

◆ Application Papers

An Integral Model for Product Liability and Safety using Hazard Analysis.

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Abstract

This paper presents an integral model for product safety and product liability resulting from a defective product. The essence of the paper is the process of supply of manufacturing products which satisfy the product liability and the product safety in terms of consumers expectation levels. The main criteria of the product safety is the hazard level which involves in the severity and frequency. The proposed model shows the process to supply the manufactured products under the conditions that they are suitable in comparison of hazard level and safety level established by each company. If the product do not meet the safety level, this paper proposes that four different types of PL and PS countermeasures for the risk types are forward, respectively.

1. Introduction

It is difficult to clarify which product liability(PL) will be more efficient or which product liability will have more risk, because there is almost no existing product liability suit data due no PL legislation in Korea so far. Therefore, it is needed to identify how to solve the problem for the prevention of PL in order to ensure safety at the standpoint of consumers.

In this study, consumer safety is defined as safety insurance on the condition of consumer use and on the condition of the determination with consumer-demanding level. Three main concepts are demonstrated as the design technique to show the process for efficient PL & PS technique. The first concept is selecting the most concerned factor when consumers determine directly their hazard perception to the product and analyzing PL using this factor. The second is to select the effective countermeasures for PL and product safety(PS).

The third is classifying these products as four types:①Type I, ②Type II,③Type III,and ④Type IV. More survey will be required for the domestic experts to find out what countermeasure will be the most efficient one among the four types.

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Hazard informations are considerably involved in consumer concerned information and safety condition survey which have been collected by Korea Consumer Protection Board (KCPB). In addition, a part of those data have been more deeply analyzed for the risk assessment. Ideas getting overall domestic product liability & safety insurance are shown here.

2. Analysis of factors for hazard recognition

In order to figure out what factors will be the most related ones to consumers recognition for the hazard, 500 sheets of questionnaire have been distributed to the people, domestic consumers with rate of response 63.1% = 317sheets. The study to select a representative factor has been done for 35 common products. Seven(7) factors such as severity, frequency, frequency of use, time of contact, familiarity, technical difficulty, reliability of product safety are selected, and then questionnaire survey is made with 5 point scale as shown in Table 1.

Questionnaire survey results are analyzed in the SAS package for multiple regression analysis. It is indicated that consumer concerned hazard information in 1997 & 1998 is considered with priority No.1.

Correlation between each factor has been calculated question by question on the survey, as shown in table 2. Positive correlation coefficient $r = 0.88202$, $p < 0.0001$ is obtained with 77.8% of total variance between hazard perception of products and severity of injury. Also, between hazard perception of product and likelihood of injury, it is shown that $r = 0.8875$, $p < 0.0001$ with 78.76% of total variance.

Table 2 shows correlation analysis result with 5% significance level in lower row. In order to predict hazard, seven(7) factors including severity of injury and likelihood of injury need to be analyzed through multiple regression.

Stepwise method to select better description factors has been used for the analysis. This shows that severity of injury and frequency reach to $R^2 = 0.08875$ ($p < 0.0001$). The other factors are not related to divergence description.

Table 1. Survey results for hazard-recognition factor selection

Product \ Factors	Product Hazard	Severity of Injury	Frequency	Frequency of Use	Time of Contact	Familiarity	Confidence	Reliability
Electronic Range	2.59	3.13	1.83	2.90	2.14	3.03	3.09	3.17
Electric Rice Cooker	2.01	2.41	1.59	3.46	2.77	3.46	2.57	3.14
Juicer	2.71	3.06	2.43	1.79	1.46	2.37	2.19	3.19
Electric Water Purifier	1.99	2.14	1.84	2.90	2.00	2.76	2.46	2.80
Electronic Washing Machine	2.10	2.70	1.83	3.17	2.59	3.26	3.13	3.19

Table 1. Survey results for hazard-recognition factor selection(Continued)

Product	Factors	Product Hazard	Severity of Injury	Frequency	Frequency of Use	Time of Contact	Familiarity	Confidence	Reliability
Elevator		3.07	4.56	2.61	3.39	2.21	3.41	3.34	3.39
Escalator		2.80	3.84	2.46	3.10	2.10	3.07	3.11	3.17
TV		1.49	2.14	1.19	4.60	3.63	4.49	3.44	3.13
Electronic Bulb		2.26	2.59	1.94	4.54	3.94	4.11	1.89	3.26
Electric Heater		3.01	3.51	2.64	3.10	2.66	2.74	2.87	3.17
Electric Fan		2.84	3.16	2.83	3.26	2.91	3.54	2.20	3.84
Electric Iron		3.20	3.24	3.13	2.86	2.24	2.94	2.21	3.87
Gas Heater		3.36	3.81	2.63	2.06	1.77	1.97	2.50	3.07
Toy Sword		2.63	2.71	2.46	1.09	1.01	1.43	1.30	3.39
Gas Range		3.27	4.07	2.76	4.03	2.77	3.60	2.30	3.49
Gas Lighter		2.41	2.77	2.20	3.83	2.36	3.53	1.59	3.56
Gas Boiler		2.69	4.11	2.20	3.13	2.83	2.73	3.00	3.00
LP Gas Tank		3.50	4.73	2.83	2.26	1.80	1.93	2.03	3.30
Toy Gun		2.83	2.94	3.16	1.20	1.13	1.56	1.94	3.60
Firecracker		3.57	3.40	3.30	1.30	1.21	1.54	1.57	3.54
Vehicle		3.86	4.93	4.29	3.97	3.19	3.80	4.30	3.74
Motorcycle		4.41	4.91	4.56	1.59	1.34	1.97	4.06	3.74
Bicycle		2.80	3.57	3.37	2.33	1.96	2.94	2.50	3.83
Tire		2.07	2.89	2.27	2.66	2.40	2.54	1.91	2.83
Contact Lens		2.17	2.76	2.41	1.31	1.33	1.47	1.96	2.71
Hairdye		2.23	2.41	1.96	1.47	1.36	1.64	1.79	2.56
Cosmetics		1.66	2.07	1.90	4.01	2.44	3.61	1.79	2.70
Ices		1.63	2.20	1.87	3.23	2.13	3.06	1.41	2.99
Cold-Storage Food		2.03	2.57	2.20	3.41	2.20	3.03	1.57	3.01
Luncheon		2.03	2.49	2.11	2.16	1.80	2.24	1.31	3.01
Snack		1.59	2.17	1.73	3.10	2.23	3.07	1.46	2.83
Paint		2.53	3.10	2.31	1.64	1.77	1.66	2.03	2.94
Detergent		2.21	2.63	2.03	3.21	2.30	2.63	2.10	2.90
Medical Products		2.80	3.89	2.86	2.89	2.13	2.70	2.90	3.04
Adhesive Substance		3.14	3.19	2.89	2.27	1.90	2.00	1.83	3.39

Eventually, it is shown that product-using consumers considers hazard perception as the most important factor. In other word, the more consumer perceive severity and frequency of hazard, the more product risk will be existed.

Table 2. Correlation coefficient among hazard recognition factors

	Product Hazard	Severity of Injury	Frequency(Likelihood)	Frequency of Use	Time of Contact	Familiarity	Confidence
Severity of Injury	0.88202 0.0001						
Frequency (Likelihood)	0.88747 0.0001	0.76420 0.0001					
Frequency of Use	-0.30747 0.0724	-0.09595 0.5835	-0.33813 0.0470				
Time of Contact	-0.24230 0.1608	-0.05113 0.7705	-0.28828 0.0931	0.91657 0.0001			
Familiarity	-0.29258 0.0881	-0.10088 0.5642	-0.28757 0.0939	0.95834 0.0001	0.88954 0.0001		
Confidence	0.44442 0.0075	0.60756 0.0001	0.36875 0.0293	0.27368 0.1116	0.33526 0.0490	0.34341 0.0434	
Reliability	0.67107 0.0001	0.52059 0.0013	0.69365 0.0001	0.01309 0.9405	0.05886 0.7370	0.14315 0.4120	0.28989 0.0912

Table 3. Multiple regression result using stepwise method

Stepwise Procedure for Dependent Variable X1						
Step 1	Variable X3 Entered	R-square = 0.78759773 C(p) = 55.70292366				
		DF	Sum of Squares	Mean Square	F	Prob>F
	Regression	1	12.23504722	12.23504722	122.37	0.0001
	Error	33	3.29959278	0.09998766		
	Total	34	15.53464000			
	Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
	INTERCEP	0.50520672	0.19798683	0.65104653	6.51	0.0155
	X3	0.85208687	0.07702900	12.23504722	122.37	0.0001
Bounds on condition number:		1,	1			
Step 2	Variable X2 Entered	R-square = 0.88745141 C(p)= 16.94250410				
		DF	Sum of Squares	Mean Square	F	Prob>F
	Regression	2	13.78623812	6.89311906	126.16	0.0001
	Error	32	1.74840188	0.05463756		
	Total	34	15.53464000			
	Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
	INTERCEP	0.11134712	0.16396305	0.02519749	0.46	0.5020
	X2	0.40544889	0.07609378	1.55119090	28.39	0.0001
	X3	0.49260117	0.08828457	1.70103227	31.13	0.0001
Bounds on condition number:		2.403899,	9.615596			

Table 3. Multiple regression result using stepwise method(Continued)

Stepwise Procedure for Dependent Variable X1						
Step 3	Variable X6 Entered	<u>R-square = 0.89780208</u>		C(p) = 14.71734270		
		DF	Sum of Squares	Mean Square	F	Prob>F
	Regression	3	13.94703214	4.64901071	90.78	0.0001
	Error	31	1.58760786	0.05121316		
	Total	34	15.53464000			
	Variable	Parameter Estimate	Standard Error	Type II Sum of Squares	F	Prob>F
	INTERCEP	0.40951238	0.23133208	0.16048848	3.13	0.0865
	X2	0.43104961	0.07507399	1.68832901	32.97	0.0001
	X3	0.44001499	0.09047885	1.21121816	23.65	0.0001
	X6	-0.09096659	0.05133786	0.16079402	3.14	0.0862
			omission			

note) X1 : Product hazard, X2 : Severity, X3 : Frequency, X4 : Familiarity

3. Efficient technique to select the Countermeasures of PL & PS

From the review of the important countermeasures in the existing paper & references^{11)~13)}, basic organization & top management's support are not included in the measures for PL & PS.

As a result of survey research, eleven(11) successful countermeasures for PL & PS are selected as follows;

- 1) Establishment Product Safety System
- 2) Product Safety Design
- 3) PL & PS Audit
- 4) Quality Control
- 5) Application of Warning
- 6) After Service
- 7) Document Control
- 8) Survey of User's Claim & Follow-up Procedure
- 9) Early Warning System
- 10) Recall
- 11) Take out on Insurance

4. Product pattern analysis by risk matrix

Risk matrix is very important for risk assessment. Fig.1 shows a risk matrix which is derived from the assessment of severity and frequency of product hazard for general 35 products selected by domestic consumers. Risk of consumer-assessing product is classified as following four(4) types.

1. Type I Risk : low frequency and severity case
2. Type II Risk : low frequency but potential hazard
3. Type III Risk : low severity but high frequency
4. Type IV Risk : high severity and frequency

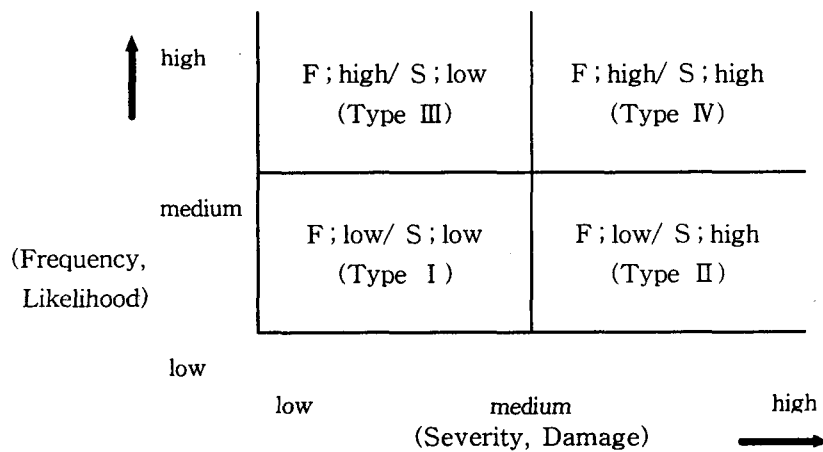


Fig.1 product liability risk on risk matrix

Risk matrix for 35 general product analyzed by domestic users is shown in Fig 2. The detailed product items are classified as four types as follows ;

Type I : a group of cookie and make-up items. These are perceived to be safe and related to safety code and SG(Safety Good) in Japan.

Type II : low possibility of injury occurrence but potential high severity of hazard, if any. They are mainly gas and chemical product. Special control continues to be compensated for these items. Chemical control regulation, gas supply code, high pressure code are introduced to the items in Japan.

Type III : Children mainly use as bullet-using toy. ST(Safety Toy) to compensate is considered as regulation in the developed countries.

Type IV : auto-bicycle, bicycle, automobile, a group of transportation machine & equipments. There are high severity of injury & frequency for this type.

The most strong countermeasure should be prepared for the PL & PS.

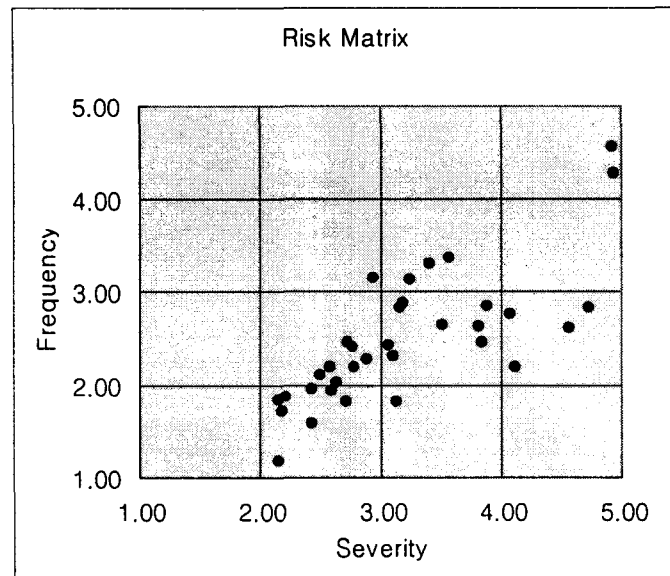


Fig. 2 Risk matrix

- ▷ Type I 16 product item list
 - : Electric Washing Machine, Tires, TV, Contact Lens, Electric Water Purifier, Electric Rice Cooker, Cold-Storage Food, Luncheon, Ices, Detergent, Snack, Hairdye, Gas Lighter, Toy Sword, Electric Bulb, Cosmetics
- ▷ Type II 13 product item list
 - : Gas Range, Gas Boiler, LP Gas Tank, Gas Heater, Electric Fan, Elevator, Escalator, Medical Products, Electric Heater, Electric Range, Adhesive Substance, Paint Juicer, Paint
- ▷ Type III one(1) product item list
 - : Toy Gun
- ▷ Type IV five(5) product item list
 - : Moto Cycle, Vehicle, Bicycle, Firecracker, Electric Iron

5. Efficient PL & PS Countermeasures By Expert Analysis

Efficient countermeasures for four types classified by the risk matrix are ranked by the order of the importance by the experts 20 people. They are mainly related to the expert board of Korea Consumer Protection Board as shown in table 4.

Questionnaire survey asked for the expert are collected and analyzed for the priority of measures in table 4. Survey of user's claim, Application of warning, Quality control and Product safety system are involved in top four(4) elements in Type I group. It means that soft measures can also be useful for keeping safety.

Also, four(4) elements such as Product safety system, Safety design, Early warning system and Quality control (TypeII) are shown by the order of the importance. It means that more fundamental hardware measures and prompt responding system should be taken.

Table 4. Survey results by specialists

Risk Type Countermeasures	Type I		Type II		Type III		Type IV	
	Mean Score	Prio- rity	Mean Score	Prio- rity	Mean Score	Prio- rity	Mean Score	Prio- rity
Product Safety System	4.67	(4)	2.67	(1)	4.11	(3)	2.22	(1)
PL and PS Audit	7.44	(8)	7.89	(8)	6.56	(6)	6.22	(6)
Quality Control	3.89	(3)	4.56	(4)	3.33	(2)	6.67	(7)
Safety Design	5.44	(6)	3.22	(2)	2.44	(1)	2.89	(2)
Early Warning System	5.44	(7)	4.11	(3)	5.00	(5)	4.67	(4)
Application of Warning	3.00	(2)	4.89	(5)	4.56	(4)	7.67	(8)
Document Control	8.89	(9)	8.78	(11)	9.67	(11)	9.44	(11)
Survey of User's Claim & follow-up Procedure	2.67	(1)	8.67	(9)	7.00	(8)	9.11	(10)
After Service	5.33	(5)	8.67	(10)	6.89	(7)	8.44	(9)
Product Recall	9.78	(10)	7.44	(7)	8.11	(9)	3.89	(3)
Take out an Insurance	10.33	(11)	6.22	(6)	9.33	(10)	5.78	(5)

A toy gun is involved in Type III, with high frequency of accident occurrence but low severity. Design improvement is shown as top priority. And then Quality control, Product safety system, Application of warning should be considered by the order. It means that both hardware and software measures should be taken simultaneously.

Automobile and bicycle are involved Type IV. Fundamental product safety system should be established with the priority No 1. Hardware element such as safety design should be fulfilled in the second. And Product recall system & Early warning system should be fulfilled next.

The flowchart depicted in Fig.3 shows an integral model for product liability and product safety through hazard analysis on the product.

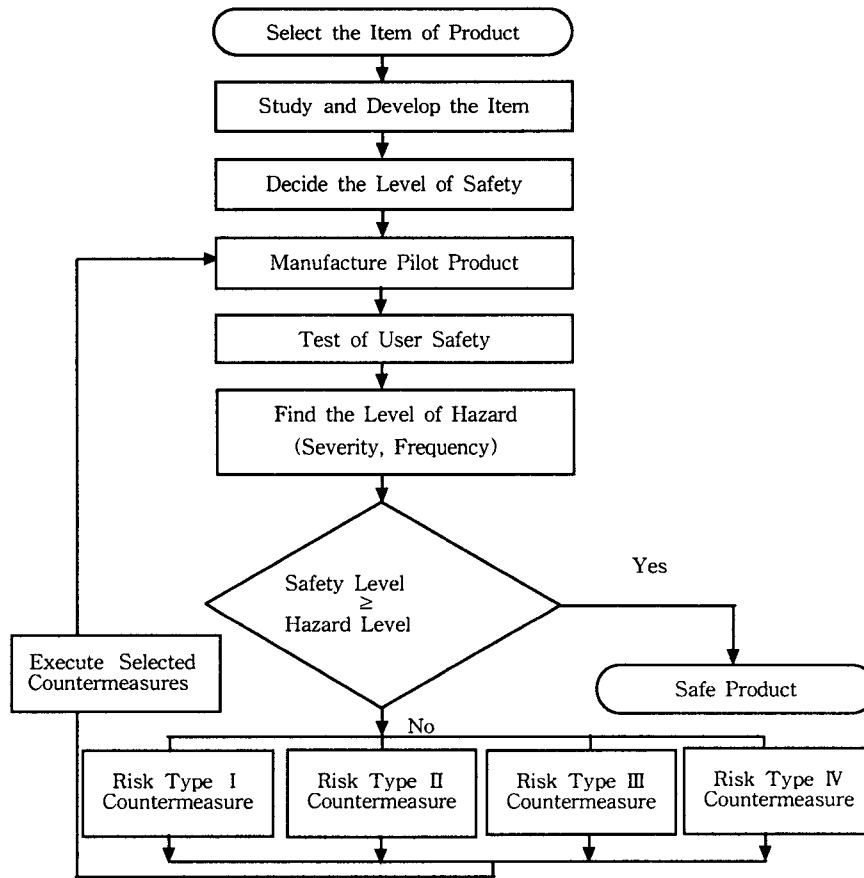


Fig. 3. An Integral Model for PL and PS through hazard analysis on the product

6. Conclusion

The contents of this study are follows;

First, a statistical evidence was established based on the results of questionnaires. The most important concern in hazard perception was severity and frequency in 35 general consumers products.

Second, mean severity and mean frequency found in the 35 products and risk matrix have been established.

Finally, these 35 products have been classified as four Types(I,II,III,IV). Moreover, efficient PL & PS countermeasures for four types have been surveyed by the domestic experts.

This study has to limit to be classified as comprehensive four types(I,II,III,IV) because of each domestic company cannot be found exactly PL&PS risk. If each company find out the risk, then it is necessary for him to present the proper prevention system.

To minimize PL exposure, manufactures should reflect comprehensive product safety concepts in establishing the TQM system. Therefore, the more detailed study should be done in consideration of the domestic company and contents of PL related code in the future.

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