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## Measures to Improve the Chemical Accident Prevention System under the 「Chemicals Control Act」



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## Summary

The purpose of this paper is to derive the means to improve the preventive system for chemical accidents under the "Chemicals Control Act", which came into effect in 2015, and to develop the measures to aid the industries that experience difficulties arising from the implementation of the same Act. In relation to technological development, the methodology behind the pre-environmental risk assessment for chemical accidents was analyzed and the trial application was conducted to prevent and counter any potential chemical accidents. Thus, this paper examined the possibility of introducing and applying the methodology for the pre-environmental risk assessment for chemical accidents in Korea and presented the direction for its future implementation. From the perspective of the policy, the difficulties experienced by business establishments and the pertinent specialized agencies were further explored in connection with the implementation of the policy for chemical accidents pursuant to the "Chemicals Control Act" so as to provide the measures to improve and facilitate the aforementioned Act.

* Please note that this paper is a summary of part of the basic research paper titled "Improvement Measures for Chemical Accident Policies in the Chemicals Control Act and Measures to Support the Industry" published by the Korea Environment Institute so as to present implications and policy directions through conducting in-depth discussions.

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# I Introduction

The 2012 hydrofluoric acid leak in Gumi resulted in human casualties and environmental damage, raising social concerns in the safety management of chemical substances, and consequently, the chemical substance safety management policy was incorporated as part of the important national agenda. Accordingly, Korea amended the previous "Toxic Chemicals Control Act" to enact the "Chemicals Control Act" (hereinafter referred to as the "CCA" and the "Act on Registration, Evaluation, Etc. of Chemicals" (hereinafter referred to as the "AREC"), which came into effect as of January 1, 2015 simultaneously. In the case of the "CCA", relevant studies were carried out for several years to minimize the industry's possible opposition prior to its enforcement, and a sufficient foundation was built to support the law. On the other hand, the policy pertaining to chemical accidents under the "CCA" was devised in haste under the circumstances in which both the government and the industry were yet unprepared, raising political and technical concerns over the law prior to its enforcement. Henceforth, the "CCA" has been amended several times, but the Act still requires continuous inspection and supplementation to manage chemical accidents more effectively. This paper diagnosed the current status and surrounding issues with focus placed on the key preventive measures for the chemical accidents of the "CCA," consisting of the off-site consequence analysis and the

risk management plan, and sought to discover the technical and political measures that would enhance the Act and ensure its effective enforcement.

In terms of technical improvement, the paper looked into the methodologies for assessing environmental risk to prevent and prepare against chemical accidents. Currently, although the off-site consequence analysis encompasses the human health risk, it does not reflect any quantitative assessment factors for the environment, requiring the review of the environmental risk assessment methodology and the preparation of the measures to be applied. Accordingly, this paper analyzed the pre-environmental risk assessment for chemical accidents overseas and carried out its pilot application in Korea to propose a measure to improve the calculation methods. With respect to the policy improvement, the preventive measures for chemical accidents at home and abroad were analyzed and the difficulties faced by the industry and specialized agencies due to the enforcement of the "CCA" were identified. Based on such analysis, the issues arising from the off-site consequence analysis, the preparation of the risk management plans, and the review and system operation were framed, and as a result, the measures to improve the system and enhance its efficiency were presented. In addition, the paper also devised the measures to enhance the infrastructure through means such as the supplementation of programs pertaining to training and preparation for the seamless enforcement of the "CCA".

# Ⅱ Technical Measures to Improve the Chemical Accident Prevention System

## 1. Current status and methodology analysis

The off-site consequence analysis under the "CCA" denotes the analysis of the extent to which a chemical accident affects people or the environment outside the workplace to determine its degree of risk. The off-site consequence analysis may be conducted by using the Korea off-site risk assessment supporting tool (KORA). After preparing the basic assessment information, the off-site consequence analysis is conducted through analyzing the potential risks within each process and drawing the accident scenarios, and among these scenarios, the worst-case scenario and the alternative-case scenario are each selected. Next, public and susceptible accommodations within the impact range of each scenario are identified to perform a risk analysis for accident impacts and possibilities, and the measures to secure safety are proposed according to the level of risk. Risk analysis is carried out to analyze the level of risk a hazardous chemical treatment facility poses to residents or the environment outside the workplace for each scenario. The level of risk is calculated by multiplying the number of residents by the frequency of accidents in the following manner:

Risk = the number of residents within the impact range × the frequency of accidents [$\Sigma$(frequency of major equipment failures × degree of safety improvements]

As such, the current off-site consequence analysis reflects the quantitative values for human health based on the number of people affected, while it does not reflect quantitative damage to the environment. Nevertheless, environmental damage arising from chemical accidents continues to occur. In Korea, 212 hectares of crops were damaged due to the 2012 hydrofluoric acid leak in Gumi, and 80,000 square meters of farmland were damaged by the leakage of silicon tetrachloride in Gunsan in 2015. Similarly, as seen in the hydrofluoric acid leak in Geumsan in 2016, in which 895 square meters of vegetation were damaged in the surrounding area, resulting in damage caused by lead blight, environmental damage continues to grow to an exorbitant rate and is occurring more frequently (press release of the Ministry of Environment, April 14 2017). In Seveso, Italy, massive environmental damage occurred along with human casualties, while in Basel, Switzerland, chemical substances spread more than 500 kilometers, resulting in severe environmental damage, including the suspension of drinking water supplied to neighboring countries and the en masse death of aquatic organisms (OECD, 2013). As such, a wide range of damages continue to occur during a chemical accident both at home and abroad, causing a severe environmental impact.

The EU devised the Seveso Directive to prevent continuously-occurring chemical accidents and minimize the resulting damage. A number of subsequent major chemical accidents have led to its continued revision, and currently the Seveso III Directive remains in effect (Jeong Sangtae et al., 2014). The Seveso III Directive has been implemented in the national legislation of countries in Europe so as to be enforced by national authorities. In the UK, the "COMAH Regulations 2015" provides that "all business owners shall take all of the necessary measures to prevent major accidents involving dangerous substances and limit the consequences to people and the environment of any major accidents which do occur". Some countries in the EU (Czech Republic, Sweden, UK, and Spain) have developed an operational methodology to predict and quantify the environmental damage from chemical accidents under national laws, with the aim of implementing the Seveso Directive.

As for the Czech Republic, the target media for the pre-environmental risk assessment method, the hazard and vulnerability index (H&V Index), are the water environment (surface water and groundwater), soil environment, and surrounding biotic environment. The evaluation is carried out in several different stages of (1) determining the toxicity risk index of a substance based on its physical and chemical properties, (2) determining environmental vulnerability, (3) calculating its toxicity index for the environment, and (4) mapping the leakage and toxicity index of the substance onto each scale to evaluate the severity of the accident through the matrix. The calculation of the toxicity index of each target subject to the assessment for the environment is carried out in the following manner:

- Toxicity index assessment for surface water contaminated by toxic substances: $I_{TSW} = \max \sqrt{I_{SW} \times T_W}; \sqrt{T_W \times I_{SW} \times I_S}$
- Toxicity index assessment for groundwater contaminated by toxic substances: $I_{TUW} = \sqrt[3]{(T_W \times I_{UW} \times I_S)}$
- Toxicity index assessment for the soil environment contaminated by toxic substances: $I_{TS} = \sqrt{(T_S \times I_S)}$
- Toxicity index assessment for the surrounding biotic environment contaminated by toxic substances: $I_{TB} = \sqrt{(T_B \times I_B)}$
- Fire hazard index assessment for the surrounding biotic environment: $I_{FR} = \sqrt{(F_R \times I_B)}$

Here, $I_{SW}$ : Environmental vulnerability index for surface water

$I_{UW}$ : Environmental vulnerability index for groundwater

$I_S$ : Environmental vulnerability index for soil

$I_B$ : Environmental vulnerability index for the surrounding biotic environment

$T_W$ : Toxicity risk index of substances for the water environment (surface water and groundwater)

$T_S$ : Toxicity risk index of substances for the soil environment

$T_B$ : Toxicity risk index of substances for the surrounding biotic environment

$F_R$ : Fire hazard index of combustible materials for the surrounding biotic environment

Considering that the possibility of environmental damage caused by chemical accidents is still open and the environmental risk assessment for off-site risks remains unsatisfactory, a review of introducing the methodology of the pre-environmental risk assessment for chemical accidents is required.

## 2. The pilot application of the overseas pre-environmental risk assessment for chemical accidents

The pilot application of the methodology for the environmental risk assessment of the Czech Republic, Sweden, United Kingdom, and Spain was carried out in Korea to devise the ideal methodology for the domestic environment and the application measure. The areas and substances subject to the pilot application were selected in consideration of the number of business establishments, the status of accidents and discharged volumes, and the properties of substances. As for the data required to apply the environmental risk assessment methodology, the analysis was made to determine whether each methodology could be obtained in Korea and the criteria presented in the overseas methodologies could be applied to the domestic data. Data for foreign criteria directly applicable to Korea was used unaltered and given scores according to their resulting values, and in the cases where the classification criteria vary between Korea and overseas, the classification criteria and scoring system were established through an expert review.

In the case of the Czech Republic, the data required to apply the environmental risk assessment methodology and the location and data name of the data applicable to Korea are shown in Table 1. The overseas classification criteria were directly applied to the

data on the toxicity, physical and chemical properties, information on the surrounding environment, types of surface water, and the amount of leakage. On the other hand, the classification criteria and scoring system were newly established regarding the data such as the soil type, geological environment, soil surface type, underground water supply type, and the degree of water quality protection.

**Table 1. Data required for the pilot application of the Czech environmental risk assessment method**

| Required data | Data location | Data name | Domestic applicability |
|---|---|---|---|
| Toxicity (LC50, rat, 4 hours)<br>Toxicity (LC50, fish, 96 hours)<br>Toxicity (EC50, LC50, IC50) | Korea Information System for Chemical Management | · Chemicals Information | · Applied the same criteria as overseas |
| Hazard alert | Korea Information System for Chemical Management | · Chemicals Information | · Applied the same criteria as overseas |
| Physical and chemical properties | Korea Information System for Chemical Management | · Chemicals Information | · Applied the same criteria as overseas |
| Surrounding environment information | Google Maps, Environmental Geographic Information Service | · Google Maps<br>· Land cover map | · Applied the same criteria as overseas |
| Soil type | Soil Environment Information System | · Soil Environment Map | · Provided criteria through an expert review |
| Type of surface water | Google Maps, Environmental Geographic Information Service | · Google Maps<br>· Land cover map | · Applied the same criteria as overseas |
| Geological environment | National Underground Information Center | · Underground Information Map | · Provided criteria through an expert review |
| Type of surface soil | National Underground Information Center | · Underground Information Map | · Provided criteria through an expert review |
| Type of groundwater supply | National Waterworks Information Center | · Water facility status | · Provided criteria through an expert review |
| Degree of water quality protection | Environmental Geographic Information Service | · Environmental Conservation Value Assessment Map | · Provided criteria through an expert review |
| Amount of leakage | Establishment's own data | · Handled amount | · Applied the same criteria as overseas |

Through this pilot application, the purpose, merits, limitations, and application plans to Korea for each methodology were summarized and presented as shown in Table 2. The environmental risk assessment methodology of the Czech Republic requires a relatively large quantity of data for calculation compared to other methodologies, and it has limitations such as the need to reset the scoring criteria to match the domestic classification system as some items in its classification system differ from those of Korea. However, its applicability as a tool to assess the environmental risk is relatively high as it enables the assessment of the surrounding biotic environment, water environment, and soil environment. The environmental risk assessment methodology of Sweden is simple and rapid, but limited in its use as an environmental risk assessment tool since it is applicable to the assessment of the water environment only. However, this methodology is worth consideration if it is to be used only for the screening purpose of a water system. The environmental risk assessment methodology of the UK can be linked to an off-site consequence analysis. However, the criteria to determine the hazard persistence requires the consideration of the exposure scenario, and the basis for judgment is not detailed, either. This tool may be useful when determining whether to install additional risk reduction tools. However, the methodology requires further concreteness for its actual application. The Spanish environmental risk assessment methodology enables the calculation based on various items, but it requires a large quantity of data while its calculation system adds further complexities.

Furthermore, the said methodology requires a number of improvements to be used as a tool for the environmental risk assessment such as its uncertainty as to the scoring criteria for the vulnerabilities of vulnerable receptors. Therefore, further review and supplementation are required to apply foreign methodologies to Korea.

**Table 2. Characteristics and application plans of the environmental risk**

| Classification | Czech Republic | Sweden | United Kingdom | Spain |
|---|---|---|---|---|
| Purpose | · Identification of the possibility of potential accidents<br>· Identification of the priorities of accident risks | · Prediction of the potential risk of chemical spills | · Screening assessment before a detailed risk assessment<br>· Determination of the priorities for facility management | · Screening assessment of potential accidents<br>· Determination of the priorities for facility management |
| Products | · 5 grades<br>· Grades A–E | · 3 grades<br>· Grades A–C<br>· A: <100,<br>· B: 100–500<br>· C: >500 | · 3 grades<br>· Permissible area, permissible area (conditional), non–permissible area | · 3 grades<br>· Moderate risk area, permissible area (conditional), high risk area |
| Benefits | · Capable of assessing the surrounding biotic environment, water environment, and soil environment | · Simple and rapid, assuming only a risk assessment for the water environment is carried out | · Similar to the off–site consequence analysis in terms of methodology and both can be linked to each other | · Various items can be considered<br>· Consideration of exposure scenarios, etc. |
| Limitations | · Compared to other methodologies, more data is required for calculation<br>· Some items of the classification system presented by the Czech Republic differ from those of Korea, and thus the scoring standards need to be reset to match the domestic classification system | · Capable of assessing the water environment only<br>· No risk assessment techniques for farmland, etc. | · Criteria for the hazard persistence are not detailed<br>· Consideration of exposure scenarios, etc. | · Compared to other methodologies, more data is required for calculation<br>· Complex calculation system<br>· Uncertainty about the vulnerability score criteria for vulnerable receptors |
| Application Plan | · Relatively high applicability as an environmental risk assessment tool | · Limited use as an environmental risk assessment tool<br>· Can be considered for the purpose of screening the risk on the water system | · May be useful when determining whether to install additional risk reduction tools in the environmental risk assessment<br>· Requires a concrete methodology for its actual application | · Complex to use as an environmental risk assessment tool and requires many improvements |

## 3. Application measures for the method of the pre-environmental risk assessment for chemical accidents

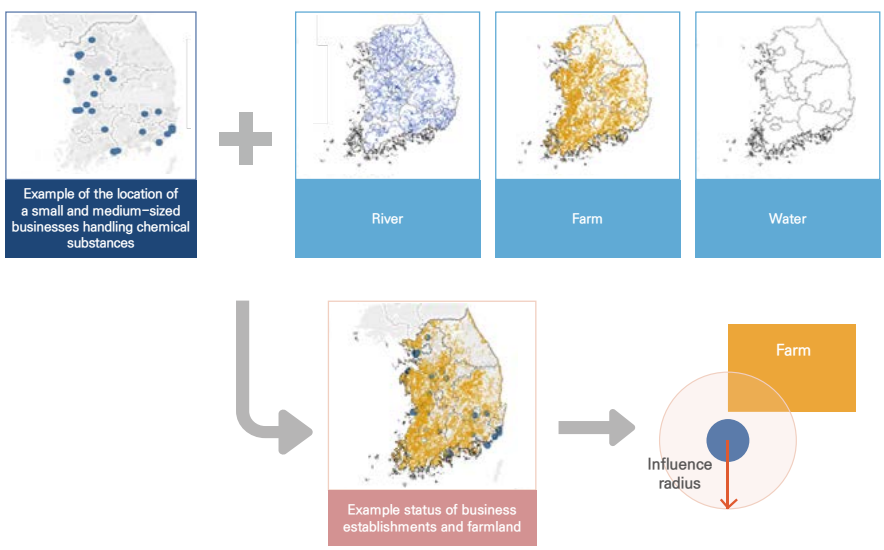
In order to apply the pre-environmental risk assessment for chemical accidents to Korea, further review as to the need for such an introduction would be required. The need to quantify the pre-environmental risk assessment for chemical accidents in the course of the off-site consequence analysis may be presented in various forms according to the surrounding conditions of each business establishment.

For example, it would not be necessary to conduct an environmental risk assessment for a business establishment that has no environmental factors in its surrounding area in the off-site consequence analysis application case. However, in the case where the residents and the environment are in complex entanglement or the environmental factor is absolute, then the current off-site consequence analysis would not be sufficient. It is believed that building a basis for the quantified assessment of environmental risks for such business establishments would complement the current off-site consequence analysis.

The need to apply the methodology for pre-environmental risk assessment for chemical accidents and the further concrete measures to draw a group of candidate business establishments subject to the environmental risk assessment are as follows. First of all, small and medium-sized business establishments that are more likely to neglect the required control among the business establishments subject to the statistical survey for chemical substances may be considered to be the subjects of the environmental risk assessment. Among them, a group of candidates subject to the prioritized assessment could be selected, considering whether the business handles hazardous chemical substances according to the chemical statistics survey, their proximity to water systems and water supply sources, and their locations within agricultural and industrial complexes. In addition, as for a business with information related to the off-site consequence analysis, its relation to the environmental receptors that are required to

provide qualitative information under the off-site consequence analysis (national parks and ecological landscape protected areas, forest and historic sites, water supply sources and water intake sources, rivers, farmland, etc.) may be considered. Next, the damage radius calculated through the KORA around the locations of business establishments selected as candidates, or the influence range of certain substances through the application of the ERG values (protective action distances), etc. where the application of the corresponding data is difficult may be set. Subsequently, an analysis as to the existence of the environmental media and receptors within the corresponding influence range would derive the need to conduct the pre-environmental risk assessment for chemical accidents and its business establishments.

Figure 1. Example of the procedure to identify the business establishments subject




The methodology of the Czech Republic may be referred to as a pre-environmental risk assessment for chemical accidents methodology applicable to Korea, as it has already been subject to the actual application based on the results of its pilot application, and it contains items that enable the easy acquirement of the related data, and it is highly expandable into various media. Based on this, this paper seeks

to propose the measures to apply the environmental risk assessment to the related systems such as the off-site consequence analysis.

As discussed earlier, the Czech Republic has a methodology that is capable of assessing the severity of accidents in the surrounding biotic environment, surface water, groundwater, and soil. In Korea, however, the use of groundwater as a water intake source is extremely rare, accounting for only about 2.5% of the total water intake volume (as of 2015), and[1)] water is treated before its use, and thus even if toxic substances are leaked, it is likely to cause very little damage. Furthermore, the methodology of the Czech Republic requires data such as the geological environment, soil type, groundwater supply type, the degree of the protection of the groundwater quality, etc., and its classification system differs from that of Korea, which is why uncertainties are likely to rise during the localization process of its classification system and scoring criteria.

In addition, the R-shape used in the calculation of the toxicity index of the soil environment under the Czech methodology indicates that the inherent hazard of chemical substances according to the EU's Dangerous Substances Directive (67/548/EEC), but it is no longer in use as it has been replaced by the GHS (Globally Harmonized System of Classification and Labelling of Chemicals). Since the GHS is a classification system based solely on the toxicity value for aquatic organisms, it will be difficult to utilize it as data to determine the soil toxicity. Due to such limitations, the surrounding biotic environment and surface water, from which the related data are relatively easy to acquire, were presented as the subject of the pre-environmental risk assessment for chemical accidents in Korea under Table 3, while excluding the groundwater and soil environment.

1) "Annual volume of groundwater and surface water intake", e-Nara indicators, accessed: 9 September 2017

**Table 3. Targets and methodology (draft) of the pre-environmental risk assessment for chemical accidents in Korea**

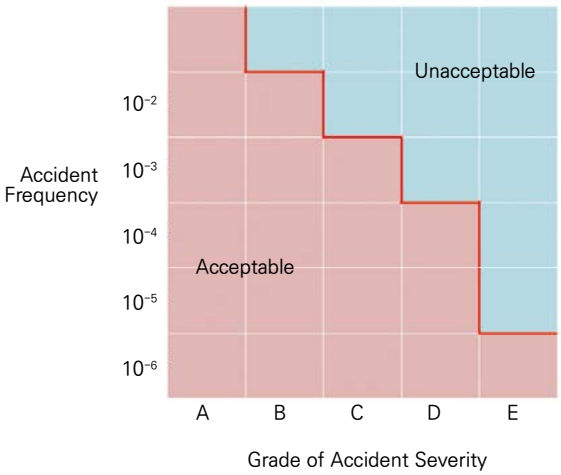
| Classification | Formula | Required data | Grade |
|---|---|---|---|
| Toxicity index assessment for the surrounding biotic environment contaminated by toxic substances | $I_{TB} = \sqrt{(T_B \times I_B)}$ | · Toxicity<br>· Physical and chemical properties (boiling point, vapor pressure)<br>· Type of surrounding biotic environment | A~E |
| Toxicity index assessment for the surface water contaminated by toxic substances | $I_{TSW} = \sqrt{I_{SW} \times T_W}$ | · Toxicity<br>· Physical and chemical properties (boiling point, vapor pressure)<br>· Type of surface water | A~E |
| Fire hazard index assessment for the surrounding biotic environment | $I_{FR} = \sqrt{(F_R \times I_B)}$ | · Hazard alert (whether corresponding to a combustible material)<br>· Type of surrounding biotic environment | A~E |

Note 1) TB: Toxicity risk index of the substance for the surrounding biotic environment
2) IB: Environmental vulnerability index for the surrounding biotic environment
3) ISW: Environmental vulnerability index for surface water
4) TW: Toxicity risk index of the substance for surface water
5) FR: Fire hazard index of combustible materials for the surrounding biotic environment
6) Grade A: Negligible, B: Low impact, C: Moderate, D: Slight impact, E: High impact.

Source: Vojkovská and Danihelka(2002), pp.15-41.

The criteria for determining risk acceptance according to the accident severity grades and accident frequency data will follow the Czech method as shown in Figure 2. If it falls within the red area based on the red line, the risk is acceptable without any serious environmental impact, whereas, if it falls within the green area, it means it is unacceptable. In the event that the risk corresponds to the unacceptable area, a mitigating device may be added or other managerial or technical measures may be required.

Figure 2. Acceptability (draft) according to the grade of accident severity




Source: LENKA FIŠEROVÁ et al.(2012), p.52.

In order to introduce the pre-environmental risk assessment for chemical accidents in the future, a legal and institutional basis needs to be prepared based on the analysis of the current situation. At the same time, as discussed earlier, it is necessary to systematically diagnose the possibility of applying the methodology for pre-environmental risk assessment for chemical accidents in Korea so as to identify its specific needs, and to establish the environmental indicators for the major assessment factors and conduct a technical review based on them. In addition, the criteria for the environmental risk assessment unique to Korea need to be created and the related applicable data such as toxicity and geographical information should be secured. In the long term, it is important to establish a technical foundation by establishing a database for the relevant data and promote the substantive domestic application of the pre-environmental risk assessment for chemical accidents.

# III Policy Suggestions to Improve the Chemical Accident Prevention System

## 1. Gathering opinions related to the policy implementation

In order to analyze the implementation status of the chemical accident policies under the "CCA", a survey was conducted to discover the difficulties and suggestions of the industry and agencies that specialize in the preparation of management plans for the relevant matters. The survey was carried out through visits and interviews, collecting information and opinions such as the general information on business establishments, information related to preparing persons, preparation and submission of the off-site consequence analysis/risk management plan, and education on the preparation and operation of the off-site consequence analysis/risk management plan. The survey results are divided into difficulties and suggestions during the preparation and review process, as shown in Table 4.

**Table 4. Results of gathering opinions of the industry and agencies that specialize in the preparation regarding the chemical accident policy**

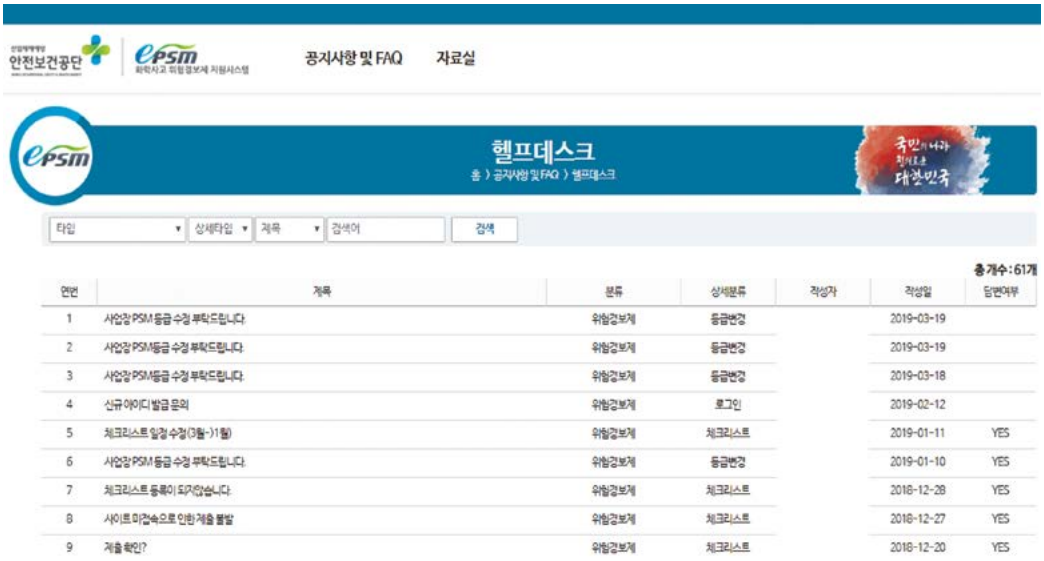
| Classification | Subsection | Difficulties and suggestions |
|---|---|---|
| Preparation | Status of awareness as the targets subject to prepare off-site consequence analyses | · Small and medium-sized business establishments lack awareness regarding the preparation and submission<br>· Small business establishments display issues of the lack of awareness, data, and human power |
| Preparation | Use of the KORA program | · KORA has substances with an excessively calculated influence range or those that cannot be assessed |
| | | · The program is frequently updated and requires repeated preparation<br>· The information linked to public receptors and environment receptors is out of date<br>· Unsatisfactory stability such as frequent restarts due to errors<br>· A separate creation of reports required due to the low usability of the reports printed out through the KORA program |
| | Education related to the off-site consequence analysis and risk management plans | · The current educational contents for persons required to prepare the off-site consequence analysis and risk management plans are somewhat difficult to learn<br>· The risk management plan requires the staff to receive professional training for control personnel through external training, etc. but not many related educational courses are available |
| | Criteria for the human power of the agencies that specialize in the preparation | · The human power of agencies that specialize in the preparation of the off-site consequence analyses is required to hold a degree in the fields of environment and safety, excluding those who major in environmental health<br>· 10 years of experience, regardless of one's major, is included in the requirements for the persons required to prepare |
| Review | Review results | · Work confusion occurs due to the reversal of the requested data<br>· Necessary to select realistic emergency control tools suitable for the business establishment |
| | Deadline for the review of risk management plans | · Due to a delay in the review of risk management plans, a setback occurs in the licensing schedule for business establishments |
| | Integrated operation of the off-site consequence analysis and risk management plan | · The simultaneous review of the off-site consequence analysis, risk management plan, process safety report and safety improvement plan is required |

## 2. Policy improvement measures

Based on the difficulties and suggestions discussed earlier, this paper seeks to present the policy improvement and industry support measures as follows. First of all, it is necessary to look into the available survey methods to identify the business establishments regarding the blind spots for management arising from the failure to be aware of being a business establishment required to prepare an off-site consequence analysis. The first option to consider is to identify the target business establishments through the statistical survey of the chemical substances of the Ministry of Environment and promote the related systems. Furthermore, where a wider range of investigations is required, it may be ideal to consider adding the survey items regarding the status of handling chemical substances in the economy census conducted by Statistics Korea.

Second, it is important to explore further support measures to help the business establishment utilize the KORA program. The process safety reports of the Korea Occupational Safety and Health Agency under the Ministry of Employment and Labor provide support for preparation using the e-PSM program that is similar to the KORA program. It has been identified that the e-PSM program operates FAQs and a helpdesk to respond to any inquiries (see Figure 3). As such, establishing and operating a helpdesk for the KORA program, and reflecting the opinions regarding the related issues through the helpdesk and updating the relevant features frequently will contribute towards the enhanced user convenience.

Figure 3. Helpdesk screen of the e-PSM program




Source: "e-PSM chemical accident risk alert and support system", Korea Occupational Safety and Health Agency, accessed: 20 March 2019

Third, the satisfaction for education including practical training provided during the education for those who prepare off-site consequence analyses and risk management plans is high, but the education, as well as the practical training, acknowledged as part of the legal training hours by the National Institute of Chemical Safety remains unsatisfactory. Therefore, it is necessary to consider complementing the educational course and related infrastructure so as to increase the practical training hours during the collective education provided by the National Institute of Chemical Safety. Furthermore, the professional control personnel is experiencing difficulties to complete the education from business establishments as not many educational courses are available at the National Institute of Chemical Safety and other external agencies. Therefore, the National Institute of Chemical Safety and other related agencies need to review the measures to expand and launch the corresponding educational courses to ensure the seamless completion of courses

in the future. Since the National Institute of Chemical Safety is planning to build an education center for chemical accidents, reflecting the demand for education and infrastructure in its construction process is expected to gradually address the relevant issues.

Fourth, an improvement to the requirements was suggested claiming that, even though the professional personnel with experience built up over a certain period of time in the agencies that specialize in the preparation of off-site consequence analyses has sufficient expertise to prepare the related documents, they are not allowed to participate in the preparation as the current eligibility is determined through one's acquisition of a major in the related field. For reference, with the process safety report, which is a system similar to the one discussed above, the related regulations have been revised to include the graduates of technical high schools with experience in the corresponding field for a certain period of time in the eligible personnel allowed to prepare the document. This paper would like to propose modifying the requirements for the human power of agencies that specialize in the preparation of off-site consequence analyses under the "CCA" by adding a clause that allows the "person who has graduated from a vocational high school or an equivalent, with the experience of working in the corresponding field for 9 years or longer". In addition, if a system that verifies the minimum requirements through the introduction of the off-site risk assessor system is simultaneously enforced, both fostering and securing the related professional personnel and enhancing the expertise will be achieved. As for the "Environmental Impact Assessment Act", the environmental impact assessor system has been in operation pursuant to Article 63 of the "Environmental Impact Assessment Act", and Article 70 of the Enforcement Decree of the same Act since its launch in 2013 as a national qualification. According to Article 2 and Article 54 of the "Environmental Impact Assessment Act", an environment impact assessor plays the role of overseeing and managing the preparation of the environmental impact assessment through means such as the preparation of environmental impact assessments, investigation, prediction, and the assessment of factors that affect the

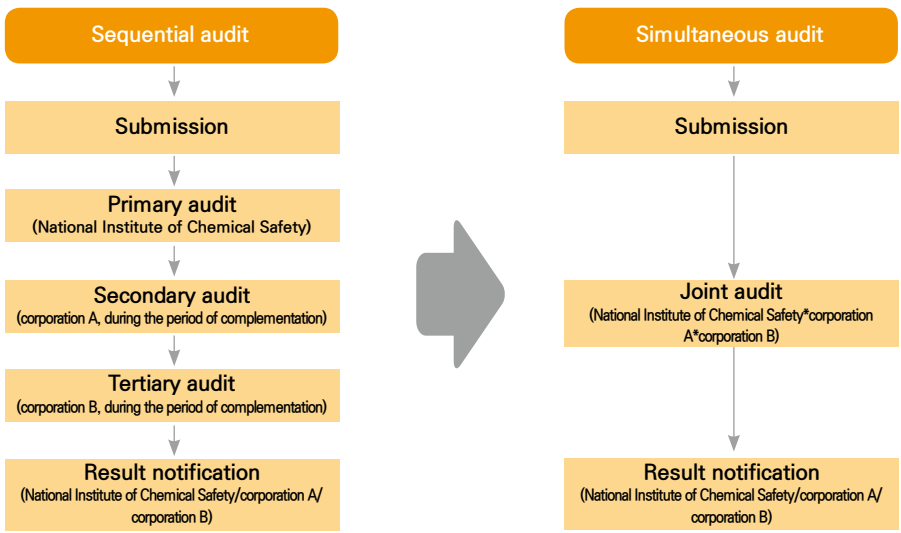
environment with the project implementation, and the establishment, assessment, and verification of measures to remove and reduce negative impacts on the environment. Creating the off-site risk assessor system in consideration of these matters and enabling them to prepare parts of the off-site consequence analyses would prevent well-intended damages arising from the preparation by non-experts. In addition to such institutional improvement, abolishing the agencies that specialize in the preparation may be considered once the time comes where sufficient experiences and technologies related to the preparation of off-site consequence analyses have built up.

In the audit stage, the issue arising from a delay due to pileup is expected to be addressed to a certain degree as a larger number of experts become secured for the National Institute of Chemical Safety in 2018.

In the audit stage, the issue arising from a delay due to pileup is expected to be addressed to a certain degree as a larger number of experts become secured for the National Institute of Chemical Safety in 2018. In the future, it will be necessary to operate a more efficient audit system by periodically reviewing the audit demand, duration, and relevant states. Second, it is important to prepare an integrated procedure and seek the relevant operational measure in relation to the separate preparation and submission of the off-site consequence analysis and risk management plan. To this end, the overlapping matters in the risk management plan, off-site consequence analysis, process safety report, and safety improvement plan, which need to be prepared and submitted for each of the Ministry of Environment, Ministry of Employment and Labor, and Ministry of Trade, Industry and Energy had been integrated to be covered in a single form, which has been announced via the "Guidelines for Preparing Risk Management Plans" by the National Institute of Chemical Safety. Starting with such an integration, the introduction of the joint audit system (simultaneous audit, sequential audit) in which the related organizations within each ministry such as the National Institute of Chemical Safety, related corporations participate altogether for the related documents. For reference, according to the related notification of the "Regulations on

the Submission, Audit, Confirmation, and Performance Status Evaluation, etc. of the Process Safety Reports", the joint audit system (simultaneous audit, sequential audit) has been introduced for the process safety reports and safety improvement plans. However, in the case of a sequential audit, the assessment audit is set to be completed within 30 days, requiring each institution to complete its audit within 10 days. Accordingly, as the sequential audit is physically impossible, the introduction of a simultaneous audit system could be considered first.

Figure 4. Operation of the simultaneous audit system (draft)




Source: "Regulations on the Submission, Audit, Confirmation, and Performance Status Evaluation, etc. of the Process Safety Reports", National Law Information Center.

# Ⅳ Conclusion and Suggestions

As the social interest in chemical accidents and safety continues to rise, it is necessary to complement and effectively implement the related systems to prevent related accidents and enforce measures in a timely manner. In order to meet such needs of the occasion, this paper proposed the technical and political measures to improve the preventive system for chemical accidents under the "CCA".

First, with regard to the technical improvement, the need to quantify the pre-environmental risk assessment for chemical accidents was proposed to complement the off-site consequence analysis system. The pre-environmental risk assessment for chemical accidents is necessary for the enforcement of the "CCA"-related systems such as the off-site consequence analysis, and it serves as a core element in deriving the major management methods while complementing the unsatisfactory parts. Furthermore, this paper explored the methodologies, assessment criteria, and assessment methods of the overseas environmental risk assessments, and identified their limitations and usabilities to propose the targets and methodology of the pre-environmental risk assessment for chemical accidents that is applicable in Korea. This is a screening-level tool that predicts the environmental damage inflicted by a chemical accident, which may prove to be ideal for complementing the related systems such as the off-site consequence analysis in the future. However, currently, there is a considerable lack of required domestic methodologies related to

each damaged medium and receptor. Therefore, a more careful review and complementation are required through means such as establishing the environmental risk assessment methodology and creating the required data at the same time so as to utilize them for the actual policies.

On the policy side, the difficulties regarding the preparation and submission of off-site consequence analyses and risk management plans were inspected for the industry, and improvement measures were sought to address the said issue. In relation to the preparation stage of the off-site consequence analyses and risk management plans, the need for a full-scale investigation to identify the targets required to prepare off-site consequence analyses and raise the awareness of the corresponding businesses was presented, and a proposal was made to include the survey regarding the business establishments handling chemical substances in the economy census to realize such a need.

Furthermore, this paper proposed the operation of a helpdesk to immediately improve the KORA program, the expansion of education related to the off-site consequence analysis and risk management plan, and the improvement in the eligibility criteria for the human power of agencies that specialize in the preparation. In terms of enhancing the efficiency of the audit process, the introduction of the simultaneous audit system for related documents as part of the measures for the integrated operation of the off-site consequence analysis and risk management plan was deemed necessary. As these measures for policy improvements aim to improve the existing regulations or infrastructure based on the system related to the off-site consequence analysis and risk management report under the "CCA", a substantial part of such measures will be taken into account in their policy reflection and realization process.

The institutional settlement and seamless enforcement of the "CCA" in the future will require an extensive collection of opinions not only from the industry and related experts but also from a wide range of stakeholders affected by the system, including local residents, while the continuous complementation of unsatisfactory institutional matters needs to be carried out.

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