Industrial Health 2013, **51**, 432–442

Original Article

Hazardous Workplace Review Program in Taiwan

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Received May 10, 2012 and accepted April 15, 2013
Published online in J-STAGE May 2, 2013

Abstract: In Taiwan, relevant mid-term plans and projects of mitigating occupational hazards have been launched in recent years in the hopes of lowering the incidence of occupational hazards. In light of the lack of objective methodologies for researches on issues pertaining occupational safety and health, this research aims to explore the priorities of safety and health issues through focal groups, expert questionnaires and interviews on relevant issues such as hazard installations identified in R181 Prevention of Major Industrial Accidents Recommendation, 1993 proposed during the 18th World Congress on Safety and Health at work in Seoul 2008. Results revealed that distribute reports of major domestic/foreign occupational disasters to relevant sectors for the prevention of major accidents is needed, both from the importance and feasibility analysis. It is the only topic that scored over 4 points in average for expert and focal group consensus. Furthermore, the experts and focal groups came to consensus in the ranking of priority for 4 items, namely: 1) Installations containing/using large quantities of hazardous materials should be prioritized for inspection, 2) Incorporation of hazard installation review/inspection into OSH management system accreditation, 3) Impose operation shutdown as a means of penalty) and 4) Prioritize the promotion of preliminary PHA.

Key words: Occupational hazards, Safety and health issues, Questionnaires, Hazard installations, Occupational safety and health

Introduction

Applicable to major hazard installation, ILO (International Labor Organization)'s C174 Prevention of Major Industrial Accidents Convention 1993, was drafted for the prevention of large-scaled disasters caused by hazardous chemicals. The documentation spelled out general principles on the prevention of chemical hazards, employee responsibilities, duties of competent authorities along with the definitions and regulations governing hazardous work places.

The ILO[1–8] National Framework Convention comprises components such as national policies, national systems, national charters and labor-employer organization negotiations. With performance indicators and systematic methods, the Convention was designed to ensure continual improvement on national occupational safety and health. In other words, in addition to lowering the mortality rate of occupational hazards, national occupational safety and health policies should also be instrumental in delivering outstanding performance for national solution systems in terms of legal compliance, labor safety culture, occupa-

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tional safety & health management systems, labor inspection, occupational health services and mechanical safety, labor construction safety, chemical management, SME support, labor partnership by collaborating with social security or insurance agencies. In fact, the Promotional Framework for Occupational Safety and Health Convention drafted by ILO in 2006 stated that apart from making a conscious effort to reduce occupational hazard mortality rate, nations should also establish/implement projects such as national solution systems, chemical management, health services, occupational safety & health management, total safety culture and so forth.

ILO prompted nations around the world to refer to C187 Promotional Framework for Occupational Safety and Health Convention adopted in 2006 in their promotion of annual labor safety week activities to encourage general participation, boost occupational safety & health departments while improving transparency of tools available, facilitate international exchanges, initiate labor safety culture movements and encourage central government agencies to plan and implement various occupational safety and health solution systems at national levels. With regards to labor education and training, the Convention stated that the focus should cover informal sector. As far as SMEs and informal sectors are concerned, competent authorities ought to collaborate with pertinent social security projects to provide the required assistance and support. This study seeks to discuss the issue of hazard installations as defined in R181 Prevention of Major Industrial Accidents Recommendation in greater depths.

The Hazardous Work Place Review and Inspection Rules stipulates that preliminary hazard analysis shall be conducted to analyze major threats of hazard in a given work place and that an appropriate safety evaluation (checklist, what-if, HazOP, FMEA, and FTA) be carried out for the potential threats identified. Evidently, the interpretation of the regulation leans towards the latter. Article 26 of the Labor Inspection Act, last revised on February 3, 1993, actually imposes similar requirements by stipulating that no business entities may subject employees to work in a hazardous environment that has failed to pass the review/inspection carried out by a labor inspection agency[9]. Incidentally, the Hazardous Work Place Review and Inspection Rules, promulgated on May 2, 1994, also stipulates that the safety of processes must be assessed for hazardous working environments involving the production, processing and use of hazardous materials. According to an EU report published in 2005, labor inspection departments should be primarily focused on the facilitation of labor safety and health and the prevention of risk elevation. The report also stated that the job of labor inspector should cover three major areas including research, on-site inspection and the elevation of risk awareness. And as such, manufacturing process hazard analysis/assessment has become a global trend. While factories are implementing pollution prevention, procedural control still remains as the root of the problem and the establishment of effective procedural safety control and safety & health management ought to mitigate the negative impact brought by industrial development. Although definitions of risk and its quantification have been covered extensively in previous researches and academic studies, risk quantification methods adopted by European/US industrial sectors still require discussion on the incidence of potential hazards and the extent of severity, impact and consequences should they unfortunately occur. Regulations governing hazardous working environments are presently adopted by ILO, European Union nations, USA and Taiwan[10–14].

Last revised Hazard Installation Review/Inspection Regulations and promulgated on February 3, 1993, Article 26 of the Taiwan Labor Inspection Act stipulates that no business entity may subject employees to work in a hazardous environment that has failed to pass the review/inspection carried out by a labor inspection agency. Promulgated by the Council of Labor Affairs on May 2, 1994, the Hazardous Work Place Review and Inspection Rules stipulates that the safety of processes must be assessed for hazardous working environments involving the production, processing and use of hazardous materials. The regulation also identified various tools of hazard analysis (checklist, what-if, HazOp, FMEA or FTA) that should be chosen for the preliminary hazard analysis of hazard installations to identify major potential threats.

In Taiwan, hazard installations are grouped in four major categories in the Hazardous Work Place Review and Inspection Rules. Facilities involved in the cracking of petroleum products; working environments that produce raw petrochemical materials or facilities producing, handling or using dangerous/hazardous materials reaching quantities specified in the regulation fall in Category A; Category B installations include manufacturing facilities that use methyl isocyanate, hydrogen chloride, ammonia, formaldehyde, hydrogen peroxide; working environments involved in the synthesis of technical materials or manufacturing facilities of chemical explosives; Category C installations include facilities with steam boilers covering over 500 m^2 of heat transfer area or high pressure gas containers with the capability to freeze more than 150

metric tons of gas/more than 1,000 m^3 of hydrogen/toxic/high pressure flammable gases/more than 5,000 m^3 of other high pressure gases; Category D installations include construction projects with top floor-height exceeding 50 meters; bridge constructions with pier-to-pier distance exceeding 50 m; construction projects involving pressure jet methods; tunneling projects exceeding 1,000 m in length/with vertical shaft exceeding 15 m in height; constructions digging more than 15 m underground/projects with more than 4 basement levels with site area over 500 m^2 or construction sites requiring formwork support over 7 m in height, covering an area over 100 m^2 (with over 60% supported by the formwork). Proprietors of these installations are required to apply for review or inspection of their premises with their local labor inspection agencies.

Research Method[15–19)]

Structured questionnaire statistical analysis

The questionnaire on the importance and feasibility of hazardous working environments in Taiwan are scored in five levels: 5 points (very important/very feasible), 4 points (important/feasible), 3 points (normal/normal), 2 points (not important/not feasible) and 1 point. The issues on the questionnaire were then prioritized based on their importance/feasibility.

Process of questionnaire compilation and content

This study aims to present an analysis based on the goal of the research and reviews of relevant literature; the authors have referred to PSM (US), CIMAH (England), EU Directives and the *Hazardous Work Place Review and Inspection Rules* for the contents of the questionnaire.

Research subjects

Focal group surveys and interviews

The surveys and interviews were conducted in the format of in-depth questionnaire and the subjects of the focal group would include representatives from labor bodies such as the Federation of Labor and Taiwan Petroleum Workers' Union, National Federation of Industries, National Association of General Contractors; representatives from major employing bodies in different municipalities; labor inspectors from various labor safety & health organizations and labor inspection institutes. 20 members from focal group were invited and interviewed in order to verify the results during two forums held in northern and middle Taiwan each.

Table 1. List of 1st expert group members

Categorization	No.	No. of questionnaires collected
Industrial experts	15	10
Government experts	67	41
Academia experts	32	17
Total	114	68

Questionnaire for expert group

Since the intended targets of the validity and reliability questionnaires were experts in specific fields, the study has invited a total of 114 experts and scholars specializing in the fields of sectors, government and academia as members of the expert group for the questionnaire (Table 1). 10 experts were invited to attend forums and give opinions.

Delphi method for expert consensus

The Delphi method (five-point scale) has been chosen in the reference of EU chemical hazard risk researches. With industrial safety & health experts, scholars and researchers as the targets, the questionnaire is designed to obtain their views and perspectives on issues pertaining domestic occupational safety & health. The main advantages of using Delphi method would be its tolerance of diverse opinions and gradual convergence of consensus to ensure optimal results from collective brainstorming. However, it is inevitable that during the process of evaluation, individual opinions would be presented with subjective views, intuitions and value judgments. And as such, researchers ought to take factors such as the experts' familiarity with contents of the questionnaire and experts' practical experience with the method into account with this technique.

To apply the Delphi method, the aforementioned questionnaires were delivered to them to obtain their opinions. Through multiple rounds of questionnaires and survey, their inputs would be revised, sorted and eventually compiled into consensus so that the authors could obtain important, groundbreaking information as the result of the forecast. In fact, the Delphi method is often used in the analysis of descriptive statistics as a way of presenting group opinions.

As Dalkey pointed out, a Delphi expert panel should comprise no less than 10 members to ensure the lowest discrepancy in their answers at the highest group reliability. Out of the 68 valid questionnaires recovered from the expert groups, the authors have chosen a total of 30 experts for the panel (10 experts each from the sectors, government and academia) for two rounds of expert consensus analysis.

Compilation of questionnaire contents

Items of the questionnaire are compiled as follows:

Collection of basic information: Including the respondent's age, level of education, discipline, expertise, location of business unit, work seniority, corporate scale, nature of business unit and so forth.

The questionnaire contains 16 items pertaining to hazard installation and risk assessment. The Likert Scale is chosen to as the psychometric scale for the questionnaire; the question for each issue is phrased in a complete, descriptive sentence to prompt the responder to choose the item that best respond to the question. For each main issue, the items are separated into two categories: "Importance" and "Feasibility". The five-point scale is named after its inventor, psychologist RA Linkert, who developed the scale in 1932. The scale is a cumulative one, comprising of psychometric items with the presumption that each item representing equal psychometric value. The items would then be tallied according to the responders' agreement or disagreement to each issue on the questionnaire. All issues on the questionnaire were phrased in positive descriptions (i.e. with no negative item); a high score awarded by the respondent reflects high level of agreement and firmer attitude towards the OSH performance issue in question. Likewise, a low score would represent low level of agreement.

For key hazard installation implementations, the experts were asked to prioritize the items to derive the best and second-best result. For the inspection/review of hazard installations, there are 10 items of priority review/inspection on the questionnaire.

For the establishment of OSH expert databank, the questionnaire requires the expert to provide six specific information, including their names, units of service, job title, email address, telephone number and address.

Expert validity analysis

Validity is a representation of the categorization's correctness and it reflects the chosen category is capable of deriving the desired characteristics and functionality. Reliability reflects the consistency or stability of categorization, and as such, it is a critical component for validity. During the design of "Pioneering Questionnaire for Expert Consensus − the Deployment of Expert Databank for OSH Priorities" for the purpose of this research, the authors have made numerous revisions and corrections to achieve consistency of results so as to improve the reliability of results, which would in turn ensure that the results obtained for the research would be valid for the objectives of the study.

The assessment of validity can be divided into the judgment and empirical method; the former emphasizes the measurement and evaluation of characteristic and quality, often involving subjective interpretation of data available by the researcher. The empirical method, on the other hand, relies on concrete quantification indices for the appraisal of validity. The assessment of validity entails three different components: content validity, criterion-related validity and construct validity. The evaluation of content validity requires a detailed analysis with systematic logic for the target of the measurement tool. The relative coefficient between the scores of criterion-related validity and validity criterion reflects the effectiveness of the measurement tool chosen. The test of construct validity involves the induction of related potential characteristics/behaviors as underlying hypotheses built on specific theoretical basis, followed by the examination of measurement results via empirical methods to see if the results would fit with the hypotheses. In order to improve the construct validity of this research, the responses from the chosen OSH experts would be sorted to identify the items that require revision to validate the framework of this research and improve the validity of the research method, followed by the adjustment of relevant parameters in the categories for the construction of a concrete model. For this research, the authors have sought to determine the relevance of the research framework and the appropriateness of the questions chosen by having OSH experts to complete the questionnaire. The review of "fitness of question" by experts and scholars would help to ensure "expert validity" for this study.

Out of 114 copies of expert validity questionnaire sent to the subjects, a total of 68 questionnaires were recovered, which translates to 59% recovery rate. The results were revised into an official questionnaire, which contains 10–20 issues that needed to be prioritized. A portion of the questionnaire was designed to be open-ended and based on the result of expert validity evaluation, the items of importance and feasibility were reduced to 16, with 10 issues to be prioritized in order by the respondents. By revising the contents according to the inputs from experts, the authors were able to refine the contents of "Pioneering Questionnaire for Expert Consensus −the Deployment of Expert Databank for OSH Priorities". A total of 335 copies of the official questionnaire were distributed to members and representatives in the focal groups, including employers, unions, labor organizations, labor inspectors and OSH affiliated representatives. Out of the 355 copies distributed,

Table 2. Table of expert reliability analysis

Variables	No. of questions	Cronbach α	Result
Importance of Hazard Installation Management	16	0.84	Reliable
Feasibility of Hazard Installation Management	16	0.87	Reliable

a total of 147 copies were recovered (41% recovery rate); out of the 147 questionnaires recovered, 113 copies were valid and the other 34 copies were deemed invalid. This might be due to the fact that the contents of the questionnaire covered three specific fields of expertise that part of the respondents may not have been adequately educated to answer. As a result, a portion of the questions was left unanswered. Questionnaires with more than 1/3 of the items answered incompletely or unanswered were deemed as invalid.

Expert reliability analysis

The analysis of reliability aims to determine consistency/stability for the results of measurement. A reliable scale of measurement would produce stable and consistent measurement results under different conditions. For the analysis of reliability, the authors have chosen to use Cronbach α value as the gauge for scale reliability. Nunally recommended that a Cronbach α reliability measure greater than 0.6 should be deemed as reliable and that any item with reliability below 0.35 should be treated as unreliable and dismissed accordingly. For the purpose of this research, the value of Cronbach α is divided into the following scoring categories: $\alpha<0.3$ − unreliable; $0.3<\alpha<0.4$ − scarcely reliable; $0.4<\alpha<0.5$ − somewhat reliable; $0.5<\alpha<0.7$ − reliable (the most commonly accepted range of reliability); $0.7<\alpha<0.9$ − very reliable (the second most commonly accepted of reliability). Cronbach α value exceeding 0.90 would indicate very high level of reliability.

Based on the results of expert reliability analysis shown in Table 2, both Cronbach α values for hazard installation management importance and feasibility fell between 0.70 and 0.90 (i.e. very reliable).

Results

Contents of professional policy documentations

Based on relevant literatures and suggestions from experts involved in the study, the authors have completed a proposal (recommendation) of professional policy by incorporating a component of statistical analysis. Results of the study were analyzed based on the importance, feasibility and priorities of hazard installation management to arrive at the following contents for the professional policy documentation:

a. Inspection of hazard installations ought to be implemented by the government. If the validation were left to be performed by competent technicians, the government should enact relevant procedures and basis for penalties to prevent the process from becoming a mere formality.
b. Installations handling/processing large quantities of hazard/dangerous materials ought to be prioritized for inspection.
c. Hazard installations ought to be incorporated into existing OSH management system regulations and accreditations.
d. Preliminary PHA ought to be conducted to prevent/regulate hazardous manufacturing processes.
e. Promotion of human reliability analysis (HRA) as a component of inspection standard on top of equipment assessment for risk evaluations.
f. Sites of large construction projects ought to be included in the inspection of hazard installations.
g. LPG containers ought to be incorporated as a part of labor inspection.
h. Quantitative methods such as FTA ought to be included as accepted methods of risk analysis for hazard installations in addition to qualitative methods.
i. Experts and scholars ought to be invited to assist inspection agencies in the review/inspection of hazard installations.
j. Operation shutdown ought to be adopted as a penalty for hazard installations failing to pass relevant reviews/inspections.
k. Distribute reports of major domestic/foreign occupational disasters to relevant sectors for the prevention of major accidents.
l. Disclose results of risk/hazard assessment for hazard installations to workers and the general public.
m. Strengthen the safety of hazardous material storage/transportation by cracking down on driver fatigue and conducting relevant safety inspection.
n. Strengthen emergency response capabilities to prevent major occupational disasters.
o. Facilities at hazard installations ought to be periodi-

Table 3. Results of the expert importance and feasibility consensus analysis

Item	Topic	Importance QD	Consensus level	Feasibility QD	Consensus level
1	The government should conduct inspections of hazard installation	0.63	medium	0.50	high
2	Inspection/review of hazard installations should be incorporated into the existing OSH Act	1.00	low	0.50	high
3	Hazard Installations should be covered under the scope of OSH Management System and regulations	0.50	high	0.50	high
4	Distribute reports of major domestic/foreign occupational disasters to relevant sectors for the prevention of major accidents	0.50	high	0.13	high
5	Forbid/control hazardous processes through preliminary PHA	0.13	high	0.50	high
6	Strengthen emergency response capabilities to prevent major occupational disasters	0.13	high	0.50	high
7	Briefing by employers' process/operation safety assessment crew during the review/inspection of hazard installations conducted by designated inspection agency	0.50	high	0.00	very high
8	Disclose results of risk/hazard assessment for hazard installations to workers and the general public	0.50	high	0.50	high
9	Implement CSR accreditations to prevent major accidents	0.13	high	0.50	high
10	Strengthen the safety of hazardous material storage/transportation by cracking down fatigue driving and conducting relevant safety inspection	0.50	high	0.50	high
11	Incorporate Human Reliability Analysis (HRA) as an inspection basis in addition to risk assessment for equipment	0.50	high	0.75	medium
12	Inclusion of large construction sites in the inspection of hazard installations	0.00	very high	0.00	very high
13	Incorporate LPG container inspection as a part of labor inspection	0.50	high	0.50	high
14	Inclusion of quantitative methods (i.e. FTA) as methods of risk analysis for hazard installations in addition to qualitative methods	0.50	high	0.50	high
15	Invite experts and scholars to assist inspection agencies in the review/inspection of hazard installations	0.50	high	0.50	high
16	Incorporate fire safety & firecracker/fireworks factory into labor inspection	0.50	high	1.00	low

cally maintained and serviced to improve the efficiency of reviews/inspections.

p. The government should encourage operators of highly hazardous processes/manufacturing/storage of hazardous materials to seek more economical/safer substitutes or technologies as replacement solutions.

q. Employers ought to assign more responsibilities and authority to their OSH management supervisors and staff to improve the results of hazard installation safety & health assessment.

Expert consensus and variability analysis

In this research, the authors have chosen the Delphi method to help the experts reach consensus after two rounds of discussions.

Consensus from Quartile Deviation (QD)

Results of the importance and feasibility consensus analysis are shown in Table 3. From the results, the experts reached high consensus on 13 issues of the importance of "hazard installation management", with 1 issue having extremely high consensus, 1 issue having moderate consensus. On the other hand, they had low consensus on the issue of "incorporating hazard installation inspection/review into the existing OSH Act", reflecting different views on the matter. As for the feasibility of the issues, the experts reached high consensus for 12 issues. On the issue of "Briefing by employers' process/operation safety assessment crew during the review/inspection of hazard installations conducted by designated inspection agency", the experts had come to extremely high consensus. One issue had moderate consensus and the experts held different views on the notion of "Incorporating fire safety & firecracker/fireworks factory into labor inspection", reaching low consensus.

Table 4. Analysis of Importance of hazard installation management

Item	Topic	Expert questionnaire (n_1=68)		Focal group questionnaire (n_2=113)		*p*-value
		Avg.	SD	Avg.	SD	
1	The government should conduct inspections of hazard installation**	3.29	1.16	3.94	0.82	0.000
2	Inspection/review of hazard installations should be incorporated into the existing OSH Act**	3.32	0.91	4.02	0.67	0.000
3	Hazard Installations should be covered under the scope of OSH Management System and regulations**	3.45	0.96	4.12	0.77	0.000
4	Distribute reports of major domestic/foreign occupational disasters to relevant sectors for the prevention of major accidents	4.29	0.79	4.35	0.68	0.865
5	Forbid/control hazardous processes through preliminary PHA**	3.88	0.76	4.27	0.70	0.001
6	Strengthen emergency response capabilities to prevent major occupational disasters	4.09	0.72	3.82	0.90	0.065
7	Briefing by employers' process/operation safety assessment crew during the review/inspection of hazard installations conducted by designated inspection agency	3.97	0.79	3.82	0.78	0.262
8	Disclose results of risk/hazard assessment for hazard installations to workers and the general public	3.53	0.92	3.79	0.83	0.265
9	Implement CSR accreditations to prevent major accidents	3.94	0.84	3.93	0.70	0.722
10	Strengthen the safety of hazardous material storage/transportation by cracking down fatigue driving and conducting relevant safety inspection	3.91	0.86	3.88	0.67	0.772
11	Incorporate Human Reliability Analysis (HRA) as an inspection basis in addition to risk assessment for equipment*	3.59	0.85	3.86	0.93	0.012
12	Inclusion of large construction sites in the inspection of hazard installations*	3.44	10.7	3.91	0.83	0.003
13	Incorporate LPG container inspection as a part of labor inspection**	3.44	0.85	4.01	0.69	0.000
14	Inclusion of quantitative methods (i.e. FTA) as methods of risk analysis for hazard installations in addition to qualitative methods**	3.47	0.89	3.83	0.75	0.004
15	Invite experts and scholars to assist inspection agencies in the review/inspection of hazard installations*	3.47	0.95	3.83	0.78	0.019
16	Incorporate fire safety & firecracker/fireworks factory into labor inspection**	2.82	1.18	3.87	0.94	0.000

*indicates $p<0.05$, **indicates $p<0.01$.

Hazard Installation Management

Analysis of Importance of Hazard Installation Management

a. There were a total of 10 items where the experts and focal groups had different views reflecting statistical significance, namely: Item 1 (The government should conduct inspections of hazard installation), Item 2 (Inspection/review of hazard installations should be incorporated into the existing OSH Act), Item 3 (Hazard Installations should be covered under the scope of OSH Management System and regulations), Item 5 (Forbid/control hazardous processes through preliminary PHA), Item 11 (Incorporate Human Reliability Analysis (HRA) as an inspection basis in addition to risk assessment for equipment), Item 12 (Inclusion of large construction sites in the inspection of hazard installations), Item 13 (Incorporate LPG container inspection as a part of labor inspection), Item 14 (Inclusion of quantitative methods (i.e. FTA) as methods of risk analysis for hazard installations in addition to qualitative methods), Item 15 (Invite experts and scholars to assist inspection agencies in the review/inspection of hazard installations) and Item 16 (Incorporate fire safety & firecracker/fireworks factory into labor inspection). The remaining six items showed no significant discrepancy.
b. Item 4 (Distribute reports of major domestic/foreign occupational disasters to relevant sectors for the prevention of major accidents) is the only topic that scored over 4 points in average for expert and focal group consensus. The scores for the remaining 15 items were all below 4 points (Table 4).

Table 5. Feasibility of hazard installation management analysis

Item	Topics	Expert questionnaire (n_1=68)		Focal group questionnaire (n_2=113)		*p*-value
		Avg.	SD	Avg.	SD	
1	The government should conduct inspections of hazard installation	3.64	0.96	3.85	0.78	0.132
2	Inspection/review of hazard installations should be incorporated into the existing OSH Act*	3.45	0.93	3.74	0.74	0.021
3	Hazard Installations should be covered under the scope of OSH Management System and regulations*	3.63	1.03	3.94	0.82	0.039
4	Distribute reports of major domestic/foreign occupational disasters to relevant sectors for the prevention of major accidents*	4.06	0.70	4.26	0.71	0.050
5	Forbid/control hazardous processes through preliminary PHA**	3.73	0.76	4.13	0.83	0.001
6	Strengthen emergency response capabilities to prevent major occupational disasters	3.78	0.79	3.81	0.84	0.729
7	Briefing by employers' process/operation safety assessment crew during the review/inspection of hazard installations conducted by designated inspection agency	3.94	0.70	3.75	0.82	0.280
8	Disclose results of risk/hazard assessment for hazard installations to workers and the general public**	3.09	1.00	3.78	0.80	0.000
9	Implement CSR accreditations to prevent major accidents	3.61	0.93	3.83	0.75	0.081
10	Strengthen the safety of hazardous material storage/transportation by cracking down fatigue driving and conducting relevant safety inspection**	3.15	1.19	3.82	0.70	0.000
11	Incorporate Human Reliability Analysis (HRA) as an inspection basis in addition to risk assessment for equipment**	3.21	0.85	3.77	0.92	0.000
12	Inclusion of large construction sites in the inspection of hazard installations	3.64	1.02	3.86	0.83	0.166
13	Incorporate LPG container inspection as a part of labor inspection*	3.36	1.24	3.93	0.73	0.003
14	Inclusion of quantitative methods (i.e. FTA) as methods of risk analysis for hazard installations in addition to qualitative methods**	3.33	0.92	3.79	0.72	0.000
15	Invite experts and scholars to assist inspection agencies in the review/inspection of hazard installations	3.48	1.19	3.81	0.76	0.137
16	Incorporate fire safety & firecracker/fireworks factory into labor inspection**	2.18	1.15	3.52	1.14	0.000

*indicates $p<0.05$, **indicates $p<0.01$.

Analysis of Feasibility of Hazard Installation Management

a. There were a total of 10 items where the experts and focal groups had different views reflecting statistical significance, namely: Item 2 (Inspection/review of hazard installations should be incorporated into the existing OSH Act), Item 3 (Hazard Installations should be covered under the scope of OSH Management System and regulations), Item 4 (Distribute reports of major domestic/foreign occupational disasters to relevant sectors for the prevention of major accidents), Item 5 (Forbid/control hazardous processes through preliminary PHA), Item 8 (Disclose results of risk/hazard assessment for hazard installations to workers and the general public), Item 10 (Strengthen the safety of hazardous material storage/transportation by cracking down fatigue driving and conducting relevant safety inspection), Item 11 (Incorporate Human Reliability Analysis (HRA) as an inspection basis in addition to risk assessment for equipment), Item 12 (Inclusion of large construction sites in the inspection of hazard installations), Item 13 (Incorporate LPG container inspection as a part of labor inspection), Item 14 (Inclusion of quantitative methods (i.e. FTA) as methods of risk analysis for hazard installations in addition to qualitative methods) and Item 16 (Incorporate fire safety & firecracker/fireworks factory into labor inspection). The remaining six items showed no significant discrepancy.
b. Item 4 (Distribute reports of major domestic/foreign occupational disasters to relevant sectors for the prevention of major accidents) is the only topic that scored over 4 points in average for expert and focal group

Table 6. Analysis of hazard installation management priorities

Item	Topics	Sample size	Ranking of Priority 1	Avg.	2	Avg.	3	Avg.
1	Hazard installation that should be prioritized for inspection	n_1=68	Installations containing/using large quantities of hazardous materials	1.94	Large construction projects	2.49	Petrochemical industries involving petroleum cracking	2.56
		n_2=113	Installations containing/using large quantities of hazardous materials	2.34	Petrochemical industries involving petroleum cracking	2.49	Large construction projects	2.67
2	The most effective method for hazard installation review/inspection	n_1=68	Adoption of OSH management system accreditation	1.79	Validation by competent technicians	2.03	Inspection by government inspectors	2.28
		n_2=113	Adoption of OSH management system accreditation	2.23	Inspection by government inspectors	2.34	Review by municipal governments	2.42
3	The penalty for employers subjecting employees to work in hazard installations that have not been reviewed by labor inspection agencies	n_1=68	Shutdown operation as means of penalty	1.85	Amend Labor Inspection Act to impose punitive damages	2.37	Raise punitive damages	2.76
		n_2=113	Shutdown operation as a means of penalty	2.28	Amend Labor Inspection Act to impose punitive damages	2.51	Raise punitive damages/penalties	2.70
4	Prioritized method for the promotion of hazard risk management	n_1=68	Preliminary PHA	1.90	Hazard and operability analysis	2.46	Checklist analysis	2.68
		n_2=113	Preliminary PHA	1.67	Hazard and operability analysis	2.24	Health risk assessment	2.71
5	Ideal frequency (interval) for hazard installation review/inspections	n_1=68	3 years	1.76	4 years	2.38	2 years	2.46
		n_2=113	2 years	2.43	3 years	2.52	4 years	2.70
6	Primary benefit for the promotion of hazard installation review/inspection by the government	n_1=68	Improve working environment	1.44	Reduce inspection frequency	1.82	Reduce property loss	2.65
		n_2=113	Reduce property loss	1.93	Improve working environment	2.24	Increase labor participation	2.90
7	Difficulties/obstacles in the implementation of hazard installation review/inspection by the government	n_1=68	Lack of professional HR	2.25	Employers are unfamiliar with the process of hazard analysis	2.31	Operation supervisors lacking hazard appraisal training	2.56
		n_2=113	Operation supervisors lacking hazard appraisal training	2.64	Lack of professional HR	2.66	Employers are unfamiliar with the process of hazard analysis	2.69
8	Discipline of technician most suited for the review/inspection of hazard installation	n_1=68	Chemical engineers	1.59	Industrial safety engineers	1.66	Mine safety & health engineers	2.06
		n_2=113	Electrical engineers	1.92	Chemical engineers	1.94	Mechanical engineers	2.37
9	Discipline of technician most suited for the review/inspection of large constructions	n_1=68	Civil engineers	2.06	Industrial safety engineers	2.25	Structural engineers	2.25
		n_2=113	Structural engineers	1.84	Civil engineers	2.31	Geotechnical engineers	2.54
10	Priorities for the safety inspection/review of hazard installation by the government/inspection agency	n_1=68	Reviews and inspections	1.93	Promotion of relevant trainings	2.25	Review of basic requirements	2.60
		n_2=113	Supervision of safety analysis	1.90	Review of basic requirements	2.19	Promotion of relevant trainings	2.49

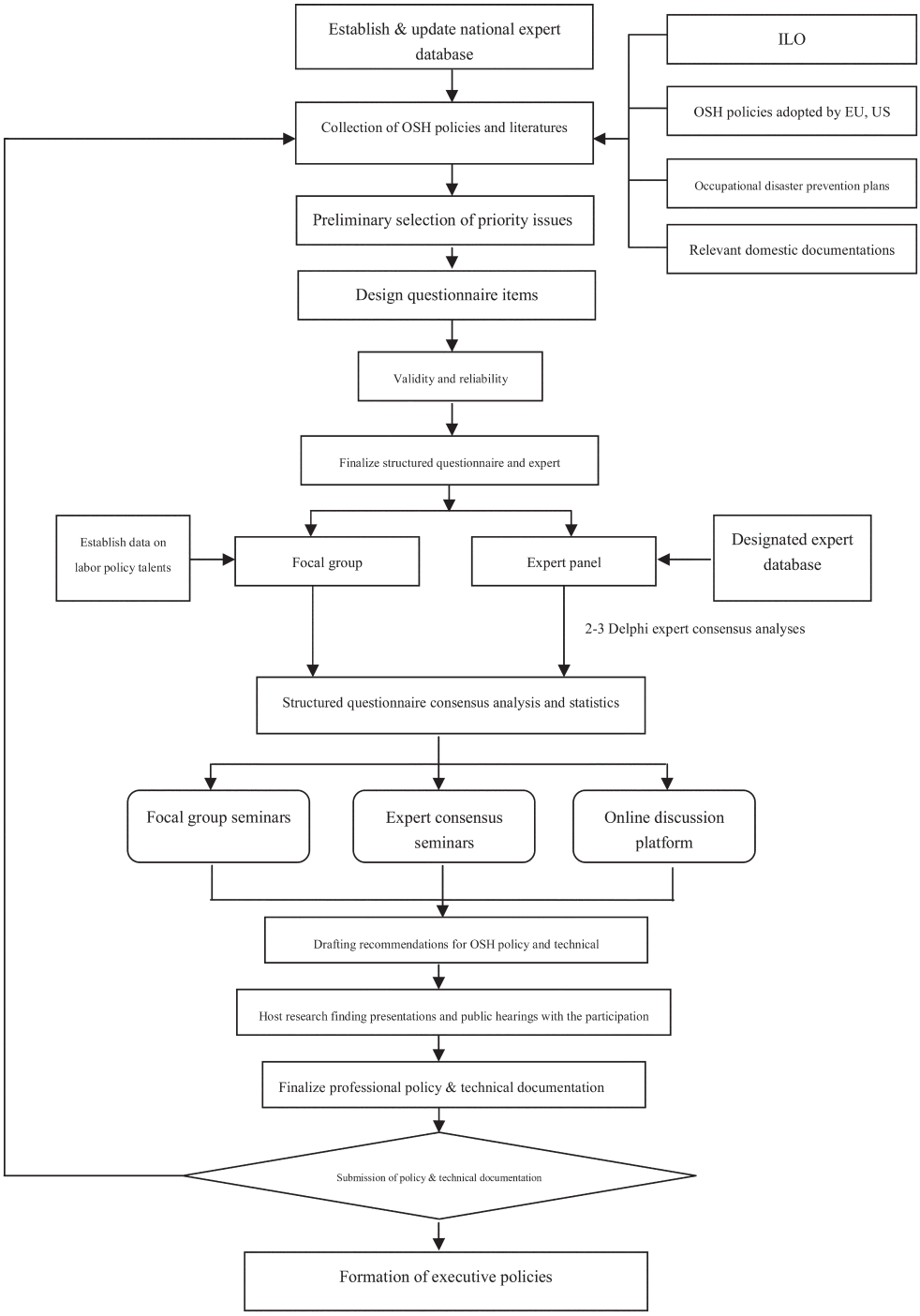

Fig. 1. Flow chart of expert consensus research model for OSH priority issues.

consensus. The scores for the remaining 15 items were all below 4 points (Table 5).

Analysis of Hazard Installation Management Priorities

The experts and focal groups came to consensus in the ranking of priority for four items, namely: Item 1 (Installations containing/using large quantities of hazardous materials should be prioritized for inspection), Item 2 (Incorporation of hazard installation review/inspection into OSH management system accreditation), Item 3 (Impose operation shutdown as a means of penalty) and Item 4 (Prioritize the promotion of preliminary PHA). The experts and focal groups did not reach consensus on the remaining six items (Table 6).

Conclusions and Suggestions

In the analysis of expert group and focal group consensus on hazard installation management, both group of subjects came to a consensus on the following points: Distribute reports of major domestic/foreign occupational disasters to relevant sectors for the prevention of major accident, strengthen emergency response capabilities to prevent major occupational disasters, briefing by employers' process/operation safety assessment crew during the review/inspection of hazard installations conducted by designated inspection agency, disclose results of risk/hazard assessment for hazard installations to workers and the general public, implement CSR accreditations to prevent major accidents, strengthen safety of hazardous material storage/transportation by cracking down driver fatigue and conducting relevant safety inspection, the government should conduct inspections of hazard installations, inclusion of large construction sites in the inspection of hazard installations and invite experts and scholars to assist inspection agencies in the review/inspection of hazard installations.

The authors' suggestions on the management of hazard installations are as follows: Incorporate hazard installation review/inspection into OSH management system accreditations, forbid/control hazardous production via preliminary PHA, include large construction sites in the inspection of hazard installations, distribute reports of major domestic/foreign occupational disasters to relevant sectors for the prevention of major accident, strengthen the safety of hazardous material storage/transportation by cracking down driver fatigue and conducting relevant safety inspection and assign more responsibilities and authority to their OSH management supervisors and staffs to improve the results of hazard installation safety & health assessment (Fig. 1).

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