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Operation Assessment of ISO 14001 : 2004 Environmental Management System in Manufacturing Industry of Southeastern Korea

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한국동남지역 제조산업의 ISO 14001 : 2004 환경경영시스템의 운용평가

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Environmental pollution including air, land, and water has become one of the most critical issues in global interest. The damages due to environmental pollution lead to serious disasters. Nations have realized the importance of environment protection and have been starting to force organizations to implement environmental management system (EMS) as way of protecting environment. ISO 14001 requirements that are the most popular standard as EMS have been developed to support continuous improvement to environment management. It has been revised once since publication and ISO 14001 : 2004 version is currently available. Organizations globally started to acquire the certificate of EMS to observe environment related laws, accept customers' and stakeholders' request, increase market share, and fulfill implementation motives. This article examines the audit data that were collected for several years from manufacturing companies including shipbuilding, machinery, metal, automobiles, and chemical companies in southeastern Korea on the basis of ISO 14001 : 2004 requirements. The audit data were classified into minor nonconformities based on factors such as business size, business type, and EMS implementation period. We conduct hypotheses test using statistical methods in order to see if there are any significant differences based on the factors. We draw conclusions for the results of hypotheses test and address the necessities of energy, greenhouse gas, green management, and continuous improvement to enhance the efficiency of EMS implementation.

Keywords : Environmental Management System, Audit Data, Minor Nonconformity, Operation Assessment

1. Introduction

1.1 Background of ISO 14001 : 2004 EMS

International Organization for standardization (ISO) is a network of the national standards institutes over 160 countries now. ISO were founded in 1947 and have published more than 19,500 International Standards covering almost all aspects of technology and business area. ISO have been pursuing a uniform international standard for environment management after successful introduction of ISO 9000 quality management system (QMS). A technical committee within

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ISO called TC 207 was organized to develop the series of environmental management. ISO 14001 environmental management system requirements were first published in 1996 and revised in 2004 [9]. ISO 14001 : 2004 version is currently served as EMS requirements. This second edition is focused on clarification of the first edition and has enhanced the compatibility between ISO 9001 QMS requirements and ISO 14001 requirements. The background of developing the requirements was found in extensive literature [2, 5, 13, 21, 25].

In this paper we focus on the performance of ISO 14001. ISO 14001 as one of the best known environmental management system specifies a set of management processes and procedures that allows organizations to analyze, control, and reduce the environmental impact of their operations and services to save cost, improve efficiency, and oversight and to streamline regulatory compliance [20, 26]. ISO 14001 : 2004 covers the requirements that are applicable to companies to be implemented whereas ISO 14004 : 2004 contains general guidance on a wide range of EMS issues. It is designed for organizations to protect the environment, to prevent pollution, and to improve their environmental performance. ISO 14001 : 2004 version is based on well-known principle, PDCA (Plan-Do-Check-Act) cycle : Plan-establish the objective and processes, Do-implement the processes, Check-monitor and measure process, Act-take actions to continually improve performance. Thus the companies should be able to achieve environmental performance by demonstrating their activities, products, and services are consistent with their policies and objectives. The companies should develop an environmental policy and objective to demonstrate that the environmental system developed confirms to the requirements of ISO 14001 : 2004.

ISO conducts a survey of certifications to ISO management standards including ISO 14001 : 2004 every year (refer URL). The survey counts the number of certificates issued by certification bodies that have been accredited by members of the IAF (International Accreditation Forum).

1.2 Implementation and Motivation of ISO 14001 : 2004 EMS

The acquisition of certificate and implementation of ISO 140001 : 2004 do not in itself guarantee the achievement of environmental objectives. The complexity and extent of documentation and resources used to conform to ISO 14001 : 2004 vary considerably in a lot of factors such as organization culture, business type, business size, system implementation period, nature of business activities, business products and services, etc. Balzarova et al. [1] identified that four dimensions of organizational culture that play an important role during the ISO 14001 implementation process are people, process, structure, and environment : People-what attitudes and behaviors occur at the work place? Process-are key processes determined? Structure-are formal mechanisms and systems in place to channel behavior towards organizational goal? Environment-how the external environment influences the business (investors, sector, size, local community)? The findings are supported by Beer [3]. They pointed out by cause and effect analysis from empirical study that four common areas to make it difficult to maintain EMS are predominant focus on ISO 14001 certification, lack of management support, inefficient environmental audit system, and lack of employee involvement.

The motivations of obtaining ISO 14001 : 2004 are external pressure, improvement of corporate image, public relations, customer demands, etc. The benefits of implementing ISO 14001 : 2004 are cost savings of energy consumption and waste management, improved competitive edge, increased market share, improved worker's knowledge, positive image and relations from customers, communities, stakeholders, and public, clarified internal procedure, better environmental performance, etc. Nevertheless, the results of implementing EMS vary depending on organization's effort to reduce environmental damages and organization's ability to adapt quickly to changes to environment protection. Research discovered that companies with strong motivation believe company's continued success depend on ISO certification. Training, worker's commitment, and identification of environmental aspects are major items to be taken care of [16].

Although many researches on ISO 19000 quality management system for Korean industry can be shown in literature [7, 17], research regarding ISO 14000 EMS implementation on Korean organizations was rarely studied [11, 12]. Despite a number of researches on ISO 14000 EMS in other countries, no empirical study, to our knowledge, has examined the operation assessment based on audits in Korean manufacturing industry. This article focuses on statistical analysis of the formal audit data from the third party detected in periodical audits in compliance with ISO 14001 : 2004. The results are discussed to find out the implications from the statistical analysis. This article organized as follows: the second section presents the methodology to proceed to the statistical analysis; the third section contains the interpretation for statistical

analysis results; the fourth section includes discussion and implications of the findings from analysis; finally we make conclusions.

2. Methodology

2.1 Structure of ISO 14001 : 2004

ISO 14001 : 2004 requirements are largely divided into four sections : 1. Scope, 2. Normative references, 3. Terms and definitions, and 4. Environmental management system requirement. Sections 1, 2, and 3 simply explain terminologies of EMS. Section 4 specifies the detailed contents of ISO 14001 : 2004 requirements that a company should establish, implement, fulfill, and continually improve an EMS to keep the certificate. Section 4 is classified into subsections and sub-subsections under subsections. The headings of Section 4 are presented in <Table 1> but the contents of sub-subsections are not provided here in detail. In this article we focus on the audit data collected on the basis of subsections of section 4 Environmental Management System Requirement of ISO 14001 : 2004.

<Table 1> Subsections of Section 4 Environmental Management System Requirement of ISO 14001 : 2004

ISO 14001 : 2004 Environmental management systems-requirements with guidance for use	
4. Environmental management system requirement	4.1 General requirement
	4.2 Environmental policy
	4.3 Planning 4.3.1 Environmental aspects 4.3.2 Legal and other requirements 4.3.3 Objectives, targets, and program
	4.4 Implementation and operation 4.4.1 Resources, rules, responsibilities, and authority 4.4.2 Competence, training, and awareness 4.4.3 Communication 4.4.4 Documentation 4.4.5 Control of documents 4.4.6 Operational control 4.4.7 Emergency preparedness and response
	4.5 Checking 4.5.1 Monitoring and measurements 4.5.2 Evaluation of compliance 4.5.3 Nonconformity, corrective action, and preventive action 4.5.4 Control of records 4.5.5 Internal audit
	4.6 Management review

2.2 Audit Data Description

The audit data are classified into major nonconformity and minor nonconformity. A major nonconformity means an item that EMS of a company was not implemented as ISO 14001 : 2004 specifies or was not performed although ISO 14001 : 2004 specifies. Even a single detection of major nonconformity leads the company to cancellation of ISO 14001 : 2004 certificate. A minor nonconformity represents an item that EMS of a company does not comply with the contents that ISO 14001 : 2004 established although it was implemented and performed. If the minor nonconformity previously pointed out is not completely corrected in follow up audit, it is not recorded as a minor nonconformity but required to supplement the inadequacy for next follow up audit. If the minor nonconformity previously pointed out is never corrected in follow up audit, it is redeemed as a future major nonconformity and three months is given to rectify.

We examined the audit data collected from Lloyd's Register Quality Assurance (LRQA), a global leading accredited provider of management certification. LRQA qualified senior auditors with hands-on experiences evaluate and review the EMS of the companies in every six-month follow up audit on the basis of ISO 14001 : 2004 requirements after regular three-year recertification. The minor nonconformity data were collected from the assessment reports written by the auditors. In order to conduct statistical analysis we exploit the minor nonconformity data that were collected in follow up audits of 43 manufacturing companies from December 2005 to March 2012. However, the minor nonconformity data of three companies were discarded because of disorganized assessment reports.

2.3 Overview of Companies in Sample

The companies in this research are selected from a manufacturing sector including shipbuilding, machinery, automobile, and chemical industry. Manufacturing sector such as shipbuilding, machinery, and automobile industry is a high value-added sector to economy. In addition, chemical industry is an essential sector that EMS is necessary due to crucially harmful substance by production process. The companies are located in southeastern area of South Korea where Korean representative shipbuilding, machinery, automobile, and chemical companies are placed. The companies have un-

dertaken internal audits and reviews to assess their environmental performance but they are not sufficient to prove the performance of companies are met and agreed with ISO 14001 requirements. The companies have to keep the certificate of ISO 14001 from a certification body to prove their companies objectively achieve EMS. Periodical external audit from a certification body is necessary to demonstrate that the performance of companies has been met in accordance with legal and policy requirements specified in ISO 14001 : 2004 requirements.

ICIN (ISO Certification Information Network) provides diverse statistics concerning ISO registration bodies of South Korea. Among the companies with ISO 14001 : 2004 EMS certificate, the proportion of companies located in southeastern area to total companies in South Korea is approximately 19%. The number of automobile, machinery, chemical, and shipbuilding companies with certificate in South Korea is calculated 2,620 as of 2011 from ICIN. In a ballpark figure, we estimate the number of automobile, machinery, chemical, and shipbuilding companies with certificate in southeastern area is 498 (2620×19%). Thus the ratio of sample size to target population in this research is roughly 8% (40/498). The response rates from survey concerning business performance are often found somewhat between 8% and 20% from literature [22]. However, the number of minor nonconformity data from 40 companies in this research is 1,122 in total. Considering the number of minor nonconformity data from 40 companies, our sample size is therefore not too small to make inferences regarding EMS operation assessment. In addition, the same certification body, LRQA Korea Ltd., does not affect the results of this study since Van der Wiele et al. [24] found no major differences between the certification bodies in terms of background of the characteristics of their companies. Thus the minor nonconformity data can be exploited to make hypothesis testing.

2.4 Research Questions

We analyze in detail the minor nonconformity data appeared in every six-month follow up audit of EMS of the companies. The characteristics of companies are classified into three categories : business type (four types), business size (three sizes), and EMS implementation period (three periods). These categories are considered as three factors that can affect minor nonconformity data (refer <Table 2>).

A research question for the data is followed as follows :

Research question 1 : Do the effects of business type, size, and EMS implementation period interact or act independently on the number of minor nonconformity data?

If these effects of business type, size, and period interact, which levels of business type, size, or period show substantial differences on the number of minor nonconformity data? If these effects of business type, size, and period do not interact, does business type, size, or period show statistical relation to the number of minor nonconformity data?

After statistical relation among business type, size, and period on the number of minor nonconformity data is examined, the degree of performance in fulfilling ISO 14001 : 2004 requirements is investigated for following research questions :

Research question 2 : Do companies with different business type achieve a similar degree of performance in fulfilling specific requirements of ISO 14001 : 2004 requirements?

Research question 3 : Do companies with different business size achieve a similar degree of performance in fulfilling specific requirements of ISO 14001 : 2004 requirements?

Research question 4 : Do companies with different EMS implementation period achieve a similar degree of performance in fulfilling specific requirements of ISO 14001 : 2004 requirements?

The questions described above are stated in terms of hypotheses as follows :

Hypothesis 1 : Are all effects including main effects and interaction effects for business types, size, and EMS implementation period equal to zero?

Hypothesis 2 : Is the proportion of minor nonconformity data falling in each subsection in 4. Environmental management system requirement of ISO 14001 : 2004 same in all four business types?

Hypothesis 3 : Is the proportion of minor nonconformity data falling in each subsection in 4. Environmental management system requirement of ISO 14001 : 2004 same in all three business sizes?

Hypothesis 4 : Is the proportion of minor nonconformity data falling in each subsection in 4. Environmental management system requirement of ISO 14001 : 2004 same in all three EMS implementation periods?

The primary objective of this study is to conduct statistical analysis and find key results for the minor nonconformity data detected in industry based on business type, size, and implementation period. We also aim to present practical considerations and implications to those who are interested in EMS operation assessment.

3. Statistical ANALYSIS

3.1 Classification of Companies in Sample

Three factors that affect the minor nonconformity data are explained. Business type is categorized into one of shipbuilding, machinery, automobile, and chemical industry. Shipbuilding encompasses the companies that manufacture equipment, tools, and materials associated with shipbuilding industry. Machinery includes the companies that produce heavy and metal materials for facilities. Automobile contains the companies that make apparatus and tools for automobile industry. Chemical includes companies that produce various kinds of chemical products. Business size is classified into small, medium, and large sized company according to Korea industry classification criterion. If the number of employees is less than 100, from 100 to 300, more than 300, then business size is respectively classified into small, medium, and large. Since ISO 14001 : 2004 certificate has to be issued every three years by a certification body and the follow up audit for ISO certificate should be conducted every six months, the EMS implementation period is classified as three-year interval. We collected 1,122 minor nonconformities from the follow up audits of 40 companies over more than six years. The number of companies categorized for this research is presented in <Table 2>.

<Table 2> The Classification of Companies

Category		The number of companies
Business type	Shipbuilding	9(22.5%)
	Machinery	19(47.5%)
	Automobile	4(10.0%)
	Chemical	8(20.0%)
Business size	Small	14(35.0%)
	Medium	13(32.5%)
	Large	13(32.5%)
EMS implementation period	Less than three years	9(22.5%)
	Three to six years	13(32.5%)
	More than six years	18(45.0%)

The individual minor nonconformity data of 40 companies are classified according to three factors business type, size, and implementation period. A three-factor analysis of variance with factors : business type, size, and implementation period, is assumed to test Hypothesis 1 in Section 2.

Analysis of variance method is applied to determine whether all main effects for three factors and the interaction effects of the factors are equal to zero. SAS (Statistical Analysis System) 9.3 for window version was utilized. As a result of analysis, all main effects and interaction effects turned out to be insignificant.

3.2 Two-Factor Analysis of Variance with Factors : Business Type and Size

A two-factor analysis of variance is now suggested to determine whether main effects and interaction effects are equal to zero. The two-factor analysis of variance with business type and size is considered. The data for minor nonconformities on business type and size are shown in <Table 3> and the minor nonconformity data Y_{ijs} in <Table 3> is assumed a composite that reflects the sum of following terms :

$$Y_{ijs} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \epsilon_{ijs}$$
$$i = 1, 2, 3, 4; \quad j = 1, 2, 3; \quad s = 1, 2, \cdots, n_{ij}$$

where Y_{ijs} is the number of minor nonconformities of the sth company in the *j*th business size in the *i*th business type, μ is overall population mean, α_i is the effect of business type i and is subject to the restriction $\sum \alpha_i = 0$, β_j is the effect of business size *j* and is subject to the restriction $\sum \beta_j = 0$, $(\alpha\beta)_{ij}$ is the interaction effect of business type i and size *j* and is subject to the restriction $\sum_i (\alpha\beta)_{ij} = \sum_j (\alpha\beta)_{ij} = 0$, ϵ_{ijs} is the experimental error that is $N(0, \sigma^2)$, n_{ij} is the number of replicate observations in cell (*i*, *j*), *i* is business type (1, 2, 3, and 4 respectively represent S, M, A, and C), and *j* is business size (1, 2, and 3 respectively represent SM, ME, and LA). Here S, M, A, and C respectively stand for shipbuilding, machinery, automobile, and chemical industry, SM, ME, and LA respectively represent small, medium, and large sized industry.

We assume that the number of minor nonconformities recorded from 40 companies in <Table 3> is normally distributed since a number of LRQA auditors with diverse hands-on experiences independently evaluated EMS of the companies. The residuals for determining the aptness of this

factorial design model with business type and size were examined. Although two outliers were detected, they were merely extreme manifestation of the random variability inherent in data so that they are retained and processed to fit this model. A Box-Scheffe test was performed to test homogeneity of error variances and a rank plot was drawn to check whether errors are normally distributed. There was no reason to doubt the tenability of the normality and homogeneity of variance assumptions.

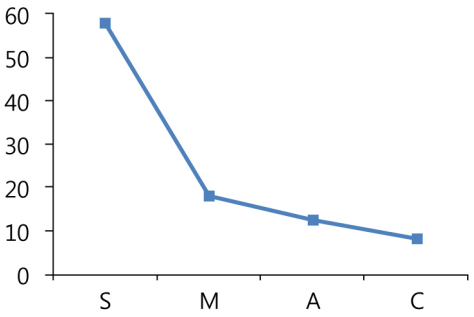
Interaction effects for business type and size are significant when the level of significance adopted is 0.05 since the p-value that all interaction effects are equal to zero is 0.0283. Thus the main effects of business type and size cannot be tested directly to determine whether they are zero since the interaction effects for business type and size are significant. Instead, simple main effects for business type at each level of business size and simple main effects for business size at each level of business type are tested to see whether their effects are zeros.

<Table 3> Individual Minor Nonconformity Data of 40 Companies for Type and Size

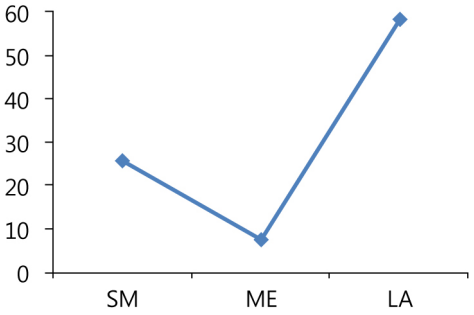
Business Type	Business Size		
	SM (Mean)	ME (Mean)	LA (Mean)
S	6, 45, 25 **(25.3)**	3, 11 **(7.0)**	27, 51, 123, 31 **(58.0)**
M	40, 34, 70, 33, 27, 112, 35, 19, 17 **(43.0)**	16, 28, 26, 20 **(22.5)**	4, 3, 8, 29, 30, 31 **(17.5)**
A	0 **(0.0)**	69, 31 **(50.0)**	8, 17 **(12.5)**
C	6, 6 **(6.0)**	27, 5, 5, 22, 14 **(14.6)**	8 **(8.0)**

As a result of analysis, there is a substantial difference for the mean number of minor nonconformities at four business types for large business size. However, other simple main effects for business type and size are not significant. The mean numbers of minor nonconformities of shipbuilding, machinery, automobile, and chemical industry at large business size are respectively presented 58.0, 17.5, 12.5, and 8.0 in <Table 3> and the result is drawn at <Figure 1>.

Shipbuilding industry shows the largest mean number of minor nonconformities and there are significant differences between shipbuilding and other industry. Shipbuilding is a huge multiple-process industry, i.e. rust removal, metal surface treatment, welding, painting, and shipbuilding equipment assembling. The processes cause a lot of environment problems such as water pollution, ground pollution, and air pollution. It is also a labor-intensive industry by its nature. Accordingly, large sized shipbuilding companies have a large number of minor nonconformities especially for legal requirements with respect to company's environment and training and emergency response-4.3 planning, 4.4.2 competence, training, and awareness, 4.4.6 operational control, and 4.4.7 emergency preparedness and response.



<Figure 1> The Mean Number of Minor Nonconformities for Each Business Type at Large Sized Companies



<Figure 2> The Mean Number of Minor nonconformities for Each Business Size at Shipbuilding Industry

In addition, there is a significant difference for the mean number of minor nonconformities at three business sizes for shipbuilding industry. That is, the mean numbers of minor nonconformities of small, medium, and large size for shipbuilding industry are respectively shown 25.3, 7.0, and 58.0 in <Table 3> and the result is drawn at <Figure 2>. Large sized companies show largest mean number of minor nonconformities and there is a significant difference between large and medium sized companies. Medium sized shipbuilding companies have smallest mean number of minor nonconformities since they obtained EMS certificates recently and had fewer audits than other sized shipbuilding companies.

3.3 Two-Factor analysis of Variance with Factors : Business Type and Implementation Period

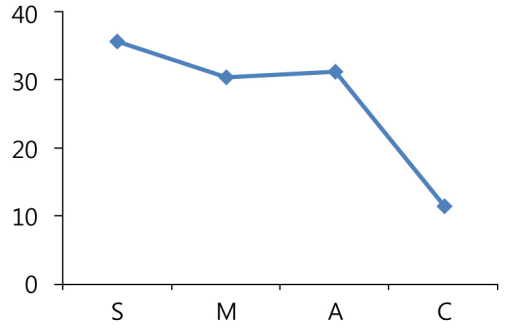
A two-factor analysis of variance with business type and implementation period is considered. The data for minor nonconformities on business type and period are shown in <Table 4> and the minor nonconformity data Y_{iks} in <Table 4> is assumed a composite that reflects the sum of following terms :

$$Y_{iks} = \mu + \alpha_i + \gamma_k + (\alpha\gamma)_{ik} + \epsilon_{iks}$$
$$i = 1, 2, 3, 4; \quad k = 1, 2, 3; \quad s = 1, 2, \cdots, n_{ik}$$

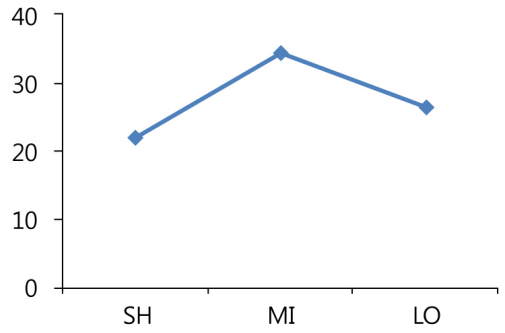
where Y_{iks} is the number of minor nonconformities of the sth company in the kth implementation period in the ith business type, γ_k is the effect of implementation period k and is subject to the restriction $\sum\gamma_k = 0$, n_{ik} is the number of replicate observations in cell (i, k), $(\alpha\gamma)_{ik}$ is the interaction effect of business type i and period k and is subject to the restriction $\sum_i(\alpha\gamma)_{ik} = \sum_k(\alpha\gamma)_{ik} = 0$, ϵ_{iks} is the experimental error that is $N(0, \sigma^2)$, n_{ik} is the number of replicate observations in cell (i, k), k is implementation period (1, 2, and 3 respectively represent SH, MI, and LO), and other notations are same as in Section 3.2. Here SH, MI, and LO respectively mean less than three years, three to six years, and more than six years

The residuals for determining the aptness of this factorial design model with business type and implementation period were examined. The independence, normality, and homogeneity of variance assumptions seemed tenable by examining residuals. Interaction effects for business type and implementation period are not significant since the p-value of all interaction effects being zero is 0.1124. The main effects of business type and period are thus tested. Their main effects of business type and period are not zero since the p-values of main effects of business type and period are respectively 0.0241 and 0.0068. The mean numbers of minor nonconformities for shipbuilding, machinery, automobile, and chemical industry are respectively shown 35.8, 30.6, 31.3, and 11.6 in <Table 4> and the result is drawn at <Figure 3>. The mean number of minor nonconformities for chemical industry is smallest and there are substantial differences between chemical and other industry. Legal requirements for chemical industry are very rigorous comparing with other industry. Chemical companies more strictly observe the EMS than other industry because the damages by chemical processes are severely serious to human life, facilities, and environment.

The mean numbers of minor nonconformities for short, middle, and long period are respectively presented 22.0, 34.5, and 26.4 in <Table 4> and the result is drawn at <Figure 4>. The mean number of minor nonconformities for short period is smallest and there are significant differences between short and other periods. Short, middle, and long implementation period can be considered as induction, maturity, and stabilization period, respectively.



<Figure 3> The Mean Number of Minor Nonconformities for Business Type



<Figure 4> The Mean Number of Minor Nonconformities for Implementation Period

<Table 4> Individual Minor Nonconformity Data of 40 Companies for Type and Period

Business Type	Implementation Period			Business Type Mean
	SH	MI	LO	
S	6, 3, 11, 27	45	25, 51, 123, 31	**35.8**
M	40, 34, 70, 4, 3	33, 27, 112, 35, 19, 16, 28, 26	17, 20, 8, 29, 30, 31	**30.6**
A	0	69	31, 8, 17	**31.3**
C	0	6, 6, 27	5, 5, 22, 14, 8	**11.6**
Implementation Period Mean	**22.0**	**34.5**	**26.4**	

Companies with short implementation period have smallest mean number of minor nonconformities since they have fewer audits than companies with other implementation periods and they can be consulted by auditors before obtaining certificate.

A two-factor analysis of variance with business size and period are not provided here since all effects associated with business size and period are not statistically significant.

3.4 Chi-Squared Tests for Homogeneity

The number of minor nonconformities for subsections of 4 Environmental Management System Requirement of ISO 14001 : 2004 according to three categories is summarized. A chi-squared test of homogeneity for all four business types is conducted using the data in <Table 5> to test Hypothesis 2. We assume that sample sizes for each category are fixed by the sampling design.

In order for homogeneity tests to be valid, all the expected values in each cell are at least 2 and at least 80% of them are 5 or more [6]. As a result of chi-squared tests for homogeneity, <Table 5> does not satisfy this condition. Since subsections 4.1 General requirement, 4.2 Environment policy, and 4.6 Management review are interrelated in terms of contents and they are comprehensive statements that organizations should establish, document, maintain, and continually improve an EMS as compared with subsections 4.3, 4.4, and 4.5, subsections 4.1, 4.2, and 4.6 are therefore collapsed and the homogeneity test is conducted again.

<Table 6> presents the data after three columns in <Table 5> were collapsed. The p-value of a homogeneity test for Hypothesis 2 is 0.0470. Similarly, subsections 4.1, 4.2, and 4.6 are collapsed and the resulting tables are shown in <Table 7> and <Table 8> in order to perform the homogeneity tests for Hypotheses 3 and 4. Their p-values are respectively 0.0094 and <0.0001, respectively. Therefore, the proportions of minor nonconformity data falling in each subsection of 4 Environmental Management System Requirement are not same for each category of business types, sizes, and periods.

The percentages of each business type in <Table 2> are compared with percentages of minor nonconformity data for each business type in <Table 6> in order to understand homogeneity for all four business types. We notice shipbuilding (28.7%) and machinery (51.9%) industry show more percentage of minor nonconformity data than percentage of their industry (22.5% and 47.5%) in the sample whereas chemical industry (8.3%) show less percentage of minor nonconformity data than its percentage (20.0%) in sample.

As mentioned above, chemical companies rather than shipbuilding and machinery companies attempt to observe strictly their EMS since damages due to accidents of chemical companies are very dangerous and there exist strict local requirements, regulations, and laws associated with stakeholders for chemical industry. We can also notice that 4.3 Planning and 4.4 Implementation and operation occupy most of minor nonconformity data when subsections are compared.

<Table 5> The Number of Minor Nonconformities Based on Business Type

Category	Subsection of 4 Environmental Management System Requirement					
	4.1 General requirement	4.2 Environmental Policy	4.3 Planning	4.4 Implementation and operation	4.5 Checking	4.6 Management review
S	1	1	129	146	41	4
M	4	6	227	217	111	17
A	0	0	50	50	19	6
C	1	0	31	38	22	1
Total	6	7	437	451	193	28

<Table 6> The Number of Minor Nonconformities Based on Business Type after Collapsing

Category	Subsection of 4 Environmental Management System Requirement				Total
	4.1, 4.2, and 4.6	4.3 Planning	4.4 Implementation and operation	4.5 Checking	
S	6	129	146	41	322(**28.7%**)
M	27	227	217	111	582(**51.9%**)
A	6	50	50	19	125(**11.1%**)
C	2	31	38	22	93(**8.3%**)
Total	41	437	451	193	1122

<Table 7> The Number of Minor Nonconformities Based on Business Size

Category	Subsection of 4 Environmental Management System Requirement				Total
	4.1, 4.2, and 4.6	4.3 Planning	4.4 Implementation and operation	4.5 Checking	
SM	24	178	180	93	475(**42.3%**)
ME	12	100	114	51	277(**24.7%**)
LA	5	159	157	49	370(**33.0%**)
Total	41	437	451	193	1122

<Table 8> The Number of Minor Nonconformities Based on Implementation Period

Category	Subsection of 4 Environmental Management System Requirement				Total
	4.1, 4.2, and 4.6	4.3 Planning	4.4 Implementation and operation	4.5 Checking	
SH	13	71	69	45	198(**17.7%**)
MI	22	171	170	86	449(**40.0%**)
LO	6	195	212	62	475(**42.3%**)
Total	41	437	451	193	1122

Similarly if we compare the percentage of each business size in <Table 2> with percentage of minor nonconformity data of each business size in <Table 7>, small sized industry (42.3%) shows more percentage of minor nonconformity data than its percentage (35.0%) whereas medium sized industry (24.7%) shows less percentage of minor nonconformity data than its percentage (32.5%) in the sample. Small sized companies are always busy taking care of many key requirements of subsections of Section 4 Environmental Management System Requirement. Since they have limited resources such as manpower, capital investment, and cost of maintaining EMS, more minor nonconformity can be detected by audits than other sized companies.

Similarly if we compare the percentage of each EMS implementation period in <Table 2> with percentage of minor nonconformity data of each implementation period in <Table 8>, middle period industry (40.0%) shows more percentage of minor nonconformity data than its percentage (32.5%) whereas short (17.7%) and long period (42.3%) industry show less percentage of minor nonconformity data than their percentage (22.5% and 45.0%) in the sample. Among many other reasons that more minor nonconformities are detected for middle period industry, we surmise that there might be a tendency of not improving actively their EMS to ensure its continuing suitability, adequacy, and effectiveness after three years passed since companies for middle period industry obtained their first ISO certificate. When they started to obtain EMS certificate, they complied with the requirements quite well but they did not make strenuous effort to enhance their EMS.

4. Discussions And Implications

From the statistical analysis, there was a substantial difference for the mean number of minor nonconformities for four business types when they are large sized companies. The mean number of minor nonconformities for shipbuilding industry at large business size was 58.0 and it was largest among four different types of industry. Since shipbuilding is a labor-intense and huge multiple-process industry, the number of minor nonconformities increases as the company size becomes big unless it maintains EMS comprehensively. This result is identified in <Figure 1>. Legal requirements such as regulations, legislation, administrative decree, and laws with respect to customers' request, stakeholders, local governments, and environment should be considered to continually improve the EMS of large shipbuilding companies. Training and emergency response of all employees should be documented and recorded for safety and environment's purpose because a lot of minor nonconformity data for section 4.3 Planning and 4.4 Implementation and operation were revealed on audits. However, the mean numbers of minor nonconformities of medium size for shipbuilding industry were unexpectedly small, 7.0, from <Figure 2> since two medium sized shipbuilding companies are the first time ISO certificate earners whereas small and large sized shipbuilding companies are recertified.

The mean number of minor nonconformities for chemical industry is smallest, 11.6, in <Figure 3> and it is abnormally low comparing with other industries. There are some reasons why chemical industry keeps the minor nonconformity data small. Pollution, damages, or loss due to chemical processes and products are unexpectedly serious to people and human environment. It is almost impossible to return to the recovery of original environment from the accidents due to chemical plants. Legal requirements for chemical industry have to be very rigid. Civil complaints around chemical companies are often filed a lawsuit. Therefore chemical industry should maintain their EMS very thoroughly. Taking all EMS implementation periods into consideration, companies with short implementation period have smallest mean number of minor nonconformities 22.0 in <Figure 4>.

When the degree of performance in fulfilling specific requirements of ISO 14001 : 2004 requirements is considered with regard to business types, sizes, and periods, shipbuilding (28.7%) and machinery (51.9%) industry show more percentage of minor nonconformity data for <Table 7> than percentage of their industry (22.5% and 47.5%) in the sample of <Table 2>. Furthermore, the number of minor nonconformities for 4.3 Planning and 4.4 Implementation and operation is very large as compared with other subsections. Therefore, care must be given to shipbuilding and machinery especially for complying with subsections 4.3 and 4.4. Small sized companies have largest portion of minor nonconformities among three business sizes in <Table 7>. Since small sized companies have limited time and resources such as manpower, capital investment, and cost of maintaining EMS, more minor nonconformity can be found out than other sized companies. From <Table 8> middle period industry (40.0%) shows more percentage of minor nonconformity data than its percentage (32.5%) in <Table 2>. Among other possible reasons that more minor nonconformities are detected for middle period industry, we conjecture that there might be a tendency of not improving continually their EMS.

The important attributes or barriers not to occur minor nonconformities might be top manager's commitment (direct support that allocate resources which are necessary to change organizational environment), education and training, worker's voluntary effort, or practitioner's effort for continuous improvement [19]. Top manager should consider the reason why his company maintains EMS. It is because of motivation to implement or cost to benefit ratio of implementing. In addition, detail and concrete instructions for works are necessary for implementing EMS. If workers or practitioners do not understand completely the goal of EMS, they might focus on relative improvement by simply comparing with previous achieved indicators. Companies seem to adopt minimal compliance when subject to periodical third party's audit. A company should comply with regulations or laws associated with environment and furthermore establish targets to achieve. Research emphasizes that the elements of the environmental policy to be followed by the organization must be specified as precisely and completely as possible [4].

Although ISO 14001 : 2004 EMS enhanced earlier version and compatibilities of ISO 9001, there is another view that many issues concerning sustainable development have not been properly addressed and that a need for the introduction of green specifications to advance green performance in construction through contract management [14, 15, 23]. Energy management and green management including green gas might be necessary to thoroughly observe and reflect EMS implementation benefits. Alternatives could be an integration of quality, environment, health and safety [18].

5. Concluding Remarks

EMS is becoming increasingly important because it is becoming a critical condition for doing global business by governmental regulations and stakeholder pressure. Fundamentally this study uncovered findings :

1. The mean number of minor nonconformities for shipbuilding industry at large business size was 58.0 and it was largest among four different types of industry. Since shipbuilding is a labor-intense and huge multiple-process industry, the number of minor nonconformities increases as the company size becomes big unless it maintains EMS comprehensively.
2. The mean number of minor nonconformities for chemical industry is smallest, 11.6 and it is abnormally low comparing with other industries. Since pollution, damages, or loss due to chemical processes and products are very serious to human life and environment, chemical industry should maintain their EMS very thoroughly.
3. Small sized industry shows more percentage of minor nonconformity data than medium and large sized industry. This is because small sized companies have limited time and resources such as manpower, capital investment, and cost of maintaining EMS.

4. Middle period industry that three years have passed after obtaining ISO certificate for the first time shows more percentage of minor nonconformity data than other period industries. We conjecture that there might be a tendency of not improving continually their EMS to ensure its continuing suitability, adequacy, and effectiveness.
5. When the degree of performance in fulfilling specific requirements of ISO 14001 : 2004 requirements is considered with regard to business types, shipbuilding and machinery industry show more percentage of minor nonconformity data than percentage of their industry in the sample. Special care must be given to shipbuilding and machinery especially for complying with subsections 4.3 Planning and 4.4 Implementation and operation.

Limitations of the research are as follows : the companies in our study are located in southeastern area of South Korea and 40 manufacturing companies used in this study are assumed to be a random sample of manufacturing sector. However, the number of minor nonconformity data is 1,122 in total and this data were collected over more than six years. The sample data are regarded big enough and valuable to make inferences about operation assessment of ISO 14001 : 2004 EMS. The findings from this research can be used practical considerations to those who are interested in EMS operation assessment for manufacturing sector. Future research should expand general industry sectors and collect more audit data compiled over a long period of time from them. Other standards such as quality management system or health and safety management system can also be reviewed to find out the implications suggested by audit data from the standards.

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