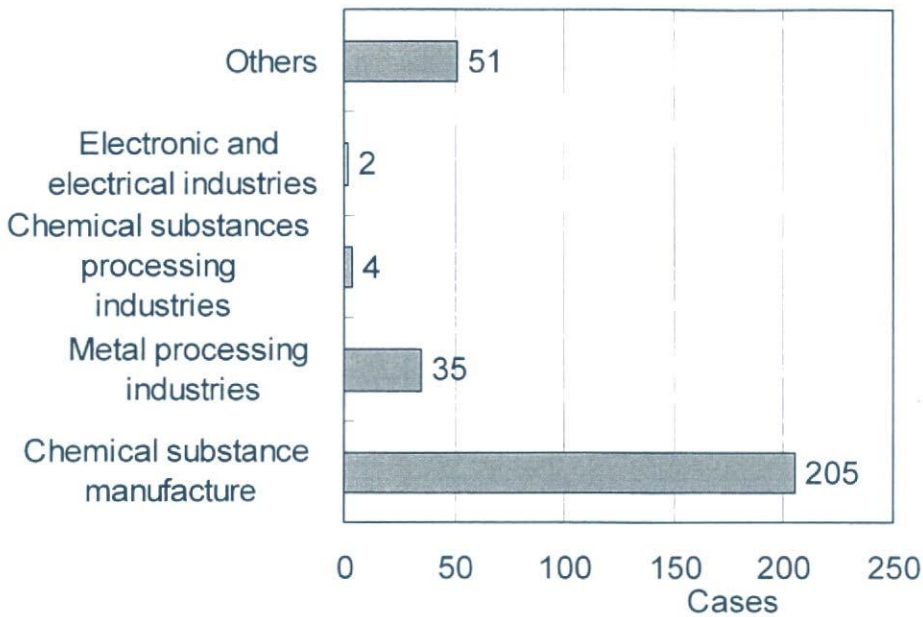

Figure 3 Cases occurred to every industry in manufacture

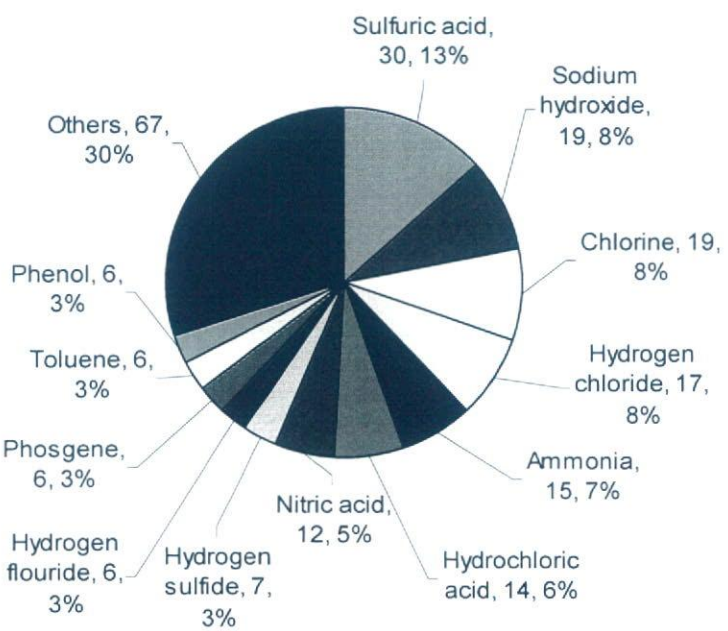

Figure 4 Concerned chemicals in the chemical substance manufacture

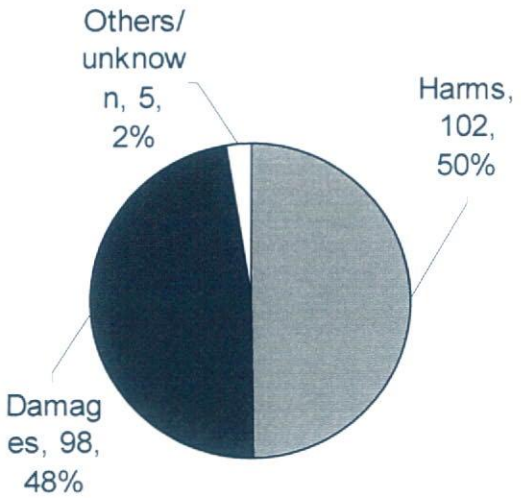

Figure 5 Technical factors on properties in the chemical substance manufacture

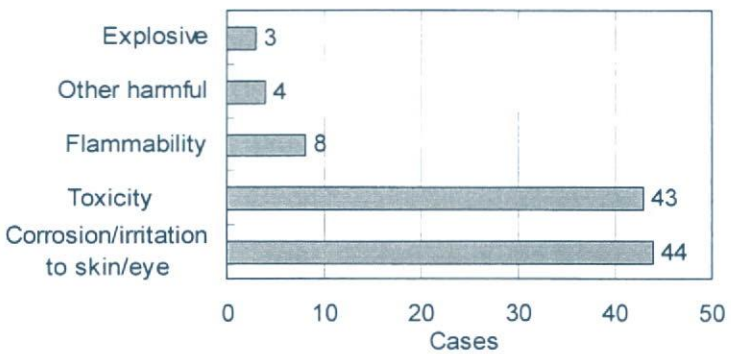

Figure 6 Properties caused to harms in the chemical substance manufacture

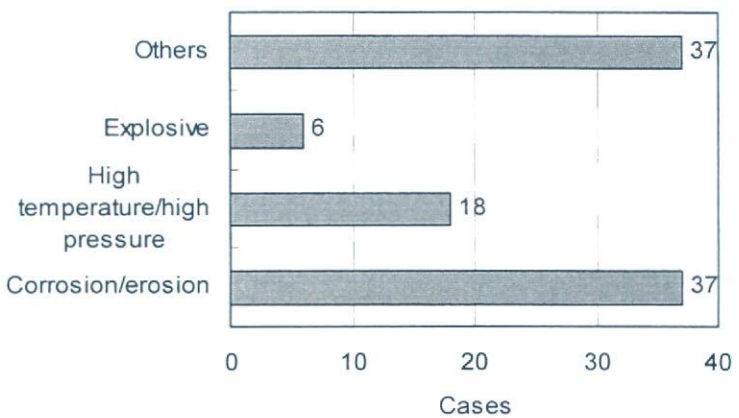

Figure 7 Properties caused to damages in the chemical substance manufacture

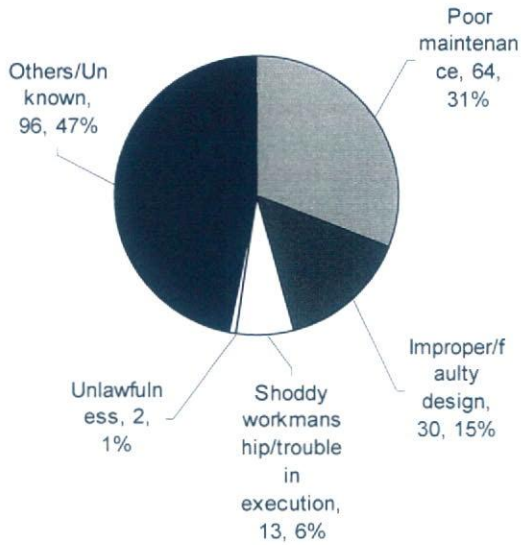

Figure 8 Problems in installation in the chemical substance manufacture

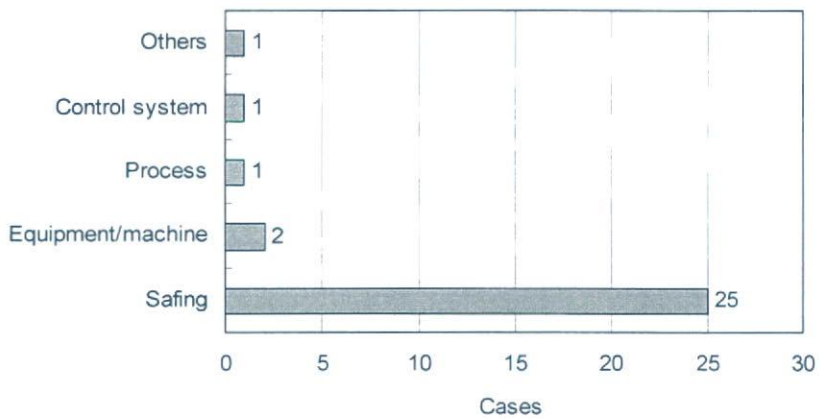

Figure 9 A breakdown of improper/faulty design in the chemical substance manufacture

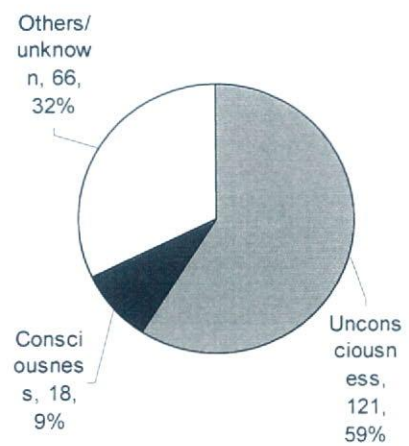

Figure 10 Human problems of organization factors in the chemical substance manufacture

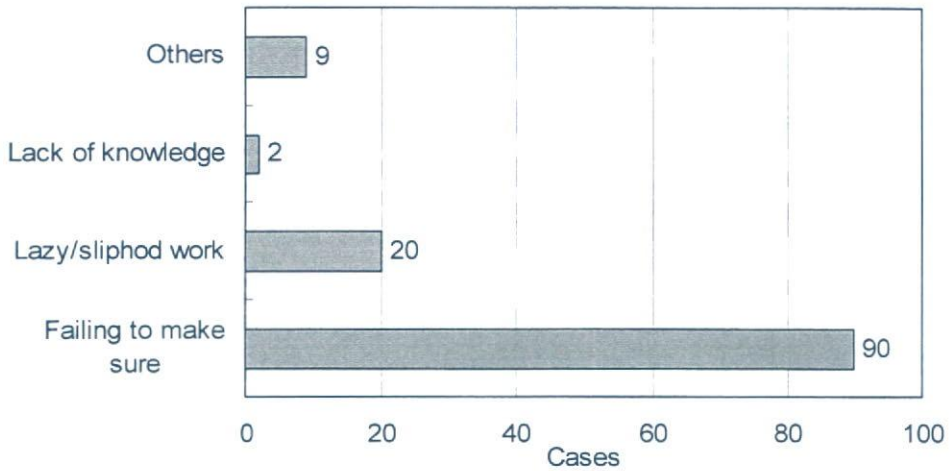

Figure 11 Problems in unconsciousness in the chemical substance manufacture

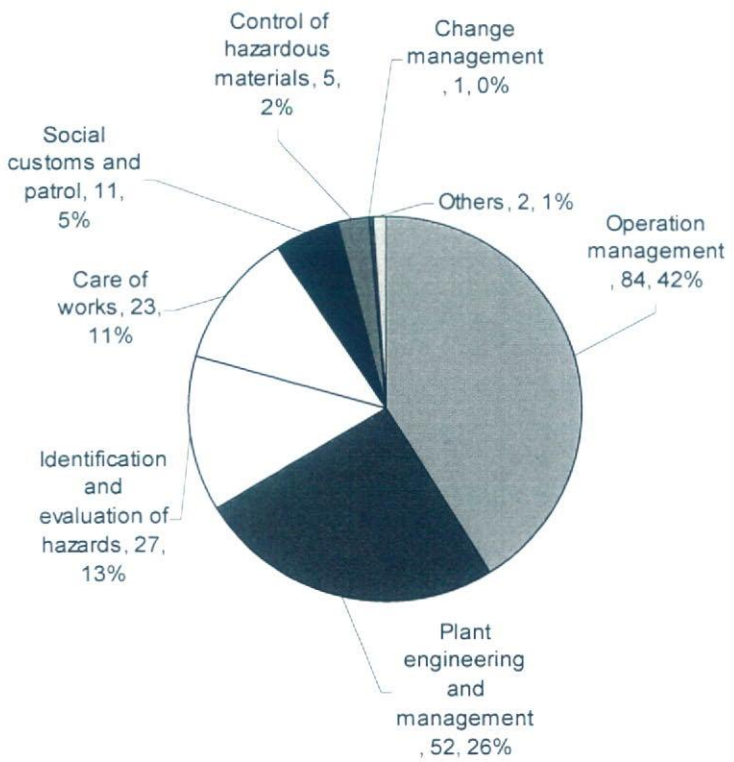

Figure 12 Inferior managements of organization factors in the chemical substance manufacture

Table 1 Technical factors

1st	2nd	3rd
Property of substance	Damages	Explosive
		Flammability
		Exotherm
		Corrosion/erosion
		High temperature/high pressure
		Others
	Harms (Injury and poisoning)	Toxicity
		Narcotic
		Explosive
		Flammability
		Corrosion/irritation to skin/eye
		Others
	Others/unknown	
Installation	Improper/faulty design	Process
		Equipment/machine
		Control system
		Safing
		Others
	Shoddy workmanship/trouble in execution	
	Poor maintenance	
	Unlawfulness	
	Others/unknown	

Table 2 Organization factors

1st	2nd	3rd
Human (individual)	Unconsciousness	Lack of knowledge
		Desultoriness (failing to make sure)
		Lazy/slipshod work
		Others
	Consciousness	Offense against manuals/ rules at work
		Illegality
		Shenanigan
		Terror/arson/ willful misconduct
	Others/unknown	
Management (inferior)	Identification and evalution of hazards	
	Improvement-planning and action	
	Care of works	
	Operation management	
	Change management	
	Control of hazardous materials	
	Plant engineering and management	
	Social customs and patrol	
	Education and training	
	Others/unknown	

論文（4）

On the Quantified Check List for Safety Promotion in the Poisonous and/or Deleterious Substances-handling Manufacturing Industries

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ABSTRACT: The authors have developed the quantitative risk assessment method of the check list, giving added weight to its check statements individually. In order to build the system of the quantified check list, firstly, the investigation reports of the whole accidents related to the poisonous and deleterious substances were collected for the chemical goods-manufacturing industry in Japan for the limited period of recent six years. Secondary, from the points of view of the technical factors and the organization factors, the accident causes were investigated and analyzed into the detailed factors. According to the statistical factor analysis, the importance of the cause factors was quantitatively calculated. Thirdly, approximately twenty check statements were extracted from each accident as the safety measures to avoid the causes in principle. The more important a check statement was, the more times the statement was repeatedly extracted. The number of times the statement was extracted was obtained. These deducted check statements were classified into and distributed to the technical factors and the organization factors. Consequently fourthly, based on both the importance of factors and the extracted times, every statement was expressed in numerical value. And, the check list was composed of about four hundreds check statements in total. And finally, the importance on the statements weighed simplistically into four magnitudes.

Keywords: risk, assessment, check list, poison, management, accident, process

INTRODUCTION

If there were no systematic data of the accidents, it would be impossible to assess the risk properly. The safety measures must be a wide variety of the methods to reduce the risk and to avoid the risk. Without an accurate risk assessment, the practicably effective measures against the risk would be never thought out. A check list is the most approved and simplest method available for executing the risk assessment. Its practical use must be really the self-imposed safety in itself. However, there is something suspicious about its practical effect, if it was not quantitative and could not follow the risk circumstances to be applied.

The purpose of this work is to invent the methodology to find out the effective measures against the risk. In this paper, how to quantify the system of the check list and how to introduce the unique characteristics of following the risk circumstances are described.

BACKGROUND

Chemical substances having the poisonous and deleterious property are controlled by Poisonous and Deleterious Substances Control Law, falling under the jurisdiction of the Ministry of Health, Labor and Welfare (MHLW) in Japan. The chemicals under the control of the law, hereinafter called PDS', are divided into three categories of poisonous substances, deleterious substances and specified poisonous substances.

If an accident should occur, it is reported to the local authority. The accidents concerning on dispersion, leakage and spill are investigated by the public health department, the district police station and/or the local fire department. The accidents on theft and loss are done by the district police station. The accidents on fire and explosions are done by the local fire department. The investigation reports from the public health departments and the district police

stations are submitted to the MHLW and ones from the local fire departments to the Fire and Disaster Management Agency (FDMA) through their own prefectural government, respectively. And then, the MHLW and the FDMA compile the investigation reports from the prefectural governments into the annual reports severally and publish them one by one officially.

PRINCIPAL PROCEDURE

The authors have developed the quantitative risk assessment method of the check list, giving added weight to its check statements individually as follows[1]:

In order to build the system of the quantified check list, firstly, the case histories of the accidents, related to the PDS' in the chemical goods-manufacturing industry, were collected all-inclusively in Japan for the limited period of recent six years. Approximately 200 case histories were done. Secondary, from the points of view of the technical factors and the organization factors, the accident causes were investigated and analyzed into the detailed factors. They were systematically arranged in a suitable format for a factor analysis. According to the statistical analysis for the cause factors, the importance of the cause factors was quantitatively calculated. The risk of accident will also become evident semi-quantitatively. Thirdly, on the other hand, based on the accident causes identified in the case histories, approximately twenty check statements were extracted from each accident as the safety measures to avoid, escape and seal the causes in principle. A total number of the extracted check statements were approximately 4,700. The more important a check statement was, the more times the statement was repeatedly extracted. The number of times the statement was extracted was obtained. These deducted check statements were classified into and distributed to the technical factors and the organization factors by the meaning of the statements. Consequently fourthly, based on both the importance of factors and the extracted times, every statement was quantitatively expressed in numerical value. The check list was composed of about 400 check statements in total. And finally, four categories of the importance on the statement were simplistically established by the magnitude of its numerical value.

COLLECTION OF CASE HISTORY

The whole accidents in Japan were collected concerning on the chemicals of PDS' by quoted from the annual reports of the MHLW and the FDMA for the limited period of recent six years from 1999 to 2004. The accidents amounted to 205 cases in the chemical goods-manufacturing industry.

FACTOR ANALYSIS

The causes shall come entirely to two divisions of the technical factors and the organization factors. The technical factors shall result in two factors of the property of substance and the installation, which seem to be equivalent to a viewpoint of hardware in material safety and process safety respectively. The organization factors shall contain the human problems and the inferior management. Furthermore, these major four factors, 1st factors, are divided into the many detailed factors, 2nd and 3rd factors, as shown in Table 1 and Table 2 [2].

Judging an accident from a standpoint of these major four factors, a factor corresponding to its causes will be chosen from the detailed 2nd factors belonging to each major factor. Namely, four detailed factors concerning on the causes will be investigated and selected for every accident. The case analysis was performed on the whole accidents.

RESULTS

Properties: The factor analysis of the causes was performed for the all 205 cases with regard to the technical factors as shown in Table 1, firstly. The accidents due to the property of substance result in the harms and the damages, whose approximately equal shares in the all accidents are shown in Figure 1. Others/unknown contain the accidents on theft and loss mostly.

The properties caused to the harms and to the damages are two terms of the corrosion/irritation to skin/eye and the toxicity and also two terms of the corrosion/erosion and the high temperature/high pressure, causing physical damage and/or burst, respectively as the principal factors.

Table 1. Technical factors

1st	2nd	3rd
Property of substance	Damages	Explosive
		Flammability
		Exotherm
		Corrosion/erosion
		High temperature/high pressure
		Others
	Harms (Injury and poisoning)	Toxicity
		Narcotic
		Explosive
		Flammability
		Corrosion/irritation to skin/eye
		Others
	Others/unknown	
Installation	Improper/faulty design	Process
		Equipment/machine
		Control system
		Safing
		Others
	Shoddy workmanship/trouble in execution	
	Poor maintenance	
	Unlawfulness	
	Others/unknown	

Table 2. Organization factors

1st	2nd	3rd
Human (individual)	Unconsciousness	Lack of knowledge
		Desultoriness (failing to make sure)
		Lazy/slipshod work
		Others
	Consciousness	Offense against manuals/ rules at work
		Illegality
		Shenanigan
		Terror/arson/ willful misconduct
	Others/unknown	
Management (inferior)	Identification and evalution of hazards	
	Improvement-planning and action	
	Care of works	
	Operation management	
	Change management	
	Control of hazardous materials	
	Plant engineering and management	
	Social customs and patrol	
	Education and training	
	Others/unknown	

Installation: Secondly, if there is a problem in the installation as a technical factor, an accident may occur and its damages will expand occasionally. As shown in Figure 2, the problems concerned in the installation are poor maintenance, improper/faulty design, shoddy workmanship/trouble in execution, and so on in order. However, approximately 50 percents of all accidents accounts for the others/unknown. This means that it is difficult to identify the cause of an accident as the problem concerned in the installation.

The detail of poor maintenance has not been elucidated, but a breakdown of improper/faulty design was analyzed as installation-safing design mainly. The factor analysis concerning the technical factors indicated to bring into basic questions on technical safety such as poor maintenance and installation-safing design.

Human: The organization factors were divided into two of the human problems and the inferior management as the major factors as shown in Table 2. Thirdly, through the analysis of all 205 cases, the human problems are established as shown in Figure 3. Doing in a state of unconsciousness leads largely you to an accident and the states of unconsciousness were in desultoriness composed of failing to make sure and lazy/slipshod. The failing to make sure was notable for the unconsciousness.

Management: Fourthly, from the view point of the management in the organization, many kinds of inferior management are found over the causes of all 205 accidents as shown in Figure 4. It seems that there are many problems in the middle-level and the daily management rather than in the professional management.

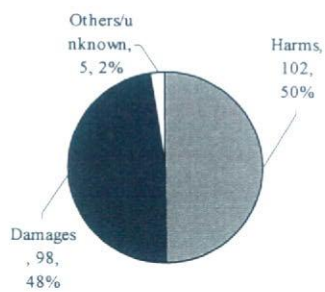

Figure 1 Technical factors on properties in the chemicals

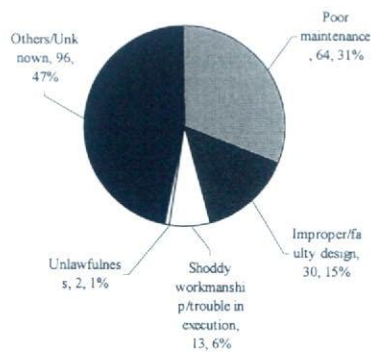

Figure 2 Problems in installation