A STUDY ON ACCIDENT -CAUSAL RELATIONSHIPS METHODOLOGY FOR SYSTEMATIZATION OF SAFETY STANDARDS

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Abstract

Due to the rapid acceleration of urbanization, the stage of maintenance and administration focused system is replacing an infrastructure building era as a general trend. As many industrial facilities are getting deteriorated, nowadays big fires and explosions occur everyday in various industrial facilities, making facility safety management a big social issue. Dozens of safety accidents which occur on a daily basis are inflicting countless casualties. In reaction to this problem, many laws and regulations dealing with this situation are being generated. However, this action causes the definition of safety technology standards set by each department under individual law to be opaque, and both users and managers are having a hard time dealing with safety management. Therefore, in this study, we systematized a safety standard by devising a method of finding the relation of relevant laws, which we found out through an analysis of major and minor causes of accidents under the rules of individual laws about safety technology standards and management standard. Through this, the paper is aiming at making a systematized administration possible so that users and administrators throughout departments can easily manage.

1. Introduction

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As each department arbitrarily decides the definition of safety standards under law and regulation, which is causing considerable confusions, both users and managers are having a hard time ensuring safety supervision. While regular safety supervision standards are usually stipulated in individual law, other safety supervision standards (e.g. detailed management standards, facility standards, audit/inspection standards, other technical standards, etc.) are generally defined by enforcement regulations of individual law, and detailed safety standards are stipulated in a subordinate law system such as notification, directive, etc. The safety standards whose meaning are somewhat different under individual law are settled through formal negotiations of each department of government, and they are stipulated and executed by notification, directive, etc. As a result, there appears to be a number of cases in which safety standards under individual law do not identically apply in even a same field. Especially, since Korean legislation system is not constituted mainly for safety standards of the object, but for the relevant factors of the object such as installation, facility, electricity, gas, elevator, boiler, material, etc. which belong to facility or material, the system is not yet sufficiently good enough to prevent safety accidents. There are consistent efforts in improving accident/safety management laws in order to build the foundation of safety management for facility/material. Although it is going well, they are still not sufficient to be fundamental measures against the occurrence of accidents. Especially, since laws regarding safety management (e.g. individual facilities, materials, etc.) are independently controlled, reorganizing and regulating systematic safety standards for all administers and users are necessary. In Korean legislation system, it is common that departments in charge of managing facilities and materials set safety standards through a relevant legislation under secondary rules such as notification or directive. As a result, if responsible departments are not the same, even identical facilities and materials are given different safety standards and then processed accordingly.

This inconsistency often confuses administrators, contractors, and managers because they are not sure which standard they should follow both for working and licensing. As the domain of domestic chemical industry is expanding and the use of chemical substance continuously growing, the probability of massive accidents and the risk of chemical pollutants being released to the environment are getting higher.

The domestic laws dealing with chemical substances include Toxic Chemicals Control Act, Accident and Safety Management Act, Industrial Safety and Health Act, Framework Act on Fire Services, High-Pressure Gas Safety Control Act, etc.

However, systematic management for domestic chemical accidents is almost absent and inconsistent statistical data from departments are causing confusion. In case of the U.S. and EU nations, even though the departments dealing with various facilities have distinct legislation system, they have systematized safety standards, and every department and legislation have to apply the systematized one.

By reviewing a safety accident case investigation, by examining legal confusions, overlaps and inconsistencies, and by analyzing current safety standards which are being applied to accidents, this paper is aiming at systematizing a safety standard so that disaster managers, safety managers, and facility administrator can use it to assess and utilize a comprehensive and systematic safety standard for facilities and materials. In order to do this, we examined the current situation of legal system, analyzed particular accidental cases that occurred in specific facilities through the safety accident case investigation, and reviewed the setting of the object range of safety standards by examining links among the laws regarding major causes of accidents.

2. Main subject

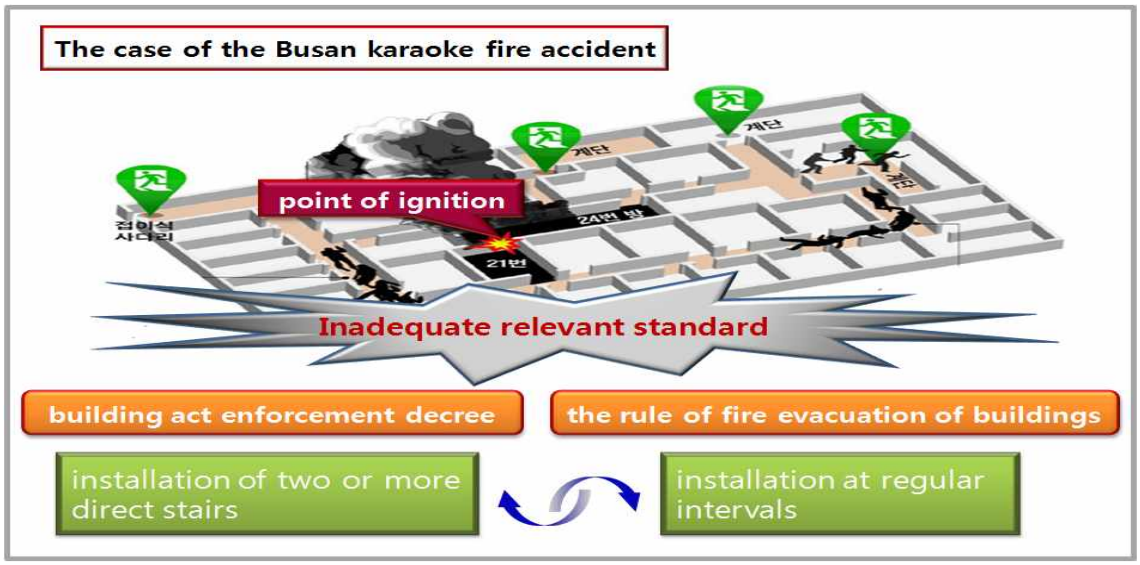
2.1 Accident type analysis

1) defective installation of direct stairs (Busan karaoke fire)

On the night of May, 6, 2012, a big fire on the third floor of the karaoke left seven man and two women dead and twenty-five people injured. The police and fire authority speculated that

the reason of the nine fatalities, all of whom died of suffocation, was because the fire started at the main entrance of the karaoke and people could not get out. Also, it is presumed that the fact that the whole building was covered with tempered glass without one single window deteriorated the situation. The police and fire authority is investigating violations of the Fire Services Act against the owner of the karaoke on the grounds that the karaoke did not have emergency stairs or sprinklers.

Fig. 1 Fire accident the in the Busan karaoke caused by human error



2) Review of the laws relevant to the accident

According to the Building Act Enforcement Decree set by the ordinance of Ministry of Land, a building has to have more than two direct stairs which are connected to a refuge floor or to the ground, and has to be three stories or higher. Also, for a type of business whose sum of floor area is more than 300 square meters, it is required to have an outdoor escape stair which connects to the ground other than direct stairs. Even though the Busan karaoke had a total floor area of 3,987 square meters, two direct stairs, and the escape ladder, all of which built in accordance with the construction law, the escape ladder was useless due to its illegal structural alterations. However, the fundamental problem of the construction law is its rather ambiguous stipulation under its rule about evacuation and fire prevention, which says "entrance of direct stairs is to be built at regular intervals in order not to disturb the process of evacuation." It is presumed that the karaoke had two direct stairs heading a same direction, which disturbed effective evacuation. In the meantime, although the construction law prescribes what to do with the structural problems of evacuation, the dual structure of fire protection seems to be a problem.

The following is the provision of a direct stair and escape stair installation under the Building Act Enforcement Decree.

Clause 34 (installation of direct stairs) ② In compliance with 49 clause of Article 1, for a building whose purpose or scale falls under the following categories, the owner of the building must install two or more direct stairs which link to an escape floor or to the ground in a way that meets the standard of the ordinance of the Ministry of Transportation. 1. Buildings whose purpose is for bar business or funeral and whose size of total area for the above purpose is larger than 200 square meters, among cultural and meeting facilities (exhibition halls, zoological gardens, and botanical gardens not included), religious facilities, recreational facilities Clause 36 (installation of escape stairs)

② In accordance with 34 clause, a third floor or the higher (escape floor excluded) whose purpose falls under the following categories must have an outdoor escape stair connected to the ground, other than direct stairs.
1. Floor whose purpose is for concert or bar business and whose size of the living room area is larger than 300 square meters, among cultural, meeting facilities and among recreational facilities respectively.

Also, the rule relevant to evacuation·fire-fighting structural standard for buildings states the installation standard of direct stairs as follows.

Clause 8 (Installation standard of direct stairs)
① In accordance with clause 34, the entrance of direct stairs must be built at regular intervals so as not to disrupt the process of evacuation, and a passage linking to a living room must be built between direct stairs.

Like this, there are many inconsistencies between provisions and they are causing confusions to users and managers.

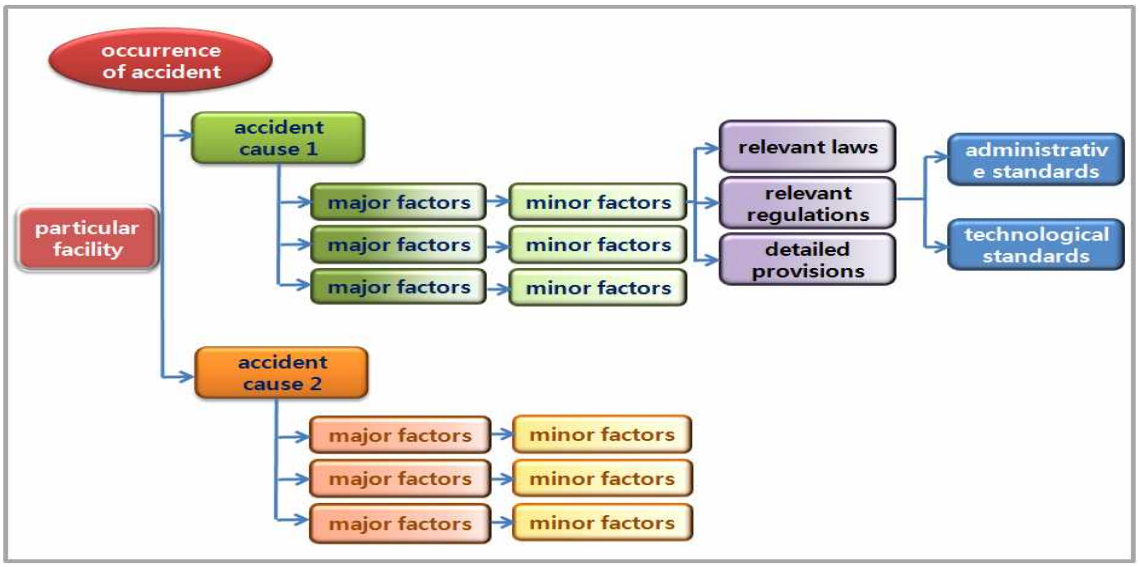
2.2 Establishment of safety standard range under a accident-cause relational methodology

To systematize safety standards requires the selection of objects to be systematized, consideration of how deep to set the range of objects within the boundary of a legal system, and study of which object to be systematized after the process of classification. In order to set the depth and the range of objects, we made various approaches. Firstly, through terminological definitions, we came up with the method capable of distinguishing between technical safety details and administrative details. We also examined which law's provision is reasonable and analyzed how far can systematization be done in terms of preventing actual accidents. Most safety accidents were made by personal errors. Also, even though there were a lot of technical standards, we were able to confirm that most accidents were associated with administrative errors which related to personal errors. Therefore, to take an accident preventative point of view, we examined and analyzed the study on the occurrence of the current safety accidents.

1) Modeling of cause-and-effect relationships regarding accident cases.

Analyzing data about the occurrence of accidents, we applied the method of analyzing 'legal system linked to an accident and the other accident' which utilized
the method of applying cause-and-effect relationships regarding major and relevant causes of accidents (the modeling of cause-and-effect relationships). This is the method that examines special accident cases, compares each causes and outcomes of accidents, reversely finds the causes of accidents and the relevant legal details, and investigates which kind of laws are related to accidents. It is a reasonable approach that identifies which legal standard are relevant to accidents and what kind of factors to be managed and controlled in order to lesson and prevent accidents. We examined relevant laws by applying what we found through the analyzation of accident cases of karaokes and ㅋconstruction sites to the cause-and-effect relationship model.

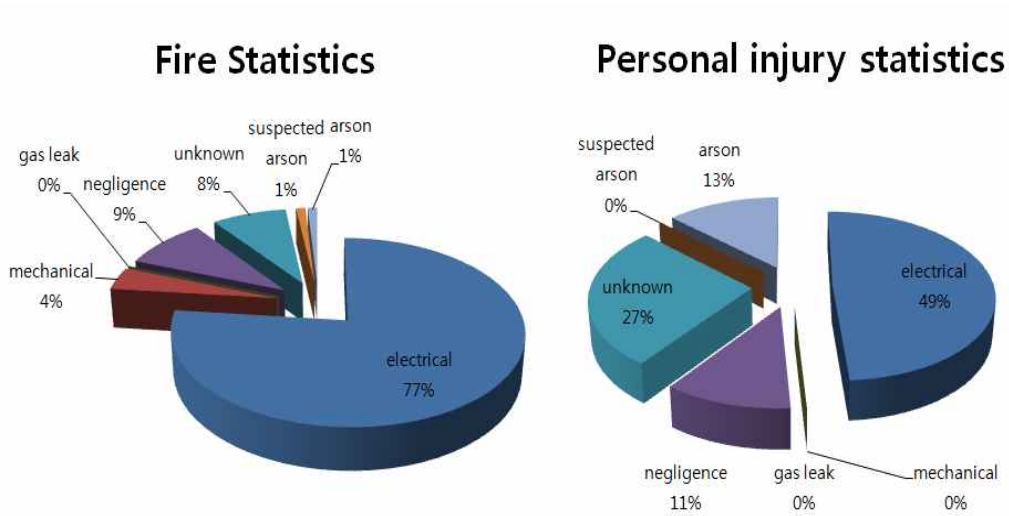
Fig. 2 Accident-relevant laws relationship analysis mechanism using the modeling of a cause-and-effect relationship.



■ **Factor and legal system analysis of accident on case 1.**

We analyzed the data (date from 2008 to September, 2012) which were provided in the National Fire Information System of the National Emergency Management. Even though there were insufficient factors in terms of the data examination period while using the data at the official website, we found electrical causes, mechanical causes, fire by leakage of gas, negligence, etc. to be the major causes of accidents. It was confirmed that electrical factors were occurred most often and inflicted the biggest damage for humans. We reviewed legal standards regarding electrical accidents. Since most electrical inspections were visual check under existing law, it was reasoned that electrical accidents were more often occurred by administrative factors than by technical factors.

Fig. 3 Statistics of the causes of karaoke accidents and casualties



■ **Analysis on detailed factors of electrical accidents and review of relevant laws**

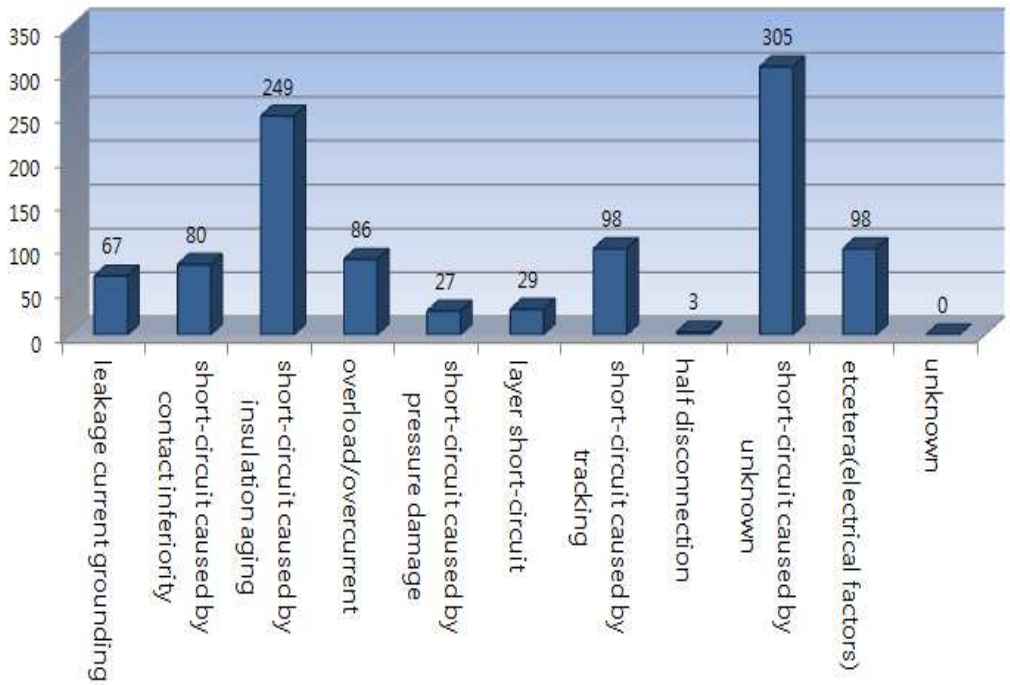
From the result above, we checked integrated data (date from January, 2008 to December, 2012) provided in the portal system of Korean Electrical Safety Corporation. Since Korean Electrical Safety Corporation incorporated karaoke into recreational facilities as a big, single category (unlike the National Emergency Management that put karaoke as an independent

category), we performed a thorough analysis on some part of the life service whose nature fell under the recreational facilities category.

Given the statistics, electrical factors and negligence caused the majority of accidents. Specifically, since the majority of accidents triggered by electrical factors were attributable to unchecked circuits and insulation aging, if management system was affectively utilized in terms of inspection and management, the accidents could have been prevented. Therefore, we examined the relevant laws in order to extract workable provisions among regulations dealing with electricity or executive rules, based on safety standards, and progressed the study by double-checking and scrutinizing those.
As to laws dealing with electrical accidents in karaoke and recreational facilities, there were the Electricity Enterprises Act, Building Act, laws regarding fire-fighting installation, maintenance, and safety management, and special laws regarding the safety management of multiplex available premises. We focused on examining the provisions of these laws. Firstly, we scrutinized regulations regarding inspections and examinations which were the most relevant safety management factors as to the facilities like karaoke. Given the substantial differences stipulated in each law, we intensively checked entire inspections, maintenance, and administration of the facilities. After examining the cases based on the Electricity Enterprises Act, we were able to find 22 inspection-related provisions, 22 administrative provisions, and 13 maintenance-and-administration-related provisions (totaled 57 provisions).

Fig. 4 Detailed factor analysis on electrical accidents

Table 1. Safety Standards Relevant to Accident Cause Analysis



(Electricity Enterprises Act/enforcement ordinance/enforcement regulations)

laws related to fire-fighting installation, maintenance, and safety management	
Law	Clause 4 (fire-fighting special examination)
	Third part of Clause 4 (methods and procedures of fire-fighting special examination)
	Clause 5 (measure orders followed by the fire-fighting special examination results)
	Clause 9 (maintenance · management of fire-fighting facilities that are installed in particular fire-fighting objects)
	Clause 10 (maintenance · management of evacuation facilities, fire compartment, and fire-prevention system
	Clause 20 (safety management of particular fire-fighting objects)
	Clause 25 (self-examination of fire-fighting facilities)
	Clause 41 (education of fire-fighting safety managers)
Enforcement Ordinance	Clause 3 (fire-fighting facilities)
	Clause 5 (particular fire-fighting objects)
	Clause 7 (details of special fire-fighting units)
	Clause 9 (method of special fire-fighting examination)
	Clause 15 (fire-fighting facilities that are needed based on the scale of particular fire-fighting objects)
	Clause 18 (range of particular fire-fighting objects that do not require fire-fighting facilities)
	Clause 19 (particular fire-fighting objects that need internal ornaments that have fire-fighting function)
	Clause 22 (particular fire-fighting objects that require fire-fighting safety managers)
	Clause 23 (senior figures of fire-fighting safety managers)
	Clause 24 (framing fire-fighting plans of fire-fighting safety management objects)
	Clause 25 (particular fire-fighting objects of senior figures of joint fire-fighting safety managers)
	Asterisk 1 (fire-fighting facilities)
	Asterisk 2 (particular fire-fighting objects)
	Asterisk 4 (type of fire-fighting facilities that are needed by people relevant to special fire-fighting objects, regarding scale, purpose, and the number of persons to be admitted)
	Asterisk 6 (range of particular fire-fighting objects and fire-fighting facilities that do not need installation of fire-fighting facilities)
Enforcement Regulations	Clause 2 (procedure such as measure order that follows special fire-fighting examination)
	Clause 14 (precedent report of fire-fighting safety managers)
	Clause 17 (range of self-examination technicians, fire-fighting facilities)
	Clause 18 (classification of self-examination of fire-fighting facilities)
	Clause 19 (submission of examination report results)
	Third part of Clause 26 (evaluation of examination ability)
	Fourth part of Clause 26 (examination records)
	Clause 29 (execution of education about fire-fighting safety managers)
	Clause 36 (practical education of fire-fighting safety managers)
	Asterisk 1 (classification of self-examination of fire-fighting facilities · object · examination · the number of people · eligibility of inspectors · inspection method and the number of inspections)
	Asterisk 2 (standards for dispatch of examination manpower in case of self-examination of fire-fighting facilities)
	Asterisk 3 (examination records)

After reviewing the Building Act, we were able to find a total of 21 inspection-and-administration-related provisions, which subdivided into 5 inspection-related provisions, 3 administrative provisions, and 6 maintenance-related provisions.

Table 2 Safety Standards Relevant to Accident Cause Analysis
(Building Act/Enforcement Ordinance/Enforcement Regulations)

Building Act	
Law	Clause 35 (maintenance·management of buildings)
	Clause 38 (building ledger)
	Clause 67 (relationship expert technicians)
	Clause 68 (technical standards)
Enforcement Ordinance	Clause 23 (maintenance·management of buildings)
	Second part of Clause 23 (execution of regular examination and optional examination)
	Third part of Clause 23 (instructions of regular examination and optional examination)
	Fourth part of Clause 23 (offer of examination-related information of buildings)
	Fifth part of Clause 23 (report of examination results of buildings)
	Sixth part of Clause 23 (detailed standards of maintenance and management)
	Third part of Clause 91 (cooperaton with relationship expert technicians)
	Clause 110 (maintenance of buildings·management monitoring)
Enforcement Regulations	Clause 23 (maintenance of buildings·administrative examination sheet)
	Second part of Clause 36 (relationship expert technicians)

After reviewing the laws related to fire-fighting installation, maintenance, and safety management, we were able to find a total of 35 inspection-and-administration-related provisions, which subdivided into 12 inspection-related provisions, 8 administrative provisions, and 15 maintenance-related provisions.

Table 3 Safety Standards Relevant to Accident Cause Analysis
(laws related to fire-fighting installation, maintenance, and safety management /Enforcement Ordinance/Enforcement Regulations)

laws related to fire-fighting installation, maintenance, and safety management	
Law	Clause 4 (fire-fighting special examination)
	Third part of Clause 4 (methods and procedures of fire-fighting special examination)
	Clause 5 (measure orders followed by the fire-fighting special examination results)
	Clause 9 (maintenance·management of fire-fighting facilities that are installed in particular fire-fighting objects)
	Clause 10 (maintenance·management of evacuation facilities, fire compartment, and fire-prevention system.
	Clause 20 (safety management of particular fire-fighting objects)
	Clause 25 (self-examination of fire-fighting facilities)
	Clause 41 (education of fire-fighting safety managers)
Enforcement Ordinance	Clause 3 (fire-fighting facilities)
	Clause 5 (particular fire-fighting objects)
	Clause 7 (details of special fire-fighting units)
	Clause 9 (method of special fire-fighting examination)
	Clause 15 (fire-fighting facilities that are needed based on the scale of particular fire-fighting objects)
	Clause 18 (range of particular fire-fighting objects that do not require fire-fighting facilities)
	Clause 19 (particular fire-fighting objects that need internal ornaments that have fire-fighting function)
	Clause 22 (particular fire-fighting objects that require fire-fighting safety managers)
	Clause 23 (senior figures of fire-fighting safety managers)
	Clause 24 (framing fire-fighting plans of fire-fighting safety management objects)
	Clause 25 (particular fire-fighting objects of senior figures of joint fire-fighting safety managers)
	Asterisk 1 (fire-fighting facilities)
	Asterisk 2 (particular fire-fighting objects)
	Asterisk 4 (type of fire-fighting facilities that are needed by people relevant to special fire-fighting objects, regarding scale, purpose, and the number of persons to be admitted)
	Asterisk 6 (range of particular fire-fighting objects and fire-fighting facilities that do not need installation of fire-fighting facilities)
Enforcement Regulations	Clause 2 (procedure such as measure order that follows special fire-fighting examination)
	Clause 14 (precedent report of fire-fighting safety managers)
	Clause 17 (range of self-examination technicians, fire-fighting facilities)
	Clause 18 (classification of self-examination of fire-fighting facilities)
	Clause 19 (submission of examination report results)
	Third part of Clause 26 (evaluation of examination ability)
	Fourth part of Clause 26 (examination records)
	Clause 29 (execution of education about fire-fighting safety managers)
	Clause 36 (practical education of fire-fighting safety managers)
	Asterisk 1 (classification of self-examination of fire-fighting facilities·object·examination·the number of people·eligibility of inspectors·inspection method and the number of inspections)
	Asterisk 2 (standards for dispatch of examination manpower in case of self-examination of fire-fighting facilities)
	Asterisk 3 (examination records)

After reviewing the special laws related to multiplex available premises safety management, we were able to find a total of 21 inspection-and-administration-related provisions, which subdivided into 3 inspection-related provisions, 3 administrative provisions, and 15 maintenance-related provisions.

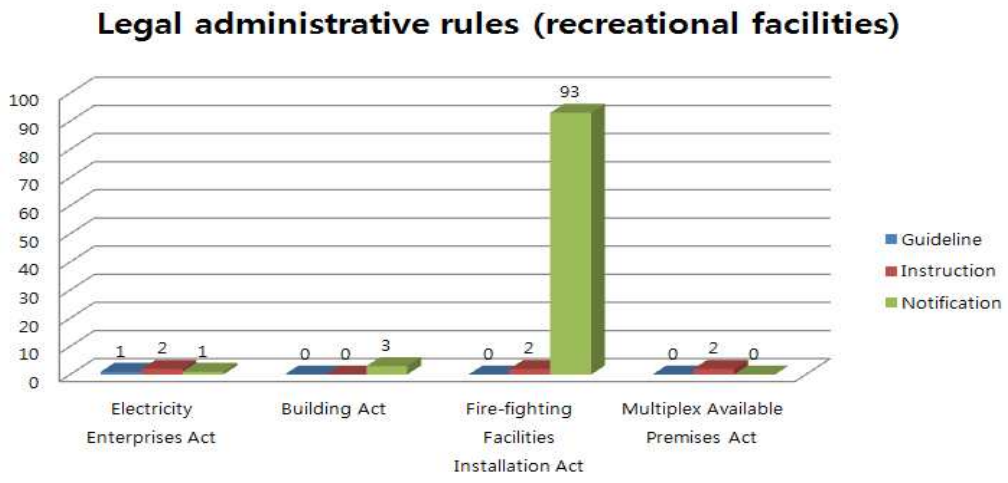
Table 4 Safety Standards Relevant to Accident Cause Analysis
(special laws relevant to safety management of multiplex available premises/Enforcement Ordinance/Enforcement Regulations)

special laws relevant to safety management of multiplex available premises	
Law	Clause 5 (establishment · execution of basic safety management plans)
	Clause 6 (establishment · execution of executive planning)
	Clause 9 (safety management standards of multiplex available premises)
	Clause 11 (establishment · execution of escape facilities, fire compartments, and fire facilities)
	Clause 13 (regular examination on safety facilities of multiplex available premises owner)
	Clause 14 (fire-fighting safety management of multiplex available premises)
	Clause 15 (danger evaluation of fire in multiplex available premises)
	Clause 19 (establishment · operation of safety management computing system)
Enforcement Ordinance	Clause 4 (establishment procedure of basic safety management plans)
	Clause 5 (ordinance of basic safety management planning)
	Clause 6 (details about basic safety management plans)
	Clause 8 (contents of executive plans)
	Clause 10 (standards for objects of fire-fighting danger evaluation)
	Clause 14 (registration of proxies for fire-fighting danger evaluation)
	Asterisk 2 (technical manpower · facilities · equipment standards that proxies for fire-fighting danger evaluation should know)
Enforcement Regulations	Clause 9 (fire safety standard of fire-fighting facilities in multiplex available premises)
	Clause 11 (installation report of safety facilities)
	Clause 13 (detailed examination table of safety facilities multiplex available premises)
	Clause 14 (objects for safety examination, eligibility of examiners)
	Clause 18 (conservation period of fire danger evaluation report)
	Asterisk 2 (installation standard of safety facilities that are intalled in multiplex available premises)

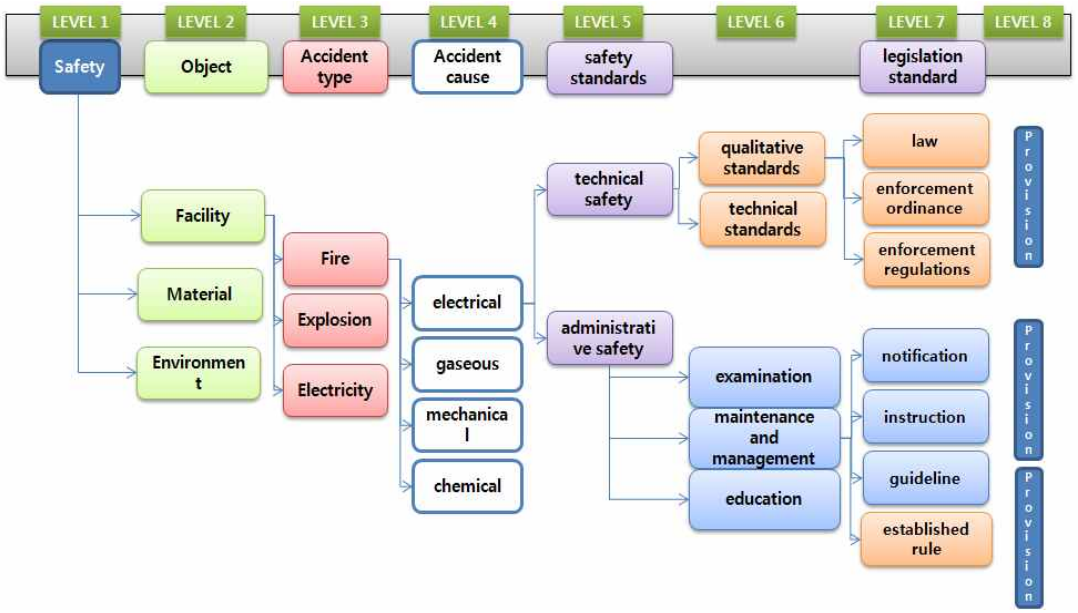
■ Classification of safety standards in view of the relationship between accident causes and relevant laws.

Those provisions related to safety accident prevention that are found in the Electricity Enterprises Act, an enforcement ordinance, and enforcement regulations can be usually classified into the contents of inspection, the contents of maintenance, administration, and repair, technical details, eligibility of inspectors, and facility standards, ect. We classified the above provisions as follows.

In the table above, we proceeded examination through provisions of the Electricity Enterprises Act, Building Act, laws related to fire-fighting installation, maintenance, and safety management, and laws relevant to multiplex available premises safety management, all of which related to karaoke.



2) Distribution diagram of a safety standard classification system based on a cause-and-effect relational perspective.
The following process was gained after we summarized the contents above. In short, when accidents occur, it is possible to know which type of accident it is and to find the major causes. Therefore, by organizing the relevant legal safety standards as the objects to be systematized, we can effectively and reasonably manage and systematize safety standards.



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