

A Study for Safety and Health Management Problem of Semiconductor Industry in Taiwan

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Abstract: The main purpose of this study is to discuss and explore the safety and health management in semiconductor industry. The researcher practically investigates and interviews the input, process and output of the safety and health management of semiconductor industry by using the questionnaires and the interview method which is developed according to the framework of the OHSAS 18001. The result shows that there are six important factors for the safety and health management in Taiwan semiconductor industry. 1. The company should make employee clearly understand the safety and health laws and standards. 2. The company should make the safety and health management policy known to the public. 3. The company should put emphasis on the pursuance of the safety and health management laws. 4. The company should prevent the accidents. 5. The safety and health message should be communicated sufficiently. 6. The company should consider safety and health norm completely.

Key words: Occupational Safety and Health Management System, Semiconductor industry

Introduction

In order to gain business profit, a safety and health management system is indispensable to the enterprise. Hayes *et al.*¹⁾ indicated that the safe management practice carried out by the supervisor was the most predictable index to the satisfaction of employee. Thompson *et al.*²⁾ further explained the model of how the management affected the work safety by the safety culture and the management's support to the safety. But few of these researches focused on the topic of semi-conductor industry safety and health management. The semi-conductor industry is a very important key in the development of Taiwan's science and technology industries, so this study focuses on the field of semi-conductor industry in Taiwan, hoping to find out the significant factors of the safety and health management in this area.

With the fast development of semi-conductor industry in Taiwan, Taiwan has already caught up with the

advanced countries in the manufacturing process ability of the semi-conductor industry. However, the related safety and health management technique was not progressing simultaneously, which causing a lot of major accidents happened in the past few years. The purpose of this research is to construct a frame of semiconductor industry safety and health management system, and with questionnaires and on-the-spot interviews, to find out the main factors of safety and health management system in semi-conductor industry. Then an in-depth interview was executed to find out the safety and health management problems in the semiconductor industry. The investigation domains are based on the most intensive and particularly important area of semi-conductor industry in Taiwan—the Hsinchu Science-based Industrial Park. The main research hypotheses are as follows: First, “Whether the main factors of safety and health management system found in this research are the same with other management system mentioned in the literature review (for example: OHSAS 18001)?” Second, “Is there any connection between organizational factors and the whole safety and

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health management in a semi-conductor industry?"

Literature review

After 2001, 12 inches of wafers factories pre-dominate the whole market. In order to avoid major accident which causes the operation to break off, the insurance fee to rise, and the orders to runs off, it is necessary to establish a comprehensive safety and health management system and carry out adequate actions for the manufacturing process, chemical toxicity, exhaust and gas usage etc. Along with the influence of global eco-environment becomes worsen gradually, the industry advanced countries have already treated product quality, environmental protection and industrial safety and health as the international competition ability index. Therefore, the ISO (International Organization for Standardization), under the current ISO 9000 and ISO 14000 management structures, will combine quality, environmental protection and safety and health into a whole in the future. As for the international industrial safety and health standards, the BS8800 and OHSAS 18001 (Occupational Health and Safety Assessment Series) are referenced frequently as the basic safety and health management structure. Therefore, by reviewing the existed occupational safety and health management systems, a study is developed to examine the safety and health integrity of semi-conductor industry, to find out the potential safe problems, and to find the insufficiency of the current management system. The results will provide the semi-conductor industry with a better safety and health management system.

Occupational accidents analysis in the semi-conductor industries

During 1977–1997, there were 407 accidents happened in the global semi-conductor factories. Taiwan had 7 among them, and the estimated average total cost of two of the accidents was \$710 million (Sherin)³⁾. Hence, both safety and health management and production performance are related as closely as each breath is to the next. Ironically, in order to get work done faster, the safety and health rules are ignored, as a result the surprised accident occurred. The main causes of semi-conductor industry accident included fire (47%), fluid leak (22%), and explosion (5%). Most of the accident causes mainly lie in the latent hazard of semi-conductor manufacturing process and the production pressure that change with each passing days continuously. Therefore, the tradeoff between production and safety and health is important issue for the enterprise, and this is the reason of why a better safe management system exists.

Reason^{4, 5)} pointed out that organization factors would

influence environmental factors, and unsafe environment continued to bring up personnel unsafe action which penetrating the defense line of the organization, then the accident just happened. Only through an effectively safety and health management, the accident can be prevented. Rahimi⁶⁾ indicated the supervisor's attitude is the important key to the success of safety and health management. Deming⁷⁾ addressed that the safety and health management is related to the product quality, only when management did not treat accident as a special condition, then the safety and health quality would get improved. Kennedy and Kirwan⁸⁾ indicated there was currently no certain way to point out clearly what kind of safety and health management is the best, so an individual evaluation must be built-up to the safety and health management in the organization separately. Hee *et al.*⁹⁾ also thought the first step to reduce the accident was to evaluate the safety and health management. Generally used evaluation tool is checklists, which are based on the current standards or principles and extended to the requirement for each company. Therefore, these checklists are good at checking machine, interface or operation procedures, but were not so useful when applied to the safety and health management aspect.

Hee *et al.*⁹⁾ showed that the quantified reliability analysis of hardware equipment can reduce the injury degree of the accident, but it was not the most effective method for accident improvement. Nivolianitou and Papazoglou¹⁰⁾ thought that the totally detailed safety and health management failure data must be acquired before quantitative safety and health management evaluation. Kennedy and Kirwan⁸⁾ indicated that in order to understand safety management problems and acquire the useful factors of safe culture fully, it must adopt qualitative analysis method.

Some researchers put forward the subjective questionnaires to measure the employee's opinion about safety and health issues in the work place, to know indirectly the levels that safety and health management should pay attention to. Those questionnaires include the Occupational Hazards Survey (OHS)¹¹⁾; the Safety Climate Survey (SCS)¹²⁾; The Physical Demands and Dangers (PDD)¹³⁾; The Perceptions of Workplace Hazards Scale (PWHS)¹⁴⁾; The Work Safety Scale (WSS)²⁾ etc. But the above surveying methods have measuring problems. For example, the internal consistency coefficient of OHS is low (.28, .30, .61); SCS has excessive items (8); WSS encountered the representative problem in sampling, especially most of the samples are matching with the industrial accident investigation on request.

By the above analysis and comparison, in order to confirm the effectiveness of the safety and health management, there must have a set of good procedure to examine and evaluate safety and health management. This

study utilize quantified analysis to evaluate directly the failure of the safety and health management, and an inductive quality analytical method is used to determine the priority of the detailed and key results of the safety and health management system.

The development of investigating tool

The contents of safety and health management are very comprehensive, and by means of exterior audits only will not be able to find the core of the safety and health problem. Therefore, the better way within a firm is to establish a set of safety and health management plan basing on the interior condition actively and progressively. Good tools are prerequisite to the successful execution of a job. As a result, this research would like to raise a set of complete management system to understand and explore deeply the safety and health issues in the semiconductor industry.

In order to reach the above goal, the management system of OHSAS 18001 (BSI)¹⁵⁾ was adopted. The OHSAS 18001 are developed mainly by referring to the structures of BS 8800 (BSI)¹⁶⁾ and ISO 14000 with the spirits of closed-loop management and continuous improvement. The contents of OHSAS 18001 include organization structure, activities, job description, procedure, work processing, execution, correction, and the resources of maintaining the safety and health policy which concretely make public the meanings and procedures of how to put the management system into effect. Therefore, the interview questionnaire in this research is according to the management structure of OHSAS 18001. At the same time, Reason's⁵⁾ accident path model was also integrated to strengthen the completeness of the management system. The evaluation procedures are divided into four steps; decide the main system factors, develop a primary survey questionnaire, confirm the related factors, and make a conclusion.

Research method

Both the quantitative and qualitative analysis method are adopted in this research. First, by using a questionnaire to collect the data toward safety and health management from the employee, then factor analysis method is used to make sure the structure factors of the and health management. Next an analysis of variance (ANOVA), a least squares method, was utilized to test whether there were differences between the means of the dependent variable for each combination of levels of the experimental factors. Finally, a Tukey's test was selected to do after-the-event pairwise comparison between all population means, because Tukey procedure controls the exper-

imentwise error rate at the selected level $\alpha=0.05$ (Montgomery)¹⁷⁾.

Subject and questionnaire

The sampling subjects are the employee in the semiconductor factories, and the questionnaire is answered by anonymity. The questionnaire is issued according to the company employee scale. 188 questionnaires were sent out and 168 completed questionnaires were returned, giving a response rate of 89.36%. After excluding those who did not fulfill the inclusion criteria, 162 subjects were included in the subsequent analysis.

The questionnaire is divided into two parts, and part 1 contains 68 topics which covers: (1) safety and health policy (2) risk identification, evaluation and control (3) safety and health laws (4) safety and health object and planning (5) responsibility, knowledge, abilities, and training of safety and health (6) communication (7) operation control and emergency response (8) performance evaluation (9) accident investigation and prevention (10) audit and reviewing. Part 2 is the basic information of the subject which includes age, gender, title, company employee number, work experience, educational background and work section etc.

Data analysis method

This research utilized reliability analysis first to find the internal consistency coefficient (Cronbach, α) of the questionnaire, and then a factor analysis was used to build up each factor immediately after. Next each factor was regarded as the dependent variable, and the safe health performance, company scale, company capital, gender, age, work title, work experience, work type and education level were served as independent variables. Finally, a statistics analysis was executed for each relation. Each factor score accounts by summing all scores of topics inside that factor, and an ANOVA is used to discuss the relationship of each factor with organization variation and personnel variation. Finally, a Tukey's test was carried on to do the after-the-event comparison.

Results

The reliability and validation of the questionnaire

In the beginning, a pilot study for the preliminary 68 questions of the questionnaire is used to test the similarity between question and question. After the reliability analysis, for those coefficients over 0.50 between questions are deleted, and the correlation coefficient over 0.2 between question and total score are kept. As a result, 36 questions are deleted, and 32 questions are kept. Next,

a factor analysis is carried on for all the variables. The KMO (Kaiser-Meyer-Olkin) value is 0.79 which means that the results of entire factor analysis are appropriate. This internal consistency index Cronbach coefficient is 0.89 (Cronbach of each factor is 0.81, 0.77, 0.72, 0.67, 0.77, and 0.62) which shows that these 32 questions measurement are rather consistent. Meanwhile, each factor reliability and validation is acceptable too. Finally, six factors are established and they explained 52.92% variation totally. The first factor was named “The company should make employee clearly understand the safety and health laws and standards”, and it included 7 topics and explained the total variation of 23.13%. The second factor was named “The company should make the safety and health management policy known to the public”, and it included 6 topics and explained the total variation of 10.72%. The third factor was named “The company should put emphasis on the pursuance of the safety and health management laws”, and it included 6 topics and explained the total variation of 6.43%. The fourth factor was named “The company should prevent the accidents”, and it included 4 topics and explained the total variation of 4.63%. The fifth factor was named “The safety and health message should be communicated sufficiently”, and it included 5 topics and explained the total variation of 4.21%. The six factor was named “The company should consider safety and health norm completely”, and it included 4 topics and explained the total variation of

3.81%. In order to understand further the effectiveness of the safety and health management factors established in this research, an interview with two supervisors in the semiconductor field is conducted to confirm the suitability of the results.

The relationship between organization factor and safety and health management variables

An ANOVA is used to test the relationships between six safety and health management factors and total safety and health management with company scale, company capital, safety and health performance. The results are shown in Table 1. A few discoveries are shown as follows:

1. The larger company scale. (1) The more employee agree that the importance of the total safety and health management. (2) The company should let the employee understand clearly the safety and health laws and standards. (3) The safety and health information should be communicated fully.
2. The greater company capital, (1) The more employee agree that the importance of the safety and health management. (2) The company should let the employee understand clearly the safety and health laws and standards. (3) The safety and health information should be communicated fully. (4) The company should make public announcement in drawing up the safety and health policy. (5) The company should

Table 1. The analysis of organizational factors and safety management variables

			Category								
			Company scale			Company capital			Safety performance		
			large	medium	small	great	moderate	few	good	fair	bad
FACTORS	1	X	26.04	23.40	21.61	25.29	21.42	23.24	25.34	22.51	22.20
		sd	2.90	3.75	3.67	3.37	3.07	4.12	3.36	3.59	4.52
	2	X	26.43	26.19	25.08	26.47	25.06	25.95	26.46	25.72	14.93
		sd	2.48	2.51	3.26	2.45	2.64	3.12	2.46	2.64	3.90
	3	X	23.68	23.17	22.42	23.64	22.03	23.24	23.68	22.71	22.47
		sd	2.97	3.03	3.53	2.65	3.65	3.42	3.22	3.08	2.64
	4	X	17.18	17.31	16.69	17.13	16.72	17.49	17.45	16.86	16.53
		sd	1.81	2.00	1.85	1.71	2.36	1.83	1.83	2.02	1.55
	5	X	19.54	2.89	16.58	19.42	16.69	18.10	19.24	17.82	17.20
		sd	2.59	1.42	2.98	2.39	2.42	3.76	3.03	2.55	3.65
	6	X	13.95	13.84	13.31	14.06	13.06	13.76	13.84	13.60	14.00
		sd	1.55	1.42	1.75	1.49	1.47	1.59	1.58	1.54	1.56

—: Significant difference at $\alpha=0.05$ level.

carry out the safety and health laws without doubt. (6) The company should have the full communication on the safety and health message. (7) The company should have the integral consideration at safety and health standard.

3. The better performance in the safety and health management, (1) The more employee agree that the importance of the safety and health management. (2) The company should have the full communication on the safety and health message. (3) The safety and health information should be communicated fully.

The relationships between the employee's variables and safety and health management variables

The relationships between six safety and health management factors and personnel variables are explored further by using ANOVA test. The results are shown in Table 2. From Table 2, it indicated that different workers do not view the effort of safety and health in the same way. The possible reason is that safety and health related workers are responsible for the safety and health work, so they are more understanding what the company have done in the safety and health affairs. Those most-experienced employee are more understanding what the hazardous characteristics are and how serious when accident happened. And from the distribution of the sample characteristics, most of the personnel responsible for safety and health are male. Due to the average level of education for female employee is lower than that of male, female workers serve as the basic assistant or technician

work which is full of hazardous exposure. They are facing hazardous operation and the disaster takes place mostly on these areas. As a result, they expected that the company can adopt the positive attitude to prevent accident. This also reflects the female employee may need to accept the related safety and health training and emergency response maneuver.

Discussion and Conclusion

From the factor analysis results, this research acquires six safety and health management factors in the semiconductor industry. These six safety and health management factors are the mostly important factors that the semiconductor industry currently should put more efforts on these things. When compared these six safety factors with the key items of OSHAS 18001, there exist a slight dissimilarities. It is because that this factor analysis is aiming directly at the semiconductor industry, and as a result it can stand for the safety and health points of emphasis in the semiconductor industry.

The research inquires into the related safety and health management problems respectively in the semiconductor industry and the conclusions that it integrate are shown in Table 3. Although the semiconductor processes are different from other manufacture industries in the types and quantities of material used, the findings in Table 3 shows that the six factors of safety and health management problems in the semiconductor industry are almost same as problems in general manufacture industry. As for

Table 2. The ANOVA of the organizational variables and personnel variables of six safety management factors

		Independent Variables			
		Work type	Work Experience	Gender	Work rank
FACTORS	1	**			
	2		*		
	3				
	4			*	
	5				
	6				*
Explanation		Safety-related workers agree that the company should make the employee understand the safety and health laws and standards clearly (x=25.87, sd= 3.85, n=31), but the others do not think so (x=23.45, sd= 3.69, n=131)	The most- experienced employee have higher scores in the factor that the safety policy of the company should be public (x=25.80, sd=2.75, n=92), the un-experienced employee are next (x=25.50, sd=2.67, n=34)	The female employee get a higher score than male employee at the factor that the accident should be prevented (female: x=17.59, sd=1.76, n=59), (male: x=16.86, sd=1.95, n=131)	The lower position got the higher scores than the medium position in the factor that the company should have integral consideration about the safety health laws and specifications (lower position: x=14.14, sd=1.59, n=49; medium position: x=13.74, sd=1.49, n=92). But the higher position have lowest score in this factor (x=12.95, sd=1.50, n=21)

** : $p < 0.01$ * : $p < 0.05$.

Table 3. The six factors of safety and health management problems in the semi-conductor industry

Factor	Explanation
1. The company should make employee clearly understand the safety and health laws and standards	When a company executed safety and health management, it should put efforts on how to make the basic employee understand what the company has done in the safety and health management. And it should hold the educational training and emergency responses actively.
2. The company should make the safety and health management policy known to the public	The supervisor should make a public explanation and commitment of the safety and health policies, and this will be a key factor to the success of the safety and health performance.
3. The company should put emphasis on the pursuance of the safety and health management laws	The performance of the safety and health management depends on the supervisor's altitude towards active or passive; compiling to the standards or meeting the employee's real need. Therefore, in addition to emphasize the training, carrying out the safety and health management actively and progressively is a good plan to reduce risk.
4. The company should prevent the accidents	The different altitude for accident prevention of personnel comes from the differences in the work content. That is, the basic personnel think the accident can be prevented actually, but not for the middle and high level personnel. It is very important for the higher manager to commit the promise about the safety and health management. Only such, the accident prevention can be carried out to all levels and the purpose of effective prevention accident can be reached.
5. The safety and health message should be communicated sufficiently	One of the reasons for better safety and health performance is that the related safety and health information can be communicated fully across the company. The makes the personnel inside company can clearly know related safety and health measurement and correction. The communication of safety and health information in semi-conductor industry counts for much. Both the internal message exchanges in the company and the external message exchanges among companies would reflect to the safety and health performance directly or indirectly.
6. The company should consider safety and health norm completely	The understanding of the safety and health standard by the employer is different from the true meaning of the standard itself. Different personnel does not explain safety and health norm in the same way. Therefore, they need a specific safety and health standard to approach the special need of semi-conductor industry.

OHSAS 18001, its safety and health management is more universal to general industries and is provided to all the related business no matter how the scale and professions are. Therefore, its contents are common in the safety and health management structure. But, along with the different technique and management need of each industry, they can reference the basic safety and health management structure with individual characteristics included. As a result, the safety and health management knowledge can be readily applied to similar industries, and this is the value of OHSAS 18000 structure which is suitable to different enterprise.

In order to make this research more attributed to the semiconductor industries, the recommendations about the future study are suggested as follows.

(1) Although this research investigates the overall study for the safety and health management factor of the semi-conductor industry only, the results show that the safety and health training plays an important role in the safety and health management system. Therefore, in the near future, the topics of safety and health training and emergency practices should be included in the safety and health management of semiconductor industries.

(2) Both the quantitative and qualitative analyses are adopted directly in this research, but there are topics (such

as the effects of organizational culture on safety and health management) which are not easy to express by quantified data. As a result, a qualitative method can be adopted to explore the related discussion.

(3) This research samples are based on the IC categories in Science-based Industrial Park industry in Taiwan, and it is trying to construct an entire content of safety and health management in semiconductor industry. The future research could combine related industry (for example: computer and peripherals industry, communication industry, light electricity industry, precise machine industries and bio-tech industry) to construct a set of safety and health management system of all industries inside the area that applies to the industrial park.

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