Objective Management and Assessment on Special Equipments Security

---- A Case Study of Elevators Security

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Abstract

Under the era of globalization, as China's rapid economic development, the amount of special equipments has been in the dramatic increase, which has brought a major challenge on how to ensure the safety in special equipments. The overall security situation in special equipments in China is not optimistic.

This dissertation takes elevators as a case study to build the dynamic security administration model of special equipments, make an assessment on the model and analyze the model under different social circumstances of state level and global level.

In this article the dynamic security administration model is created to achieve the management objective --- safety, based on the analysis and study of various processes and management entities of elevators, effectively making use of social resources to tighten the control over special equipments manufacture, installation, maintenance, operation, inspection, and supervision. AHP is used to determine assessment factors of multi-level analysis and weight of all factors. And it takes Fuzzy mathematic method to calculate assessment result, pointing out factors with existing issues, which can be rectified and perfected by continuous improvement.

We also try to analyze the influence of five social environment factors: government administration, market economy, information technology, education and regulations on special equipments safe administration. Then we compare the differences of this model applying to Sweden and global level.

Key words: **Special Equipments, Security Administration, Fuzzy-AHP**

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Chapter 1

Introduction

In the first chapter the background of the dissertation is described. The research problem and the purpose of the dissertation are discussed. Finally, the limitations, the research questions are presented.

1.1 Background

Industry Security is a hot issue in an era of globalization, which has been attached growing importance by countries and enterprises. Globalization primarily is production globalization. The globalization of production refers to the sourcing of goods and services from locations around the globe to take advantage of national differences in the cost and quality of factor of production (such as labor, energy, land, and capital). By doing this, companies hope to lower their overall cost structure and/or improve the quality or functionality of their product offering, thereby allowing them to compete more effectively (Hill Charles W.L, 2005). In order to gain a competitive advantage in the international market, countries have done a lot to give prominence to their own resources and industrial clusters feature. The fact that the globalization of production makes it harder to control the quality and safety of products demands a higher quality and safety management. For example, the thousands of parts of an elevator are manufactured in different countries and regions, and the insecurity of any part will lead to the insecurity of an elevator. Secondly, it is market globalization. The globalization of market refers to the merging of historically distinct and separate national markets into one huge global marketplace (Hill Charles W.L, 2005). The globalization of markets results in increasingly fierce competition that requires enterprises increase market share and earn more profits with lower production cost. However, the reduction of product cost will certainly bring on lower product safety features, leading to increased insecurity factors and decreased market share. Finally, from a deep sense, the globalization of the economy is the convergence

process of the competition rules. The competition and cooperation between enterprises in a competitive international market will create a fair competition rule, which will be gradually widely used. Therefore, under the acceleration of economic globalization process, countries at different development levels will formulate rules to control the product safety, which will be eventually dominated by rules globally accepted.

The safety in special equipments is one of the important parts of industry security in China. Because the accidents in special equipments will bring great loss to individuals, families and the state, Special equipments are special products, ensuring safety in special equipments is a component for the public administration management in China. The overall security situation in special equipments in China is not optimistic, China now at a stage of multiple security accidents being occurred. The security foundation in China is weak, and the industry accidents have brought great loss to individuals, families and the state. Fatalness of the special equipments relies on their special requirement to the safe use. Once the accident happens, it is really possible to make mass killing and injuring. The effective monitoring on the special equipments has become a necessary security base to the good economic and social development and people's lives. The task of monitoring the security of special equipments is extremely heavy. To solve this problem and supervise the process, the Chinese government is striving to build a dynamic security administration system for special equipments and to make the system working efficiently and effectively.

One of the writers of this dissertation is a supervisor of special equipments in the departments of Ningbo Municipality. During the past 16 years, she has been working in the safety management department, having rich experience. The other writer has been engaging in the safety management more than 5 years in Hi-Tech Park of Ningbo Municipality. Another copartner also has great experience in administration, having worked in administrative office more than 6 years.

1.2 Problem

In the age of economic globalization, as China's rapid economic development, the amount of special equipments used has been in the dramatic increase, which has brought a major challenge on how to ensure the safety in special equipments. For example, incomplete laws and regulations, nonfeasance of the government, poor management of production, unqualified staff, and little communication of information between relevant departments, all these factors are hidden dangers to the safety in the special equipments.

On these issues, the article takes elevators, one of the special equipments, as a case study to research. We will analyze the different factors influencing the safety in elevators and build a dynamic security administration system for special equipments and to make the system working efficiently and effectively.

1.3 Purpose

This research is on special equipments, referred to boilers, pressurized vessels and pipes, elevators, cranes, passenger ropeways, and large entertainment equipments. This dissertation takes elevators as a case study to build the dynamic security administration model of special equipments, make an assessment on the model and analyze the model under different social circumstances.

Presently, the articles of safety assessment we collected from professional journals are only suitable for one enterprise or one project. Therefore, in this article we try to build a comprehensive management system effectively making use of social resources to tighten the control over special equipments manufacture, installation, maintenance, operation, inspection, and supervision, and to have an assessment on this system. We also try to analyze and improve the weak process from the result of the assessment.

1.4 Limitations

We have reviewed some of the most recognized researchers in the field of special

equipments security. Since it would be possible to investigate more researchers and publications, this constitutes one limitation. Further, for the particularity of case in this dissertation, the questionnaire is only limited to the experts who have special knowledge in special equipments.

1.5 Research Questions

The dissertation is based on the following questions:

1. What are the processes and entities of elevators security administration?
2. How do the entities fulfill their responsibilities of safety at various processes?
3. How to analyze hierarchically safety management target?
4. Why and how do we take Fuzzy-AHP theory to assess?
5. What are the influences on the assessment of model from different social resources?

Chapter 2

Theoretical Framework

We will here present the methodology of research philosophy, scientific approach, research strategy, and the theories within the field of management and decision-making approach, which have been used as our starting point in our research.

2.1 Methodology

There are three dominating views about the research process in the literature, namely positivism, interpretivism and realism (Saunders, Lewis& Thornhill, 2003). According to the fact, the research philosophy of this work is based on the principle of realism. The concept of realism aims to develop knowledge the authors discussed in an objective way and interpreted data in a value-free manner. And for the scientific approach, there are two main research methods to understand different procedure to link existing theory to the empirical research, namely the inductive and the deductive method. The inductive method starts the research from reality, and develops a theory based on the data collected. The deductive method means using existing theories to test and interpret these data (Saunders, Lewis& Thornhill, 2003). This dissertation is of the deductive approach. Then according to Saunders, Lewis & Thornhill, there are different research strategies: experiment, survey, case study, grounded theory, ethnography, and action research (Saunders, Lewis & Thornhill, 2003). Which strategy to be used in the research will depend on the different condition. In this dissertation, we only take case study as our research strategy.

2.2 Management Theory

The field of management grew in its formalization during the latter part of the Nineteenth Century and throughout the Twentieth Century along with the rise of the industrial revolution. The growth of management concepts was needed to guide the growth of industrial manufacturing. A similar growth in safety management theory

also evolved in response to the need for theory, concepts and proven practices in response to the devastating impacts. Some of existing management theories provided a sound basis for supporting safety management.

2.2.1 Theory of Management by Objectives

Management by Objectives (MBO), first popularized by Peter Drucker in 1954 in his book *The Practice of Management*, is an effective planning tool to help the supervisor set objectives. MBO is a collaborative process whereby the supervisor and the subordinate jointly determine objectives what it is that everyone is trying to achieve (Peter, 1954). To be successful MBO programs should include commitment and participation in the MBO process at all levels, from top management to the lowest position in the organization.

MBO begins when the supervisor explains the goals. The subordinate takes the goals and proposes objectives for his or her particular job. The supervisor meets with the subordinate to approve and, if necessary, modify the individual objectives. Modification of the individual's objectives is accomplished through negotiation since the supervisor has resources to help the subordinate commit to the achievement of the objective. Thus, a set of objectives for each individual are jointly determined, prioritized, and formalized. The process requires that the supervisor and the subordinate agree to what the supervisor will attempt to achieve in the period ahead, and the subordinate accept the objectives, otherwise commitment will be lacking.

MBO is often achieved using set targets. Reliable management information systems are needed to establish relevant objectives and monitor their "reach ratio" in an objective way. This management by objective leverages the power of goals and shared information that directly supports individual and group success. This is simply the best solution available for companies interested in a goal setting, action plan, and results format to change the way people work.

When it comes to explain the safety administration of special equipments model which we want to build later, MBO is of main value. The overall objective of this model is safety. To meet this target, first of all, we divide the whole process of special equipments into six processes: manufacture, installation, maintenance, operation, inspection, and supervision, and ensure the security of each process. Second, we analyze sub-elements affecting each process security, finding out and correcting the weak points to ensure the fulfillment of general target.

2.2.2 System Theory

System theory is based on the idea that everything is part of a larger, interdependent arrangement. It is centered on clarifying the whole, its parts, and the relations between them (Bertalanffy, 1972). Some concepts include some of the following: open system, subsystems, synergy and so on.

An open system involves the dynamic interaction of the system with its environment. This theory is fundamental to understanding hazards and emergency management for it maintains that everything is related to everything else. These systems are open not only in relation to their environment but also in relation to themselves; the interactions between components affect the system as a whole. The open system adapts to its environment by changing the structure and processes of the internal components.

System is composed of sub-system. That is, the parts that form the system may themselves be a system. Understanding how the parts relate and that each part has sub-parts that impact the functioning of the whole is important.

Synergy is characterized by the whole being greater than the sum of its parts. It explains why the performance of a system as a whole depends more on how its parts relate than on how well each part operates. Indeed, the inter-dependence of the parts is such that even if each part independently performs as efficiently as possible, the

system as a whole may not. Synergy is an important concept that it emphasizes the need for individuals, as well as departments to work together in a cooperative fashion (Bedeian, 1989).

Coming to our dissertation, a system approach does not provide a means for solving all problems. But it is useful for viewing the relationships between interdependent parts in terms of how these relationships affect the performance of the overall system (Freemont 1985). System theory provides us to view and understand different factors how to influence safety administration and mitigate their adverse impacts.

2.3 Decision-making Approach

Hazards are anything that has the potential to cause harm, they can affect people, property, processes; they can cause accidents, loss of output, damage to machinery, etc. decision-makers look for method as a more solid basis on which to quantify risky decisions and the uncertainty of these decisions. Safety Assessment, Analytical Hierarchy Process and Fuzzy- Analytical Hierarchy Process are the useful tool to deal with the problems.

2.3.1 Safety Assessment

Safety Assessment (SA) appeared in American insurance profession at the beginning of 1930’s, being large-scale and more complicated in industrial production system and the fatal accidents After World War II. Since 1960’s experts have begun their comprehensive, systematical study on the safety assessment to identify hazards.

Generally, the experts collect information in some sources: for instance, technical data of the equipment, materials, or substances used at the workplace; technological procedures and work manuals; results of measurements of noxious and hazardous factors at the workplace; records of work accidents and other factors that may have an impact on the workplace, then, the experts decide if risk is small, medium, or high taking into account the probability and severity of harm which can be caused by each

identified hazard ,and give the scores according to standardizing level, finally, the experts is to make the decision whether risk arising from a hazard is acceptable or unacceptable.

SA provides decision-making proofs, with its aim to carry out system safety, and SA identifies and analyzes the existing dangerous factors in system, with theories and methods of safety system engineering, to estimate probability and degree of accidents. Based on the estimation, measures on design, construction, production and sale should be done. The main aim of risk assessment is to minimize the possibility of the workers or the environment being harmed.

2.3.2 Analytical Hierarchy Process

Analytic Hierarchy Process (AHP) was proposed by Saaty, T.L. in 1977, and has been widely used in decision making. Analytical Hierarchy Process (AHP) is an approach to decision making that involves structuring multiple choice criteria into a hierarchy, assessing the relative importance of these criteria, comparing alternatives for each criterion, and determining an overall ranking of the alternatives. Steps of the AHP are following: Decompose the unstructured problem into systematic hierarchies, from top (the more general) to bottom (the more specific). Through the hierarchy from top to bottom, the AHP structure comprises goals, criteria and alternative ratings. This drawback is compensated by assigning a weight to each criterion. Assign a relative weight to each criterion, based on its importance within the node to which it belongs. The sum of all the criteria beneath a given parent criterion in each tier of the model must equal 100%. Using AHP, a relative score for each alternative is assigned to each leaf within the hierarchy, then to the branch the leaf belongs to, and so on up to the top of the hierarchy, where an overall score is computed. Indeed, AHP allows a better, and more efficient identification of selection criteria, their weighting and analysis. Thus, AHP reduces drastically the decision cycle.

2.3.3 Fuzzy- Analytical Hierarchy Process

Fuzzy-AHP is an extension of normal AHP, It is a multi-criteria decision-making method which grafts Fuzzy theory into AHP. Fuzzy-AHP has both an advantage of AHP that structures complex problems into a hierarchy and an advantage of Fuzzy theory that reflects ambiguity and uncertainty in decision-making process. When we actually use AHP, it often occurs that the best alternative can not be found, since there is not great deal of difference in the overall weights of the alternatives. Thus, it is very important to investigate how the components of a pair-wise comparison matrix exert influence on the weights. Otherwise, in system security, it is thought that there is no absolute security, which is a concept of Fuzzy Mathematics. According to the idea of Fuzzy math, fatalness is the degree of subjection to security. When it comes down to certain degree, it is thought safe.

2.4 Summary

MBO theory is very suitable to explain the model of special equipments security administration being created in the article. The overall objective of this model is safety. In order to realize this purpose, we apply system management theory, regarding security of special equipments as a system; six processes: manufacture, installation, maintenance, operation, inspection, and supervision, as sub-systems; influences of social resources as environmental effects, to create security administration model of special equipments. Then this chapter makes a theoretical review of Safety Assessment, and Fuzzy-AHP theory, which both will be adopted in the following chapters to assess the model in order to identify weaknesses in security management and correct them for the achievement of overall security.

Chapter 3

Analysis on Processes of Elevators Security Administration

This chapter presents the definition of elevators and six processes of elevators. Then it mentions the issues in these six processes and influences of social environment on security administration in China.

3.1 Introduction

This chapter takes elevators—one kind of special equipments—as the example, mainly analyzing impact of technology and management in each process on elevator's overall safety. The essential running stages of elevators are manufacture, installation, maintenance, operation and inspection. Supervision is a special process to supervise the other processes and also plays an important role in the whole safety administration, and it buckles closely with each stage having great impact on overall security condition. Safety is one of the main characters of elevators, the safety of products and the quality of services relate closely to the goodwill in the market.

3.2 Definition and Classification of Elevators

Elevator, driven by power, uses boxes moving along the rigid path or stairs along the fixed line to transport goods or people. With the authorization by the State Council, State Bureau of quality & technical supervision of P.R.China issued "Lists of Special equipments". This list categorizes elevators as: passenger elevators, including (tractive passenger elevator, compulsive passenger elevator, non-engine room passenger elevator, fire elevator, sightseeing elevator, hospital elevator) freight elevators, including (tractive goods elevator, compulsive goods elevator, non-engine room goods elevator, automobile elevator, explosion-proof goods elevator), the hydraulic pressure elevator ,including (hydraulic pressure passenger elevator, explosion-proof hydraulic pressure passenger elevator),sundries elevator, the escalator and the automatic sidewalk.

3.3 Issues of Elevators Management in China

3.3.1 Elevator Manufacture (Design) Stage

The Chinese enterprises and the scientific research institutions, having low independent ability in research and development on technology, are still far from those of European and American advanced countries. The domestic technology of elevator is mainly based on the imported complete set of production lines or imported computer controlled integrate circuit board, and for the confidentiality and monopoly of most advanced techniques, domestic enterprises and institutions often meet difficulties in key technologies. Thus, the low match has brought a higher failure rate and the security performance comes under the influence.

Most large-scale domestic elevators enterprises are invested or jointly invested from transnational elevators companies, for example: OTIS, Mitsubishi, Nunda, Hitachi, KONE, and so on.

Small and medium-sized elevators enterprises are mostly domestic, starting from producing freight elevators. Thus their abilities in product design and development, skills in production management, and quality in staffs and outfit of equipments and apparatuses are still far from broad enterprises. After more than 20 years' development in China, elevators has had a sharp growth, in 2002 reaching 346,000, and has raised groups of installation technicians, which make the staffs quality improved.

3.3.2 Elevator Installation (Alteration) Stage

The shortage of advanced technicians in debugging and alteration results in unstable alteration quality, and in varying service levels. Scenery management level of elevators installation and alteration can not meet the standard. Elevator manufacturers usually inspect the installation stage, whereas the alteration and repair stages have not been in their effective supervision. This brings the differences of supervision. The qualities of manufacture, installation, alteration and repair relate to the capacity and

safety of elevators. Nevertheless the lack of comprehensive supervision department coordinating the relations always brings managers' irresponsible behavior, which shirks their responsibilities off when failure or accident occurs. It has been a hidden danger to the overall management of elevators.

3.3.3 Elevator Operation Stage

The use of elevators involved in production and daily life, and particularly the use of residential elevators has become an increasing problem and it has brought the increasing attention. There are three problems. First, real estate developers consider reducing costs, often advertising one or two outstanding characteristics of a different configuration to attract owners, but the distribution of the remaining resource is poor. Second, the poor level of property management and low quality of some users make it hard to carry out the day-to-day management responsibilities. In addition, the shortage of capital for maintenance and alteration is another important factor.

In recent years, power shortages have often caused power-cut of elevators, thus the rescue work has been tough and critical. For the reason that only one part of the incorporations is in remote monitoring, the percentage of those enterprises that can attain the information automatically is still small.

3.3.4 Elevator Maintenance Stage

The failure rate and accident rate is directly related to the quality of maintenance, so the maintenance is the key stage to the management of daily use. For financial reasons and sense of safety, elevators under professional maintenance are only about half of the total. Therefore, the responsibilities on use and maintenance management being not carried out effectively have resulted in the out-of-state of the safety of daily use at the lift.

3.3.5 Elevator Inspection and Supervision Stages

China took up elevators safety inspection and supervision at the end of the 1980s, and

has presently created a dynamic database of elevators, which is still at an exploratory stage to the information dynamic management. How to manufacture, install, repair, maintain, use, inspect and establish long-term dynamics security administration system of elevators are stepping up research, developing and implementing by the quality supervision departments. Elevators are one kind of special equipments and the supervision department on elevators, belonging to special equipments safety supervision organizations, is an important component of industrial safety supervision and management. At present time, it is very pivotal to build a dynamic safety management system to analyze and solve the main problems of special equipments from enterprises, governments, supervision authorities, operation personnel, and social security awareness. It is the only way to protect the safety of special equipments by delegate responsibility ring on ring.

3.4 The Main Effects of Social Factors

At present, there are several social factors: government administration, market economy, education, regulations and so on, affecting on special equipments safe administration. the major problems of special equipments safe administration are: failure to implement main responsibility on enterprise security; small investment in safety; weak awareness of production safety; the non-standardized management on operation; failure of personnel distribution to meet government departments; out of joint management; ineffective management of information channels; gap between the government forces, means and the social need; poor level of social attention to security; little efficiency of public supervision; and weak sense of self-protection.

3.4.1 Government Administration’s Influence to the Safety Administration

Firstly, the disappearing of bridging role of the industry departments in China. The bridging role between the government and enterprises played by relevant leading departments of their trades at the central level, having been repealed after China's reform of government institutions, has disappeared. Many security management functions born by former leading industrial departments are now directly taken by the

enterprises themselves. It is inevitable to implement this reform on the analysis of development trend. But there are still numerous companies which know little about the national policies, statues, and technology standards, and which will be at loose ends when encountering issues for their gap management.

Secondly, the deficiency of the department supervision. Presently Chinese government makes special equipments safety management department subordinate to the quality and technology inspection unit. With the recent years' quick economic development, the number of the special equipments has risen sharply, while the department of quality and technical supervision staffing, institutional setup, vehicles such practical problems have not yet been solved. Additionally, for the great differences between pressure special equipments and electronic machinery equipment, the safety inspectors' low professional quality make it difficult to deal with the spot security issues. And special equipments are commonly characterized by great danger, fast-change in velocity and pressure, complex chemical reaction of kinds of mediums. And various safety sense and management levels bring supervision and management to a very difficult situation.

Finally, the distance of the legislation and government financial investment. Increasing importance has been attached to production safety from central government to local level. Safety supervision and management network is growing better and laws and regulations are becoming more perfect. But compared to the pace of our economic development, the government's investment in safety management planning, finance, public safety facilities is still far from enough, and is difficult to adapt the present severe situation of production safety. The ambiguity of the departments' function has resulted in management line out-of-joint, blindness to the new problems of production safety, unfulfilment of the responsibility. The contradiction of safety management is still protrudent.

3.4.2 Market Economy's Influence to the Safety Administration

Numerous hidden troubles threat special equipments. Special equipments always require mechanical equipments and systems with high level of automation and safety capacity and need industrial workplace for the suddenly leakage of toxic substances or inflammable and explosive gas or liquid. Special equipments must be equipped with continuous monitoring and automatic control devices, when the monitored temperature, pressure, liquid level and flow rate of toxic, hazardous, flammable and explosive gases exceed the prescribed state, then the monitoring device will automatically drive control devices or cut power off to stop adding and to operate ventilation machine ventilating and reducing harmful concentration. And some production lines require the allocation of various interacting devices, security device and alarm devices, and so on.

Market economy demands companies to lower their overall cost and gain more profit. From data of the inspection and testing in China, 50% of old enterprises have outdated equipments, and the level of automation is not high, meanwhile for the irregular maintenance or improper maintenance, the failure rate is relatively high. Some of those equipments are even traced back to the 1960s, whose security is really a serious problem. Some warehouse is even stored flammable and explosible solids, gases, liquids, and the storage tanks are not equipped with automatic monitoring control device; Some old warehouses, and storage tanks have not enough space to residents, schools, roads; and some are aged equipment, excess storage; Some tanks are without anti-fire devices and breathing valve; Some small and medium-sized non-state-owned and private enterprises purchase scraped equipments and various mining vehicles from state-owned enterprises or recycling companies in order to save money. For its poor safety quality, this has become a major reason for accidents.

3.4.3 Education's Influence to the Safety Administration

It is urgent to improve the qualities and sense of security of management personnel and employees. Any accident is involved factors as human unsafe behaviors, material

insecurity, management and environmental conditions, etc., of which human behavior is vital, especially at the present time. Because some old industrial sites, even other new ones, are still far from the required standard and production facilities safety level. Therefore, the better safety management quality and better operators' safety sense are much needed and through the implementation of the responsibility system and the systematic scientific management, as well as the safe operation of its staff, it is necessary to make up for the deficiencies of basic conditions. However, in reality, safety sense and quality of a considerable part of the current management personnel and employees need improving. In those units having stable staffs, especially in state-owned ones, their staffs are better in knowing crisis, recognizing crisis and preventing crisis. But there still exists some irregular widespread phenomena, that is because staffs' weak safety sense, idea of leaving things to chance, unwillingness to abide by operation rules, and their not wearing protective labor supplies. For those non-state-owned and private enterprises which have high staff liquidity ratio, through their employees have taken short-term three-level safety education with low effectiveness, they are still weak in security sense and skill, and for those who were poor educated, they even do not know safe operation rules of their posts and the surrounding risk factors.

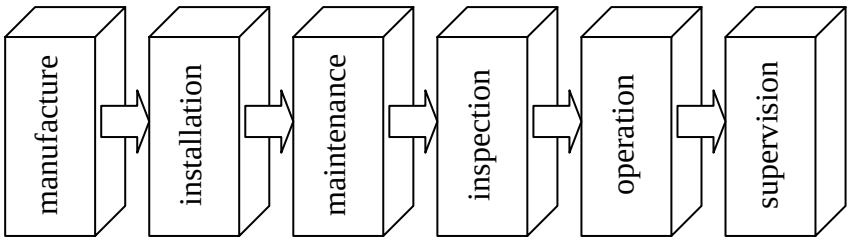
3.4.4 Regulation's Influence to the Safety Administration

It is urgent to revise the safety management regulations. The government has issued some regulations on the management of production safety and special equipments safety, but some enterprises did not carry out these regulations only with accordance with their old ones, and some even did not establish rules on regular scrapping and updating management systems.

3.5 Summary

To sum up, the main component of the elevators safety management processes are as following Figure 3-1:

Figure 3-1 the elevators safety management processes



This chapter studies the elevators safety management processes and the existing problems by comprehensively analyzing six stages of the elevator manufacture, installation, maintenance, operation, inspection, and supervision, and social factors: government administration, market economy, education, regulations.

Chapter 4

Creation and Analysis on the Model of Elevator Security Administration

This chapter presents the creation of the model of elevator security administration, and the analysis on the model, and illustrates the responsibilities of each entity, and analyzes the factors of each process.

4.1 Creation of Model

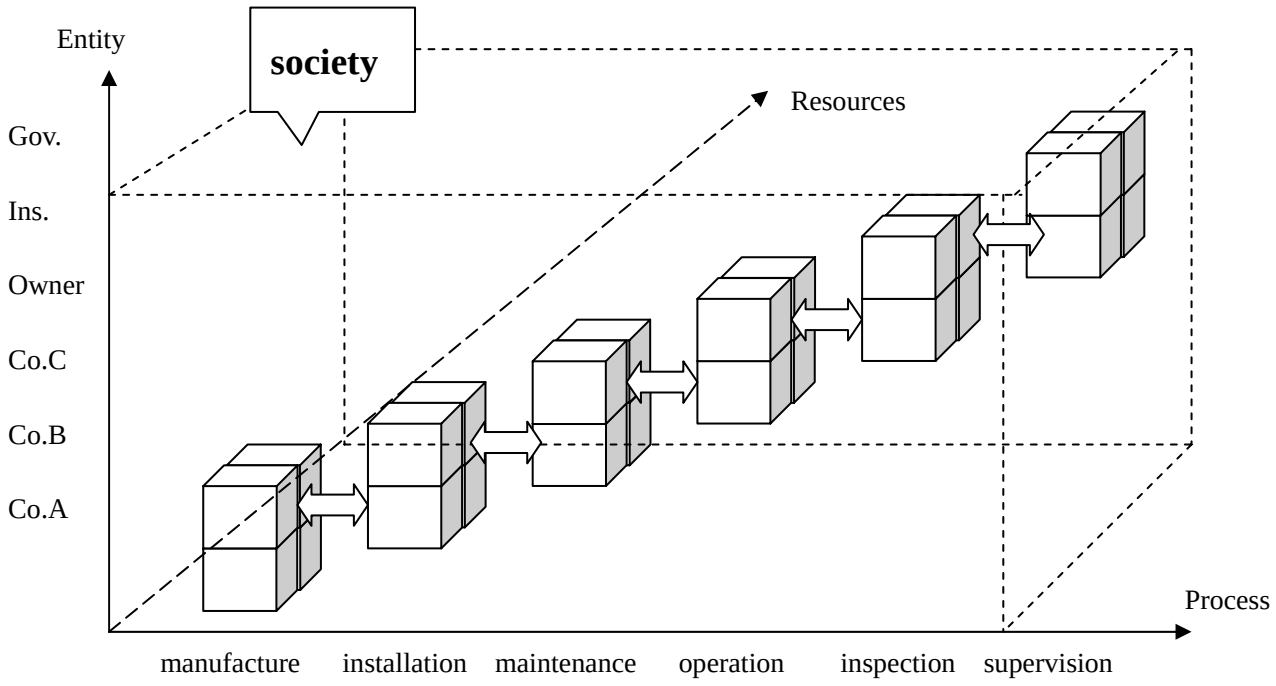
4.1.1 Illustration of Model

This model, (shown as Figure 4-1) based on the analysis and study of various processes and management entities of elevators, is to help implement safety target management by studying how the entities use social resources to fulfill management responsibility. This article analyzes and assesses main factors, government management, market economy, education, information technology and regulation, affecting safety management according to grades from experts, and then it takes Fuzzy mathematic method to calculate assessment result, pointing out factors with existing issues, which can be rectified and perfected by continuous improvement.

Coordinate X in the model shows elevators safety management processes, including manufacture (design), installation (repair \ alteration), maintenance, operation, inspection, and supervision. Coordinate Y stands for corresponding safety responsibility entities to the six different processes. Coordinate Z expresses resources. The big cubes of coordinates, first-level factors unit of elevators overall safety, represent the safety management responsibility in various stages. The four small cubes, second-level factors unit affecting safety management of various processes of elevators, represent primary factors having an impact on safety management of all processes. And these small cubes also show that each entity effectively use social

resources to carry out safety responsibility of this process by these four factors. The communication between six processes is through human resource flow, material flow, and information flow. And the entire management system is discussed under a given social environment that results in different influence with changed one. AHP is used to determine assessment factors of multi-level analysis and weight of all factors. The matrix formed through the coupling of each factor in the model means scientific calculation by Fuzzy mathematic theory.

Figure 4-1 ***the Model of Elevator Security Administration***



Note: Gov.. refers to government; Ins. refers to inspection institutor; Co. A refers to Manufacture company; B, installation company; C, maintenance company.

4.1.2 Research Methods

Questionnaire: The forms of questionnaire and spot assessment are adopted in this article. Totally, ten experts are surveyed in three separate times and these ten experts make a scene-assessment on the safety situation of one residential elevator in Ningbo.

Total amount of the survey and evaluation is 40. See Appendix 1, 2, 3, 4.

The experts: During the evaluation process, 10 experts are needed, who are advanced technicians and engineers, engaged in elevators manufacture, installation, maintenance, operation, inspection and supervision, having over ten years' working experience in elevators. And these ten experts are from different management departments, therefore, their assessment process, showing their rich work experience and abundant profession knowledge, is strongly representative.

Appraisal Meeting: Because the authors of this dissertation are now in Sweden, considering the time, finance and other various reasons, Ningbo special equipments industry association is commissioned to organize the ten experts to hold this appraisal meeting on one residential elevator in Ningbo. Based on quality identification and information checking, experts score specific evaluation items.

Information collection: In this paper, the relevant investigation is on the phased implementation. Because the time requires more compact, and it goes between China and Sweden, the information is transmitted primarily through Internet, which is effective and convenient for long-distance communication.

4.2 Responsibility of Each Entity

4.2.1 Elevator Manufacture Company's Safety Responsibility

Security certification is the prerequisite for the access of market. The main duty of elevators manufacturers is to ensure that their products reach safety certification. To meet this responsibility, first, enterprises should strengthen their management, mainly including: management of the supply of parts and components; management of the production process; and a total quality management approach governing every aspect of the production process. Second, enterprises should constantly standardize and improve the technical criterion of design. Technical standard is a premise for the

qualified products. The third way is to continuously enhance the quality of designers and fabricants to improve their awareness to products safety by education. Thus, it is helpful to avoid and correct insecurity in the processes of design and manufacture. Finally, enterprises must invest more in research and development. The core of market competition is the core of technology. It is necessary to strengthen investment in research and development, enhancing the function and reliability of the product, in order to gain more market share.

4.2.2 Elevator Installation Company's Safety Responsibility

The main responsibility of installation corporations is to ensure the elevators installed meet safety standards. To meet this responsibility, first of all, it is necessary to train relevant staffs to improve their technical level to heighten the quality of the installation team. Furthermore, it is necessary to better working condition. The space for elevators must be suitable so as to reduce unsafe environmental factors. And advanced apparatus are used to ensure the quality of test to determine the safe operation. In addition, it is essential to increase site management level to prevent unnecessary damage to the elevator.

4.2.3 Elevator Maintenance Company's Safety Responsibility

The main duty of maintenance enterprises is to assure elevators safe operation through maintenance. Two ways can be done to fulfill this responsibility. One is to establish information systems. The system record fault maintenance information of each elevator, ensuring each elevator get timely maintenance. And the system can help analyze hidden trouble to make a necessary prepare. The other is to create essential emergency rescue program. Once elevators do not operate well, various departments can be coordinated to attend emergency rescue promptly to reduce the losses caused by the later rescue.

4.2.4 Elevator Owners' Safety Responsibility

Elevators' owner is a key factor to elevators safe operation. Three ways can be taken to achieve owners' responsibilities. First, to supervise elevators safety operation. Second, to establish indispensable systems. These systems can ensure the implementation of the elevators security management through annual inspection, professional maintenance, and overall safety education. Third, to create emergency rescue plan. Essential exercises of the plan ensure the timely and effective disposal to reduce losses.

4.2.5 Statutory Inspection Institution's Safety Responsibility

The mandatory inspection system should be strictly enforced on special equipments. The processes of special equipments manufacture, installation(alteration), major maintenance must be monitored and inspected by approved supervision institutions. Those special equipments in use must be checked regularly by approved inspection agencies. The newly developed special equipments must be tested by authorized inspection institutions. Special equipments inspectors must take responsibilities for the result and conclusion of the inspection.

4.2.6 Government's Safety Responsibility

Governments at various levels are responsible for the special equipments security, supporting, supervising and urging quality and technical supervision departments to perform security functions; timely coordinating and settling the major problems in special equipments safety supervision; taking effective means to supervise and help to eliminate potential accidents; and having periodic analysis on the security situation of special equipments, according to the "production safety law" and the "Bill", to coordinate the relevant departments to carry out safety work.

4.3 Social Resources Affect the Model

System theory provides us to view and understand different factors how to influence safety administration. In this Model, we apply system theory, regarding security of

special equipments as a system; influences of social resources as environmental effects, the entities use social resources to fulfill management responsibility, the interaction of the system with its environment is to help implement safety target management, the whole is greater safety than the sum of its parts.

The main social resources are five society factors: government administration, market economy, information technology, education and regulations, which affect on special equipments safe administration. Governments are the fundamental forces to supervise the safety of special equipments, administrators attach great importance to the effective supervision network and operation system. Regulations play an important role in safe administration. Security supervisors and identifiers according to *Special equipments Safety Supervision Regulation* should strictly perform their respective responsibilities and duties on special equipments, carrying out their duties on legal supervision, enforcement inspection, and incidents handling; not being permitted to engage in the production and sales of equipments. The rapid development of information technology go fast with large capacity and dynamic convenient updating, Internet is the technical foundation of effective dynamic safety management. Education has a significant impact on security management, training personnel to improve their professional levels is staff foundation of the effective dynamic safety management.

4.4 Analysis on Factors of the Six Stages of the Elevator Security Administration

Elevators safety concerns technologies and management of elevators manufacture (design), installation, maintenance, operation, inspection, and supervision. The characteristics of special products, elevators, decide that elevators are gradually fixed to integrations with the scattered components, whose qualities and management on them are vital to the elevators safety. Otherwise, it is a hard work to list and analyze thoroughly all the factors affecting elevators safety. This part is mainly to analyze the general safety situation, and to achieve elevators dynamic safety supervision by analyzing and assessing levels of effect of quality management in each stage on overall safety.

4.4.1 Elevators Manufacture Management and Safety Assessment Factors

Elevators' characteristics are as follows: complex structure, numerous components, various types, and a certain percentage of common parts. Elevators manufacturers presently are still far from independent technology innovation, advanced manufacturing technology and equipments, and modern management.

First, the out-dated mode of production planning control and low level of information management. The majority of elevators manufacturers have created an approach of manufacturing product by sets. They take the longest production-cycle as stock and manufacture lead time of various materials. Exaggerating the period in advance is the root cause of resulting in high rate of products reserves and under-manufactured products, and little active capital. Second, enterprises' weak ability to meet an emergency. Today's market is a fast-changing one with various demands and types, and complex production and procurement. A complete supply chain management, customers-sales-design-production-procurement – finance-cost, is necessary to make a dynamically rapid response to satisfy customers' needs, to meet the changing market demands. And nowadays, most of the enterprises are still in a single computer or manual decentralized management stage because of their laggard management instruments. Some enterprises have established their intranets, but it is still in scattered application, not achieving information communion and optimizing the distribution of resources. Therefore, inaccurate cost, bad cost control, and separated information have not helped to build an organic integration of elevators production, supply, sale, personnel, finance and material, which has greatly affected science of decision-making process. Management in enterprises, being short of standardizations, standards and procedures, varies from person to person. Applications of modern management new ideas, new methods, and new technologies are different. For example: Agile Manufacturing (AM), virtual manufacturing (VM), just-in-time production (JIT), customer relationship management (CRM), supply chain management (SCM), Business Intelligence (BI), e-commerce (EC), enterprise resource planning (ERP).

It is a good way to solve those issues above by adopting information technology to the use of information technology to enhance the mechanical manufacture management level, which will result in effective business administration, management efficiency and the competitiveness of the enterprises. Thus, it is critical for enterprises to adopt modern management ideas, methods and computer network communication technology to achieve innovations in machinery manufacturing, system, and technology. And it is essential for enterprises, facing knowledge economy and economic globalization, to build intranet and internet, and to choose advanced and mature software, which are suitable for enterprise management needs: Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), Supply Chain Management (SCM), Business Intelligence (BI), e-commerce (EC). Through management consulting and business process reengineering, and optimize the design of the organization, management model, business processes and the application software system, enterprise management of information technology, enterprises face of a knowledge-based economy and globalization of the world economy to make the inevitable choice.

According to the above analysis and reference from the General Administration of Quality Supervision “special machinery and electronic equipment manufacturing licensing rules,” the major factors being assessed are as follows:

Factors affecting elevators manufacture and design safety: technological advantages; process quality control; personnel quality; equipment and machines.

4.4.2 Elevators Installation Management and Safety Assessment Factors

The main components of elevators are: structural parts, power systems, information systems, and safety systems. Personnel analyze key links on each stage by installation procedure. The assembly, repair, updating and debugging of standardized parts are main stages in elevators installation, alteration, repair processes, but there are still some key points: for example, security devices. Based on analysis of causes

of elevators accidents, we can see the top five risks: purler, extrusion, shear, impact and electric shock. Most accidents are because of the failure or short circuit of elevators safety devices. Therefore, to a variety of potential hazards, in addition to reasonableness of structure, and reliability of structures, of electrical control and drive, specialized safety devices must be taken into account.

First, to prevent elevators running out of the itinerary. Second, to prevent elevators speeding and ropes breaking. Third, to prevent personnel shearing and crashing. Fourth, to install buffer. Fifth, to set up alarm and rescue devices. Sixth, to shut switches and repair operation devices. Seven, to fit fire facilities. Eighth, to prevent mechanical damage. Ninth, to hold electrical safety protection.

The following factors have an impact on elevators installation(alteration, repair): scene management, workers technical capabilities, quality assurance system, and technology of inspection.

4.4.3 Elevators Operation Management and Safety Assessment Factors

With the continuous increase in high-storey buildings, elevators are in gradually frequent use in the daily life and work, meanwhile, contradictory is obvious in the process of use. The main reasons are as following:

First, unfulfilment of security responsibilities at operation stage. Some owners or property management departments, regardless of safety in using elevators, did not constitute elevators safety management system; did not follow “regulations” to sign contracts with professionally qualified units to carry out routine maintenance; did not create emergency rescue plans in advance; did not declare annual check on time, and employed operators without licenses. Certain elevators maintenance units and their staffs, leaving regulations aside, disrupt maintenance market maliciously engaging in low-priced competition. This is main factor currently affecting elevators safety, and resulting in frequent failure of the elevators.

Second, inexplicit mandatory disposal time of elevators. Elevators, as special mechanical and electrical products, are essential to be inspected periodically each year before their coming operation. Certain components of elevators have been updated during maintenance inspection process and currently there are no clear mandatory provisions for disposals. Some elevators operated in early time cannot meet present requests of safety technology, and are to be altered or updated. Otherwise, for short of capital, behindhand alteration or renovation has become hidden dangers to safety. One hand, quality supervision departments, for the limitation of functions, can only close down equipments to temporarily stop hidden dangers. If taking coercive means to dispose equipments, it not only brings inconvenience to people's life and work, but also is easy to intensify contradictions. On the other hand, some old elevators, because of financial reasons, have only been partly altered or repaired, managing to reach basic requirements of safety inspection. But after running some time, it comes with frequent troubles. Therefore, the owners strongly demand inspection units dispose those equipments, on the contrary, property companies insist that repair can make those elevators meet basic safety requirements. This situation leaves inspection units in a dilemma.

Third, disjunction of elevators management stages. To save cost, real estate exploiters often select unappreciated types during elevators bidding, which result in gap of convenience, comfort from consumers demands, bringing about consumers' complaints. Usually, when properties companies begin to manage communities, elevators have been installed; therefore, it is beyond their duty and property companies hope that municipal government can coordinate relevant departments (e.g. construction department) to set up rules to resolve conflicts.

Fourth, great risks in elevators rescue safety. Urban power shortage has been newly increased insecurity factor in recent years. Since the majority of units have not established emergency programs to carry out rescue methods, and the lack of common safe knowledge of lift use or because of their tension, they often take incorrect

self-salvation. Police, limited in technology knowledge of elevators, sometimes take destructive ways of emergency rescue, which put rescuers' own safety in greater risk.

Fifth, remote-monitoring system on elevators is still at an exploratory stage. Because there is no uniform standard, some major elevators manufacturers are developing their own monitoring system respectively, which has brought great waste in both finance and material. For their various complicated monitoring systems with poor uniformity and compatibility, the application seems undistinguished. The remote control function is in air.

Thereby, the main factors affecting the operation safety are as follows: property management, remote monitoring, users' quality, and emergency programs.

4.4.4 Elevators Maintenance Management and Safety Assessment Factors

Firstly, it is essential establish post responsibility policy to closely relate maintenance work management with consumers' confirmation and supervision management.

Secondly, it is necessary to create policies of periodically visiting consumers collecting their feedbacks and of taking selective examination and supervision management on maintenance work, to carry out effective supervision, control and management on periodical maintenance work (attendance, safety, quality and service, etc.). Furthermore, it is vital to set up maintained elevators consumers' files----maintained elevators database management system----to enhance maintenance work efficiency. The database management system includes failure situations of elevators operation and major parts (door system, electrical control systems, mechanical systems, etc.), and categorizes, calculates and analyzes those data. The system can help to identify reasons for high failure rate and then to solve problems, continually improving product quality and quality of installation and maintenance, improving reliability of elevators. Based on the calculation and analysis of these data, personnel can deal with factors affecting elevators reliability in advance or exchange

vulnerable replacement. Active, preventive maintenance measures can be taken to improve the efficiency of maintenance and user satisfaction. And inputting maintenance men routine data, maintenance records, situation of operational elevators, failures and components replacements into the management system is to strengthen supervision, control and management on maintenance men, to find out the specific maintenance work cycle of operational elevators to formulate the maintenance scheme or repair level. Meanwhile, it is also propitious to implement all managements and detailed management measures. Professional periodical maintenance technology regulations must be formulated according to various elevators' characteristics and practical situations. Usually, regular maintenance cycles are mentioned as follows, daily, weekly, monthly, quarterly, yearly and specialized. Maintenance men should strictly carry out maintenance plan formulated by the technical regulations to achieve the aim of assuring elevators safe operation, reducing failure rate, and extending elevators lifetime.

Factors affecting elevator maintenance security: quality assurance systems, staffs' comprehensive quality, service and emergency program.

4.4.5 Elevators Inspection Management and Safety Assessment Factors

Inspection technology is somewhat weak link at present time. In order to protect elevators safe, reliable operation, detection technologies should work out following development: firstly, to improve the accuracy of test data, reduce the uncertainty of measurement system, and to increase the effectiveness of consistency between test data and real one. Secondly, to extend detection diagnosis and prediction function to enhance their functional skills. Thirdly, to strengthen research, development and simulation on detection technology and non-damage detection technology. Fourthly, to improve inspection technology to develop service. Fifthly, to explore new ways of remote inspecting.

With reference to the basic requirements in "regulations on special equipments

inspection agencies” issued by General Administration of Quality Supervision, factors affecting inspection safety are: inspection facilities, personnel quality, quality assurance system, technique criterion.

4.4.6 Elevators Supervision Management and Safety Assessment Factors

Because of the complication and specification of supervision, we will discuss it in the next chapter.

Chapter 5

Analysis on the Supervision Stage

This chapter analyzes the necessity to supervise the security of special equipments, and the three systems by which government can implement security supervision. And finally, the sub-factors affecting safety at supervision stage are concluded.

5. 1 Introduction

Particularity of supervision: supervising the whole process, from parts to whole. Government departments, in accordance with Chinese State Council's *regulations of safety supervision on special equipments*, should take responsibilities carrying out safety supervising on manufacture, installation, maintenance, operation and inspection. Due to the great volumes and large locations of special equipments, which have great relevance to national economy and people's lives, it is significant to control dynamic safety situation of special equipments.

5.2 Necessity to Supervise the Security of Special Equipments

Boilers, pressure vessels, pressure pipes, elevators, cranes, passenger ropeways, large entertainment equipments are dangerous special equipments relating to people's lives and property safety. Accidents of these equipments have brought great losses to people's lives and property in China. For instance, media in boilers, pressure vessels (including cylinders), pressure pipes and other special pressure equipments are toxic, inflammable, explosive, dangerous chemicals, or liquid with high temperature and high pressure. In the event of leakage or explosion, it would bring about great loss to people's lives, property, and enormous destruction to social production. And once elevators, cranes, passenger ropeways, large entertainment facilities, which are featured with running high-speed or in the air, cause incidents, it is easy to kill and injure many, leaving great impact on society. Therefore, it is essential to have special equipments supervised under the current Chinese social development level.

5.2.1 General Introduction of the Special Equipments in China and Ningbo

By December 31, 2002, according to the statistics from General Administration of Quality Supervision, Inspection and Quarantine, there were 2,927,735 special equipments in China (see table 5-1).

Table 5-1：the Special equipments in China

Motor vehicle	Passenger ropeway	Entertainment facility	Elevator	Crane	Boiler	Pressure vessel	Total
229,464	292	21,087	346,067	521,798	548,174	1,260,220	2,927,735

Ningbo City is an important port and industry city in Zhejiang Province. Developed petrochemical industry, rapid development of urban construction, and industrial structure determine special equipments with large volumes, great locations, and complicated situation. Ningbo is a city with great use of special equipments. By the end of 2004, there have been 48,001 special equipments. (see Table 5-2, Figure 5-1, Figure 5-2).

Table 5-2：the Special equipments in Ningbo

Year	Elevator	Crane	Boiler	Pressure Vessels	Total
2002	5159	8299	5349	15103	33910
2003	6760	11020	5822	15991	39590
2004	8488	14016	6272	19225	48001

Figure 5-1：the Components of Special Equipments in Ningbo

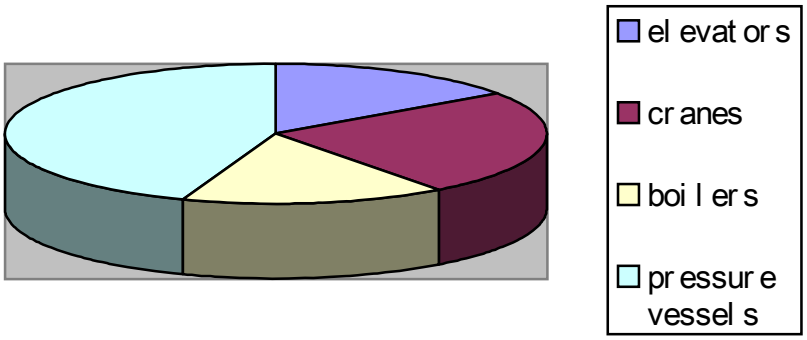
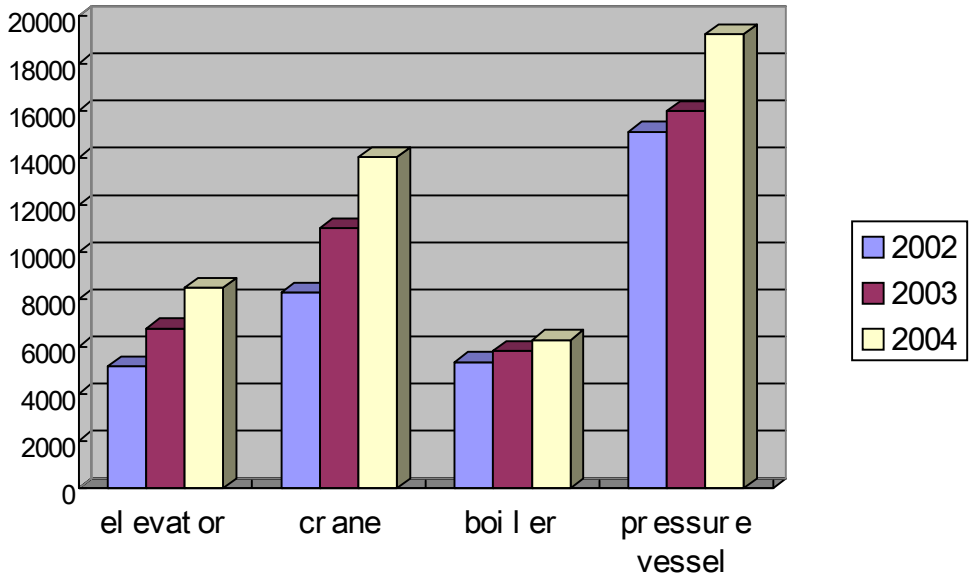
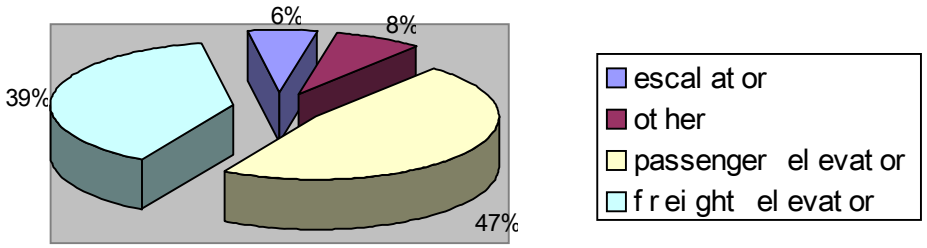


Figure 5-2：the Special equipments in Ningbo



By the end of 2004, the number of elevators used in Ningbo is 8488, mainly distributed high-rise residential buildings and office buildings. Nowadays, the annual increase in elevators is around 1500 for the expansion of the cities and the large number of high-rise residential development. There are the Components of Elevators in Ningbo (see the Figure 5-3).

Figure 5-3 the Components of Elevators in Ningbo



5.2.2 General Introduction of the Special equipments Accidents in China

According to statistics in 2004, there were 289 accidents of special equipments, including 12 extraordinary serious accidents involved more than three people, 277 major accidents. In those accidents, 235 people died, 379 people were injured, and direct economic loss was 30.9143 million Yuan (RMB). In 289 accidents, of which 159 were caused by accidents of boilers, pressure vessels and pressure pipes (hereinafter referred to Pressure Equipments), with 114 dead, 281 injured, and direct economic loss of 17.7963 million Yuan. Another 130 were caused by accident of elevators, cranes, motor vehicles, large entertainment facilities, and passenger ropeways (hereinafter referred to machinery and electronic equipment), with 121 dead, 98 injured and economic loss of 13.118 million Yuan. Accident rate of Pressure Equipment (excluding cylinders, pipes) is 0.35/10,000, and that of machinery and electronic equipments is 1.05 / 10,000. National statistics on equipment accidents in 2004 are shown in Table 5-3 (see appendix 9).

5.2.3 Analysis on Accidents and Main Reasons

First, 98 accidents, accounting for 33.9%, were caused by the quality of the equipments. Among which, four major accidents were caused by boilers; two extraordinary serious accidents and thirty-four major ones by self-made boilers; sixteen major ones by pressure vessels; two serious accidents by cylinders; three by pressure pipes; seventeen by elevators; nineteen by cranes; one by motor vehicles.

Second, ninety-eight accidents were due to irregular or improper operation, accounting for 33.9%. Among them, seven boilers major accidents; six self-made boilers major incidents; two pressure vessels extraordinary serious ones and fourteen serious; twelve cylinders serious accidents; four pressure pipelines serious accidents; twenty-five elevators serious ones; one crane extraordinary and nineteen major ones; six motor vehicles accidents; one entertainment facility accident; and one passenger ropeway accident.

Third, forty-seven accidents, accounting for 16.3%, resulted from hidden troubles undiscovered because of irregular or refusal to inspection. Among that, four boilers major accidents; one self-made boilers major incident; one pressure vessels extraordinary serious accident and five serious; one cylinders extraordinary serious and six major ones; one pressure pipelines extraordinary serious and seven major accidents; one elevator serious accident; one crane extraordinary and nineteen major ones; six motor vehicles accidents; two cranes extraordinary serious and seventeen major accidents; and one motor vehicle accident.

Fourth, thirty-one accidents, accounting for 10.7%, were due to failures of security annexes and security devices. Among them, eight serious ones were caused by boilers; one extraordinary serious and four major accidents by pressure vessels; nine major ones by elevators; two extraordinary serious and seven major accidents by cranes.

Fifth, twelve major accidents, accounting for 4.2%, were caused by inappropriate ways of storage management.

Compared with other countries, the rate of accident in China is higher. Many American states cities take ASME A17 as their standard. The rate of elevator accident in American approximately is one out of 1000 each year. For example, 70, 000 elevators in California, then approximately 50 – 100 accidents, most are minor ones; 54, 000 elevators in New York, 46 accidents in 1998, 48 in 1997, 36 in 1996.

5.3 Measures to Supervise Special Equipments Security by Government

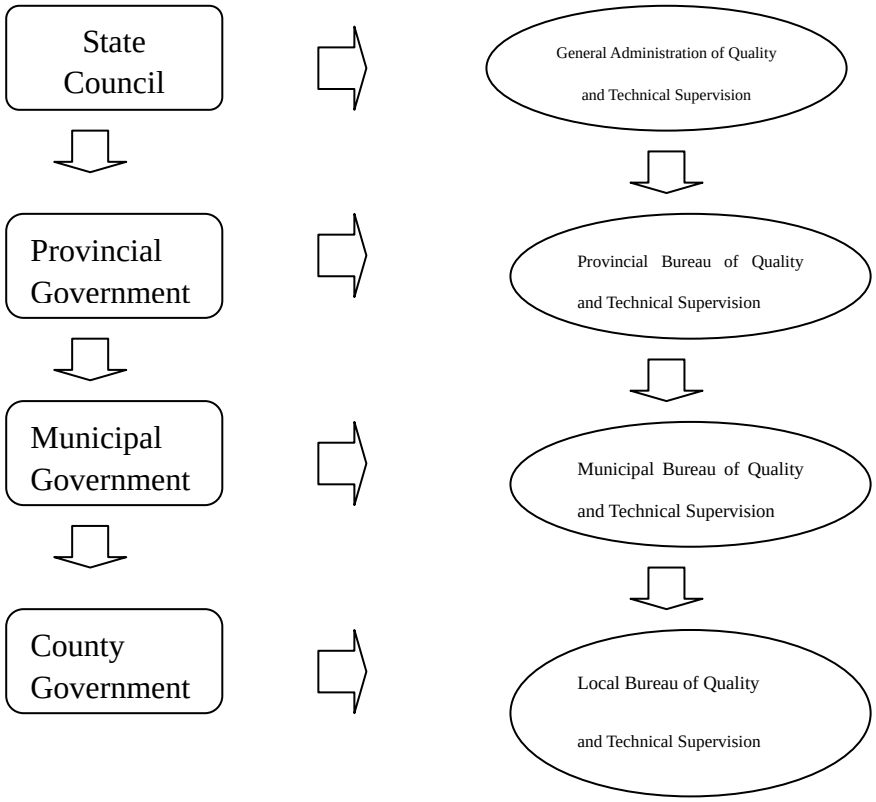
Effective supervision on special equipments has become necessary foundations to good economic and social development and to people's life and property safety. Safety supervision is an arduous task, and security responsibility is extremely heavy. It is governments' bounden duty at all levels to serve social economic construction and to ensure safety of social production and people's lives and property. *Law on Administrative permission* and *No.14 Decision* issued by the Chinese State Council, which both endue 11 administrative permissions to special equipments supervision and management departments, have fully demonstrated the importance of special equipments safety supervision. Governments supervise on the special equipments security through organization, operation, and information network system.

5.3.1 the Organization Network System

China's security supervision can be analyzed from various organizational levels:

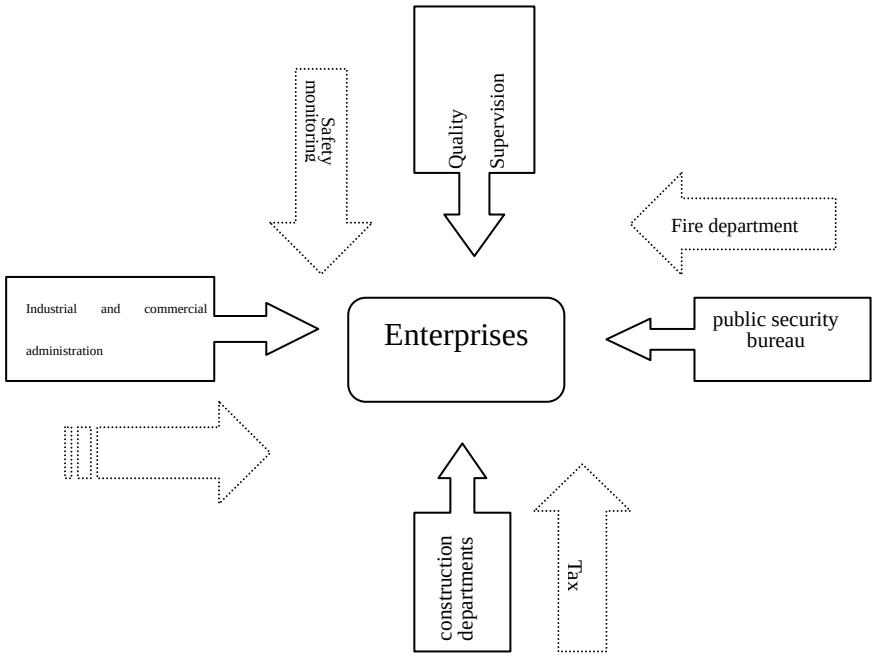
Government: State Council, provincial governments, municipal governments, county governments. The government management network is as following Figure 5-4.

Figure 5-4 : Government Management Network



Department Supervision: Quality supervision departments at all levels take charge of the special equipments safety supervision according to "production safety law" and "special equipments safety supervision regulations". Various production safety supervision and management departments, in accordance with the "production safety law", fulfill their comprehensive monitoring and management on local production safety. Industrial and commercial administration, public security bureau, construction departments, tourism departments and other sectors implement their duties by relevant laws and regulations in their respective functions to successfully carry out assignments on special equipments (see Figure 5-5).

Figure 5-5: Department Supervision System



Corporate Accountability: It is necessary to constitute special equipments safety administration policy, post safety responsibility policy and special equipments technical files among special equipments manufacture companies (including design, manufacture, installation, alteration, repair), use units and individuals. Manufacture companies should reach the approved manufacture standard, use units should achieve the safety request accordance with technology standards, and individual operators and management staff should get operation certificates passing examination. Corporations

of manufacture and use units, being regarded as the primary legal representatives, should bear corresponding legal liability. Enterprises should take initiative actions to form self-restraint mechanisms, and fulfill security management system and responsibilities completely.

Mass Supervision: Social forces (including mass and media) are important factors in special equipments safety supervision work. It is essential to actively motivate social forces, especially news media, to vigorously propagandize safety supervision, to popularize safety knowledge and to improve the safety awareness of the whole society. Meanwhile, quality technical supervision departments at all levels should be under the supervision of the masses by opening hotlines to promptly handle mass, should try to finance to found report reward fund.

5.3.2 the Operation Network System

First, to establish a sound monitoring network security at local levels. In urban subdistricts, communities, rural townships and large and medium-sized enterprises, it is necessary to employ assistants of special equipments safety supervision. Provincial quality inspection departments are responsible for the management documents and certificates, and appointment departments are charge of special training, certificates distribution and management.

Second, to effectively operate security-monitoring network. Building a responsibility system, in which various departments and agencies are involved with specific division of responsibilities. In their respective areas, departments and agencies coordinate with each other, timely report relevant statistical data, and earnestly fulfill all work to ensure the effective implementation of security monitoring network.

Third, to carry out supervision and inspection works. Departments and agencies inspect and supervise manufacture, operation, and inspection activities in conformity with legal provisions to promptly investigate and punish the activities violating the

law and discipline. And the inspection and supervision promote rise in registration, periodical inspection, and hidden dangers rectification of special equipments.

Fourth, to establish a system effectively monitoring major risks source. Departments and agencies identify local major hazard areas, and establish a job responsibility system to conduct regular supervision and inspection with key points.

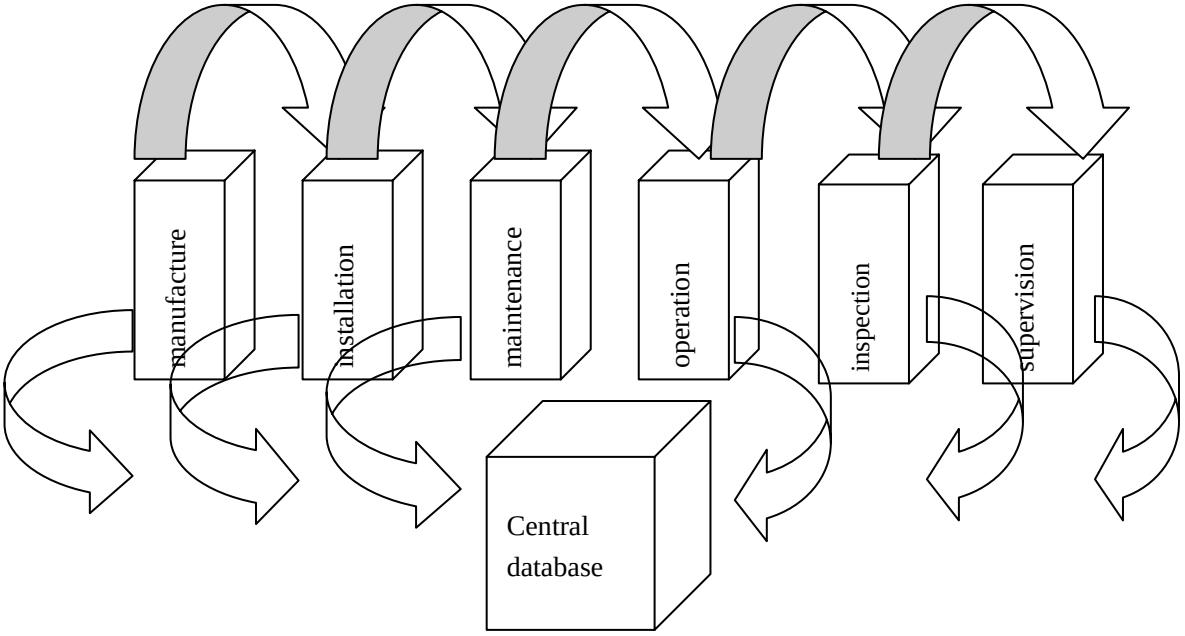
Fifth, to promptly deal with various accidents. Departments and agencies timely accept special equipments accidents reports, and get to the spot in time to coordinate relevant departments with their own suggestions for settlement, and report the situation to the leaderships in accordance with provisions.

5.3.3 the Information Network System

Information network is the foundation of dynamic security supervision whose operational effectiveness is determined by the method and accuracy of collected information. Due to special equipments quantity, location and distribution vary from time to time, the information of special equipments is dynamic data, which are collected from manufacture (design), installation, maintenance, operation, inspection, and supervision stages. As the varieties of information origins and standards, it has brought difficulty to collection and analysis of information, which result in poor accuracy and reliability of information. So, it is necessary to establish a unified standard for data collection and analysis, ensuring the effective operation of a central database.

Means to Collect Information：Data acquisition origins from manufacture (design), installation (repair, alteration), maintenance, operation, inspection and supervision, then gather into central database. See Figure 5-6.

Figure 5-6: Special Equipments Information Acquisition Means



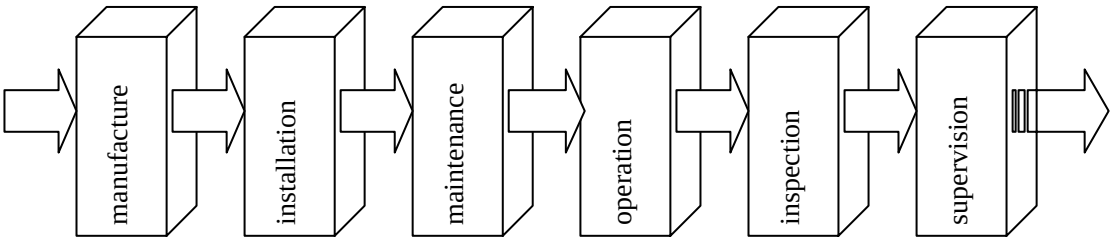
Means of Data-input：In terms of technological criterion and legal provisions, all units, relating to manufacture (design), installation (repair, alteration), maintenance, operation, inspection and supervision, and special equipments inspection agencies take charge of data-input that includes full and true data of manufacture, installation, operation record, alteration, maintenance, inspection, personnel assessment, spot inspection, administrative licensing, and administrative execution. Special equipments inspection agencies create special equipments database based on the technical information inputted during the periods of design appraisal, inspection and supervision on manufacture, installation, alteration, repair, and operation. These data are designed for various interfaces that make it convenient to provide information service for inspection agencies and most enterprises. On these provided information, agencies report special equipments dynamic security situation and data to local and upper governments who can understand security situation, find out hidden dangers and timely take effective measures to protect special equipments and operators safety.

Information Module：Information in special equipments central database is mainly

from seven categories of equipments: boilers, pressure vessels, pressure pipes, elevators, cranes, passenger ropeways, large entertainment facilities, and six stages: manufacture (design), installation, alteration, maintenance, operation, inspection.

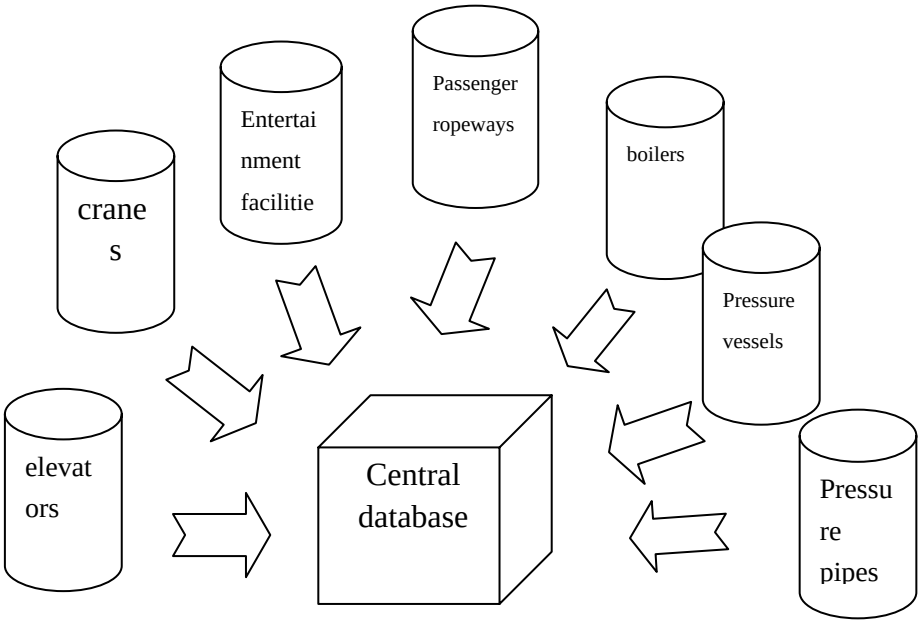
Flow Design to Information Transaction：Data in special equipments central database is processed according to seven categories and their six parts. First, in accordance with technological differences in boilers, pressure vessels, pressure pipes, elevators, cranes, passenger ropeways, large entertainment facilities, personnel design various corresponding data-input methods. Second, technicians gather all the data from these seven equipments in central database. Third, all the data must be driven from this unique central database, different data with different interfaces. See Figure 5-7.

Figure 5-7: Processing Procedure of Elevators Branch Database



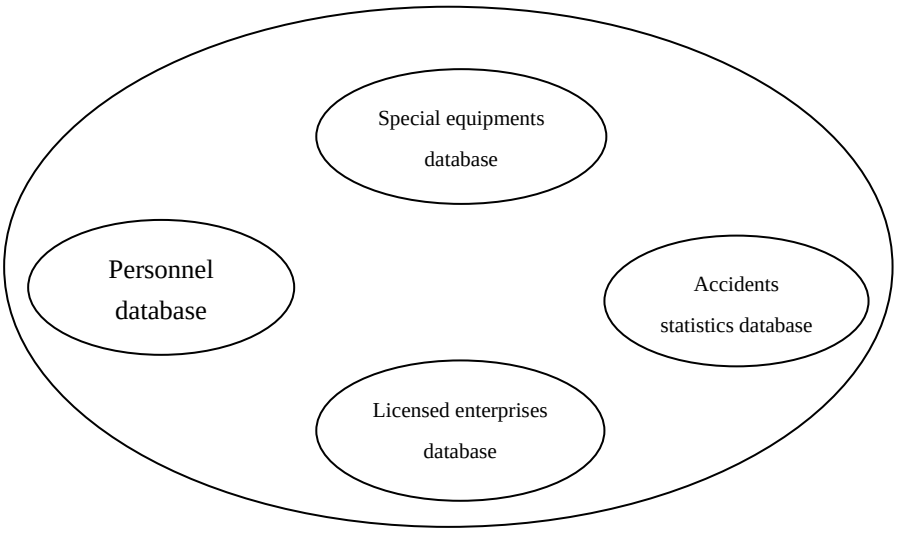
In the base of the branch databases of elevators, pressure vessels, pressure pipes, boilers, cranes, passenger ropeways, and large recreational facilities, technicians input branch data into the central database. See Figure 5-8.

Figure 5-8: Processing Procedure of Special Equipments Central Database



Computer System Foundation Construction: Quality and Technical Supervision departments and various special equipments inspection agencies, equipped with necessary computers and Internet connection hardware, create municipal unified special equipments central database to share data. Firstly, to create special equipments database. Special equipments agencies create a database to reflect the status of special equipments. Secondly, to create special equipments operators database. Departments build operators database, which include security supervisors, checkers, township assistants, managers, and operators citywide, to carry out dynamic management on certificated operators. Thirdly, to create special equipments safety licensed enterprises database. Departments establish the database including special equipments manufacture, installation, alteration, repair safety permission units, to provide a basis for a market access system. Fourthly, to create special equipments accidents statistics database. Agencies conduct a comprehensive analysis on causes of special equipments accidents to identify plots of effective measures to prevent the recurrence of similar incidents. Special equipments central data is shown in Figure 5-9.

Figure 5-9: Special Equipments central database



Information Distribution Network Construction: At first, departments gradually complete dynamic information network of special equipments with national and provincial quality and technical supervision departments, in accordance with national and provincial experiment need, and timely report to upper leaderships the information of central database of special equipments, quarterly and annual statistical reports, and accident information. And, second is to connect the government information site, providing government-oriented with scientific and accurate decision support, and society with information services. This helps to publicize special equipments laws, regulations and standards; to issue municipal special equipments dynamic information; to promulgate quality and technical supervision department's special equipments safety supervision function, work basis, procedures and specific requirements.

According to analysis above, the factors affecting the safety supervision stages include: legislation, information, organization and finance etc.

Chapter 6

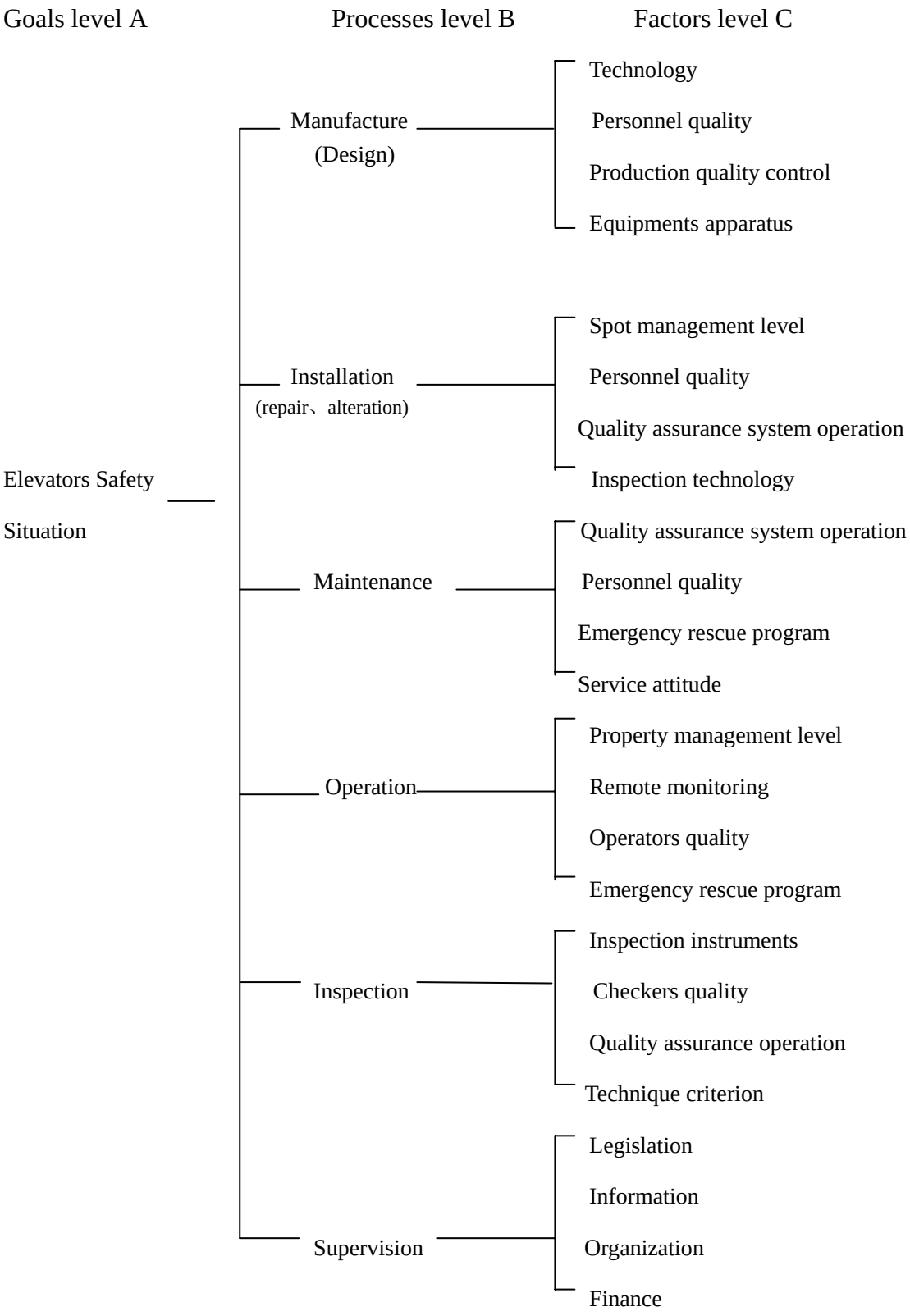
Assessment on Elevators Security by Fuzzy-AHP

This chapter presents the evaluation and calculation of the elevator security by Fuzzy-AHP. It's a case study on a passenger elevator in Ningbo, China.

6.1 Introduction

Fuzzy-AHP theory analyzes multilevel goals by Fuzzy mathematics and level analysis method to establish safety regulations and safety standards and to make assessment on security through Fuzzy mathematics. The reason why we take Fuzzy-AHP assessment method to evaluate elevators safety is on the grounds that: elevators safety index, featured with obvious hierarchical character, is as quantitative and qualitative as assessment factors. If only AHP, it will be quite hard to accurately descript qualitative factors. But the subjection functions and subjection degree of Fuzzy-AHP are set to describe qualitative or uncertain factors precisely. This is very suitable for safety assessment. Safety assessment is a comprehensively Fuzzy-AHP evaluation process. For the space limit, the whole evaluation process will only be divided into two levels. As the same reason, the sub-level here will be simplified. Hierarchical assessment structure takes elevators safety as goal level A, and builds a multi-level analysis constructer model (see Figure 6-1) by relevancies between processes level B and factors level C.

Figure 6-1: Elevators Safety Assessment Structure



6.2 Comprehensive Assessment on Primary Level

This paper is mainly on the evaluation of safety management. And the technology is a prerequisite for evaluation to reach the elevators safety inspection standards and specific technical issues will not be commented here.

The experts overall assess the relevant requirements of elevators safety and determine the weight distribution of evaluation factors and sub-factors (see Table 6-1).

Table 6-1 Comprehensive Grades from Experts

Goal	Elements	Weight distribution	Sub-elements	Weight distribution	Evaluation					Normalization
					V1	V2	V3	V4	V5	
Safety assess-ment	Manufacture (design)	0.18	Technology	0.28	2	6	2	0	0	(0.258，0.476，0.202，0.064，0)
			Personnel quality	0.20	3	5	1	1	0	
			Production quality	0.22	1	4	3	2	0	
			equipments	0.30	4	4	2	0	0	
	Installation (repair, alteration)	0.20	Scenery management	0.28	4	3	3	0	0	(0.316，0.372，0.244，0.068，0)
			Personnel quality	0.12	2	4	3	1	0	
			Quality assurance operation	0.28	3	4	1	2	0	
			Inspection technology	0.32	3	4	3	0	0	
	Maintenance	0.16	Quality assurance operation	0.26	4	4	2	0	0	(0.272，0.420，0.308， 0，0)
			Personnel quality	0.30	2	6	2	0	0	
			Emergency rescue	0.32	3	2	5	0	0	
			Service attitude	0.12	1	6	3	0	0	
	Operation	0.12	Property management	0.22	4	3	3	0	0	(0.248，0.246，0.472，0，0)
			Remote monitoring	0.34	2	2	5	1	0	
			Operators quality	0.32	1	2	7	0	0	
			Emergency program	0.12	5	4	1	0	0	

	Inspection	0.22	Apparatus	0.34	4	3	2	1	0	(0.394，0.418，0.154，0.034，0)
			Checkers quality	0.26	3	6	1	0	0	
			Quality assurance	0.20	4	5	1	0	0	
			Emergency program	0.20	5	3	2	0	0	
	Supervision	0.12	Legislation and execution	0.32	3	4	3	0	0	(0.384，0.400，0.196，0.020，0)
			Organization	0.30	4	4	2	0	0	
			Information	0.20	3	4	2	1	0	
			Finance	0.18	6	4	0	0	0	

6.2.1 Safety Assessment on Elevators Manufacture

First, to determine four factors affecting elevators manufacture (design) safety: They are marked: Technology progressiveness (U1), personnel qualities (U2), production quality control (U3), and equipments apparatus (U4); and there are five degrees of assessment: V={very good (V1), good (V2), usual (V3), bad (V4), very bad (V5)}.

Second, to determine the factors subjection: During the evaluation process, 10 experts are needed, who are advanced technicians and engineers, engaged in elevators manufacture, installation, maintenance, operation, inspection and supervision, having over ten years' working experience in elevators. These ten experts score detailed programs according to quality tracking and data checking on a residential elevator's various stages.

Here we take technicians as an example and there are three forms to evaluate technicians' qualities: (a) to ensure posts and amount of technicians qualified. (b) to test their knowledge of technology standards, laws and regulations. (c) to make a scene assessment on their abilities of solving practical technical problems.

From the Table 6-1, the number shows that three of ten evaluate personnel quality as V1, accounting for 30%; five V2, accounting for 50%; one V3, 10%; one V4, 10%; non V5. Then the subjection of personnel qualities is: r2 = (0.3,0.5,0.1,0.1,0). With

the same method, we can get the subjection of technology: r1 = (0.2，0.6，0.2,0,0); production quality control subjection: r3 = (0.1，0.4，0.3，0.2，0); equipments apparatus subjection: r4 = (0.4，0.4，0.2,0,0). And these four factors in elevators manufacture consist of the following assessment matrix:

$$\begin{pmatrix} 0.2 & 0.6 & 0.2 & 0 & 0 \\ 0.3 & 0.5 & 0.1 & 0.1 & 0 \\ 0.1 & 0.4 & 0.3 & 0.2 & 0 \\ 0.4 & 0.4 & 0.2 & 0 & 0 \end{pmatrix}$$

Third, to determine weight (see Appendix 11): Based on analysis on assessment factors of elevators manufacture (design), experts compare the safety level of factors affecting construction safety and make a comprehensive analysis on the comparison. Firstly, mathematic average method will be chosen to calculate experts' marks on various factors and find average value. Then, hierarchical assessment method will be adopted to validate whether the distribution of weight is reasonable, and calculate by computers and staffs to reach the weight of factors. As shown in Appendix 11, the weight of technology in elevators manufacture is 0.28; personnel quality, 0.20; production quality control, 0.22; and equipments apparatus, 0.30. All these weight must meet normalization, four numerical value of weight compose a fuzzy vector of factors unit U: A1 = (0.28　0.20　0.22　0.30). There comes comprehensive assessment on elevators manufacture (design) safety:

$$B1 = A1*R1 = (0.28\ 0.20\ 0.22\ 0.30) * \begin{pmatrix} 0.2 & 0.6 & 0.2 & 0 & 0 \\ 0.3 & 0.5 & 0.1 & 0.1 & 0 \\ 0.1 & 0.4 & 0.3 & 0.2 & 0 \\ 0.4 & 0.4 & 0.2 & 0 & 0 \end{pmatrix}$$

$$= (0.258 \quad 0.476 \quad 0.202 \quad 0.064 \quad 0)$$

This is evaluation result of normalization. If it is out of normalization, each result can

be divided by summation of evaluation results.

6.2.2 Safety Assessment on Elevators Installation

Since there exists many similarities between elevators installation (repair, alteration) and elevators manufacture (design), installation process is simplified here. Similarly, based on evaluation of experts on the four factors of installation, scenery management level, personnel quality, quality assurance operation, and inspection technology, evaluation, matrix and weights can be concluded as followed.

$$B2 = A2*R2 = (0.28 \quad 0.12 \quad 0.28 \quad 0.32) * \begin{pmatrix} 0.4 & 0.3 & 0.3 & 0 & 0 \\ 0.2 & 0.4 & 0.3 & 0.1 & 0 \\ 0.3 & 0.4 & 0.1 & 0.2 & 0 \\ 0.3 & 0.4 & 0.3 & 0 & 0 \end{pmatrix}$$

$$= (0.316 \; 0.372 \; 0.244 \; 0.068 \; 0)$$

6.2.3 Safety Assessment on Elevators Maintenance

Experts check maintenance records and daily failure records of the residential elevator, and read relevant data from the data records of remote monitoring. Similarly, it can be worked out as follows:

$$B3 = A3*R3 = (0.26 \quad 0.30 \quad 0.32 \quad 0.12) * \begin{pmatrix} 0.4 & 0.4 & 0.2 & 0 & 0 \\ 0.2 & 0.6 & 0.2 & 0 & 0 \\ 0.3 & 0.2 & 0.5 & 0 & 0 \\ 0.1 & 0.6 & 0.3 & 0 & 0 \end{pmatrix}$$

$$= (0.272 \; 0.420 \; 0.308 \; 0 \; 0)$$

6.2.4 Safety Assessment on Elevators Operation

The experts make the corresponding evaluation by reviewing the daily use records of the elevator, the property management regulations and inspection records, elevator fault records, maintenance records, safety training records and rehearsal records of emergency rescue plans, and by knowing the operation safety and management situation of the elevator daily use from management departments and users. With the same method, the result comes as follows:

$$B4 = A4*R4=(0.22 \quad 0.34 \quad 0.32 \quad 0.12) * \begin{pmatrix} 0.4 & 0.3 & 0.3 & 0 & 0 \\ 0.2 & 0.2 & 0.5 & 0.1 & 0 \\ 0.1 & 0.2 & 0.7 & 0 & 0 \\ 0.5 & 0.4 & 0.1 & 0 & 0 \end{pmatrix}$$

$$=(0.248\ 0.246\ 0.472\ 0\ 0)$$

6.2.5 Safety Assessment on Elevators Inspection

According to the first check situation and regular annual inspection records from Ningbo City special equipments inspection and testing center and the daily breakdowns and accidents records, experts get to know about the inspection of the elevator and evaluate inspection qualification, testing proof, equipments' standard, and checkers' qualities of the inspection agency. And here comes the result for the same method as above.

$$B5 = A5*R5=(0.34 \quad 0.26 \quad 0.20 \quad 0.20) * \begin{pmatrix} 0.4 & 0.3 & 0.2 & 0.1 & 0 \\ 0.3 & 0.6 & 0.1 & 0 & 0 \\ 0.4 & 0.5 & 0.1 & 0 & 0 \\ 0.5 & 0.3 & 0.2 & 0 & 0 \end{pmatrix}$$

$$=(0.394\ 0.418\ 0.154\ 0.034\ 0)$$

6.2.6 Safety Assessment on Elevators Supervision

Similarly, it can be concluded as follows:

$$B6 = A6*R6 = (0.32 \quad 0.30 \quad 0.20 \quad 0.18) * \begin{pmatrix} 0.3 & 0.4 & 0.3 & 0 & 0 \\ 0.4 & 0.4 & 0.2 & 0 & 0 \\ 0.3 & 0.4 & 0.2 & 0.1 & 0 \\ 0.6 & 0.4 & 0 & 0 & 0 \end{pmatrix}$$

$$= (0.384\ 0.400\ 0.196\ 0.020\ 0)$$

6.3 Illustration on Indicators Weight Distribution

Determining indicator weight is a difficult job, which requires experts survey method. Theses ten experts are experienced experts and the authorities in their own professions

respectively. For the determination of the weight, the experts think three assessment factors should be considered:

To solve the issue of comparability between various indicators.

To resolve accuracy and scientificity of quantification of qualitative indicators

To avoid the repeated indexes phenomenon.

Experts have overall made several adjustments and repeated summarizing to conclude the indicators weight distribution with quantitative method. After discussion, experts decide to take the most convenient method, arithmetic average method, one of weight distribution mathematical methods, as the first level project. And the sub-level, Hierarchical analysis method, is taken to prove he accuracy of arithmetic average method and to make timely adjustments as necessary. The calculation process of the weight sees appendix 10.

6.4 Comprehensive Assessment on Sub-level

Weight data of various processes as manufacture, installation, maintenance, operation, inspection, and supervision consist of a vague vector of elevators safety (see Table 6-1): *A*1*=（0.18，0.20，0.16，0.12, 0.22, 0.12）. Bi = Ai*Ri is the formula to reach comprehensive assessment results as following:

B1 = A1*R1 =（0.18，0.20，0.16，0.12, 0.22, 0.12）*

$$\begin{pmatrix} 0.258 & 0.476 & 0.202 & 0.064 & 0 \\ 0.316 & 0.372 & 0.244 & 0.068 & 0 \\ 0.272 & 0.420 & 0.308 & 0 & 0 \\ 0.248 & 0.246 & 0.472 & 0 & 0 \\ 0.394 & 0.418 & 0.154 & 0.034 & 0 \\ 0.384 & 0.400 & 0.196 & 0.020 & 0 \end{pmatrix}$$

= (0.31568 0.39676 0.24848 0.035 0)

Safety level of elevators safety comprehensive assessment is in Table 6-2.

Table 6-2: safety grade of elevators safety comprehensive assessment

Grade	V1	V2	V3	V4	V5
ratio	1—0.90	0.89—0.70	0.69—0.50	0.49—0.30	0.29—0

The above assessment results: *B*1、*B*2、*B*3、B4、B5 and B6, is a level vague subset, namely *Bi**=（*b*1，*b*2，　，*b*5）. To make best use of the information from *B**，the rule of most subjection is not adopted to achieve *Vj* , corresponding level of maximal *bj*, as assessment result, but to take parameter vectors, *C*=（*c*1，*c*2，*c*3，*c*4，*c*5）*T*=（1，0.8，0.6，0.4，0.2，0）*T*, of various *Vj* in remark level. Therefore, it comes：

U i= *C* **Bi* *=（*c*1，*c*2，*c*3，*c*4，*c*5）*T* *(*b*1，*b*2，*b*3，*b*4，*b*5)

And the overall standardization ratios of elevators safety：

$$U1=(0.31568\ 0.39676\ 0.24848\ 0.035\ 0)*\begin{pmatrix}0.8\\0.6\\0.4\\0.2\end{pmatrix}=0.79617$$

similarly, standardization ratio of manufacture U1 is 0.7856.

U2 for installation is 0.7872.

U3 for maintenance is 0.7928.

U4 for operation is 0.7280.

U5 for inspection is 0.8344

U6 for supervision is 0.8296.

6.5 Summary

The assessment of each processes and the calculation by Fuzzy-AHP on the basis of the experts' evolution are presented. Because of the limitation of the pages, we illustrate them briefly and try to make it clearly and being understood.

Chapter 7

Conclusion

This chapter presents the conclusion of safety assessment of elevator, and points out the problems existing in some process. We try to make methods to deal with the problem and improve the management of the weak process.

7.1 Introduction

And the overall standardization ratio of elevators safety U is 0.79617. Similarly, standardization ratio of each process is U1 for manufacture 0.7856; U2 for installation 0.7872; U3 for maintenance 0.7928; U4 for operation 0.7280; U5 for inspection 0.8344; U6 for supervision 0.8296. The safety grade of elevators safety comprehensive assessment is shown in Table 6-1. All the six ratios are from 0.70 to 0.89 that within the safety grade of V2 which means good in the elevators safety comprehensive assessment.

7.2 Conclusion

Evaluation results show that the overall security situation of the elevator is good. The efficiency of safety management at the processes of manufacturing, installation, and maintenance is common. The processes of inspection and supervision are effectively controlled, having better safety management efficiency. And there exists some weak links at the process of operation, which require effective measures to raise the safety management of operation. Because risk factors are not under full control and there exists possibility of hidden dangers in operation developing into accidents.

7.3 Analysis on Reasons of Each Assessment Result

The manufacture, installation and maintenance companies' assessment results are similar as 0.7856, 0.7872 and 0.7928. They attach the technical standards of elevator

safety and the basic administration of safety in three processes. Why they control the safety management at that level is their consideration of the balance of cost and profit. The target of a company is to get more profit and pay less cost, if they pay more resources in the safety management, the cost will increase, as well as the profit will decrease. But they must reach the basic standards of safety either in technology or in management, because one of the important characters of elevator is safety .Safety of elevator means the goodwill of product and service in the market. If any accident happens because of the quality of their products or services, the company will lose their market under the competitive environment.

The ratios of inspection and supervision are 0.8344 and 0.8296, it is higher than others. As we have analyzed before, Chinese government has invested a lot of resources to improve the security administration and decrease the accidents of special equipments. Although it is really costly, the result is delightful.

The main problem of the process is operation whose ratio is 0.7280. It is near the lowest standard of Good, still exit the risk of unsafe elements in the daily management. After we search the data in the questionnaires the experts have evaluated on various aspects of operation process, we find that the main problem is as follows: firstly, the operators lack the necessary knowledge and safety ideology to use the elevator well enough. Because it is a passenger elevator in a social community, the people living in the building have various education and ages; the property management company of the community lack the experiences of elevator safety management and never tell the users of elevator the necessary knowledge and safety information. They have the regulation of safety management and the methods of emergency dealing in their documents but never to rehearse in practice.

7.4 Improvement of Operation Safety Management

The methods to solve the problem are as follows:

Firstly, the regulations and knowledge of elevator should be known by the people living in this community. And the rehearsing of elevator emergence also should be arranged by the property management company and the elevator maintenance company at least once every year to the public.

Secondly, the remote monitoring of this elevator should be performed by the elevator manufacture company efficiently instead of only showing on the computer as a name list picture and lacking the information system or the professional worker to deal with the emergencies of elevator.

Thirdly, the employees in the property management company should fulfill their safety management responsibilities to monitor the situation of elevator and protect the various users, avoiding the potential risk of accident happened.

Finally, the public rescue system should be connected closely the emergency rescue of elevator user as soon as possible to decrease the risks.

7.5 Summary

We calculate out the result of the safety assessment of the elevator and the situation of each process and find out the problem of operation safety management. To take the advantage of various resources to deal with the problem and improve the quality of management is important to achieve the persistent improvement.

Chapter 8

Foreground Analysis on the Security Administration

This chapter analyzes the security administration model of special equipments under different social circumstances of Sweden and Globalization regarding five social resources: government administration, market economy, information technology, education and regulation.

8.1 Introduction.

Through the case study of elevators, one of special equipments used in China, this article analyzes the factors affecting the safety of special equipments, and creates a special equipments safety administration model, and later analyzes the method of how to use various social resources by which security entities at different processes realize safety administration. Although such a safety administration need plenty of manpower, material，financial resources and cost a lot, it is really necessary to ensure the safety in special equipments at current stage of Chinese society.

This chapter begins analyzing five society factors: government administration, market economy, information technology, education and regulations, affecting on special equipments safe administration. And then we assume that this model is applied to the other stage of social development---- Sweden, a developed country. Comparing with present China's social development, Sweden is at a higher level of social development. And there exists significant difference once the special equipments safety administration model created above is applied in the Swedish social environment to analyze safety management situation in Sweden. We will illustrate the differences of safety management at two different social development stages to offer reference for the continued correction of Chinese safety administration. Finally, we assume that this model is applied to the environment of globalization and analyze the effect of society factors on the special equipments safety administration at six processes.

8.2 Comparison with the Different Effects on Security Administration between China and Sweden

8.2.1 General Introduction of Sweden

As a Northern European country located on the Scandinavian Peninsula, Sweden has a territory of 450, 000 square kilometers and a population of 8.7 million inhabitants. This is a developed, highly industrialized nation; a typical feature of the state is that rapid development of economy and social equity are both regarded as priority by Swedish government. It attained remarkable achievements in the 20th century leading to the well-known Swedish model. The Swedish model has three famous features. One is high level of social welfare democratic welfare system; second is high rates of tax, third is uniform standards based on equity and fairness.

Sweden has shown great importance to safety administration. According to the Work Environment Act, The Swedish Work Environment Authority is the administrative authority to reduce the risks of accidents at work. It contains the basic rules defining the powers of the supervisory authority, they are entitled on request to obtain the information and documents which they require for their supervisory activities (section 3). They are also entitled to obtain specimens and to have investigations carried out (Section 4). The Work Environment Authority can issue injunctions against any party not complying with these stipulations. As an ultimate resort, the Authority can request police assistance. That is to say, the task of the Work Environment Authority is to verify that the employer lives up to the stipulations made in the Work Environment Act and in the Provisions issued by the Authority itself. This verification is usually based on inspection.

8.2.2 Government Administration’s Effect on Security Administration

In Sweden, The Work Environment Authority must at all times pursue greater security under the regulations. One of important task of government administration is to supervise, all supervisory work employs three tools: inspection, regulatory work and information. For example, inspections in Sweden are carried out by inspectors

from the Work Environment Authority. 440 inspectors are stationed in 10 districts and between them carry out 38.000 inspections annually. Another important task of government is that of stimulating all interested parties in the sector to shoulder their responsibility and play an active part in work environment activities.

Administration in China is a comprehensive, nanny style, whereas macro management is prevailing in Sweden. Its uniformity of supervision and effective use of competence and resources in all activities promotes parties to toe the mark to ensure safety administration.

8.2.3 Market Economy's Effects on Security Administration

In a pure market economy all productive activities are privately owned, as opposed to being owned by the state (Hill Charles W.L, 2005). Not too long ago, Sweden was mixed economy that is between market economies and command economies, but extensive privatization has reduced state owner-ship of business (Hill Charles W.L, 2005). According to the Swedish Act, It is always the employer who is responsible for the operation being conducted in such a way that accidents are prevented. China has moved rapidly toward a market economy, but there are a lot of state owner-ship entities.

The economy in China, on its way to market economy, is featured with the majority state-owned enterprises, whose losses incurred by security reasons is equivalent to that of nation, therefore, the state must invest adequately in enterprises' security management. When the market economy is gradually improving with a rise in the proportion of private enterprises, the occurrence of one accident may lead to a private enterprise bankruptcy. The market economy requires managers to put safety and benefit in right place, thus the government could gradually withdraw from the specific safety management practices.

8.2.4 Education's Effects on Security Administration

Sweden attaches great importance to education. The idea that only education can make small countries as Sweden survives in the face of fierce competition of the international community has been deeply in their mind. Sweden, one of the countries carrying out compulsory earlier, is coming out top in universal education in Europe. Sweden fulfills the nine-year compulsory education, and though senior high school education is not compulsory, the rate of admission into higher schools has still reached 98%. And about 45% of high school graduates will enter universities. In addition, adult education is very developed in Sweden. According to the statistics survey of education in China, college and higher-level graduates account for only 3.6% of the total population. The Chinese universal educational level is relatively low.

The quality of residents has a significant impact on national security management. All six processes in the model are influenced by this factor. The higher the quality of people, the better the situation. It will be more helpful for people to enhance the safety consciousness, and master safety knowledge and safety skills, and this makes all behaviors meet the safety requirements, and reduce and remove artificial mistakes.

8.2.5 Information Technology's Effects on Security Administration

The Global Information Technology Report has become a valuable and unique benchmarking tool to determine national information and communications technology strengths and weaknesses. In the report of 2006, Sweden ranks 8^{th}, and China is 50^{th}. This shows that information technology has been in wider use in Sweden compared with China. In March 1994, Sweden has founded National IT Committee, which has done much to the spread and development of information technology. In March 2000, the submission of the proposal of universal

informatization to parliament defined Swedish goal of information technology development to be the first country of universal informatization. Swedish Internet users have accounted for 44.3% of the country's population, ranking first in the world in per capita ratio of the Internet. People could even communicate with the government departments at home through the network, for the extensive application of information technology.

The rapid development of information technology, especially the Internet, simplifies a lot of work procedures and also results in more smooth communicate. Under Swedish law, the government is entitled to collect and promulgate information that is net-linked, shared and speedy. The unimpeded of information brings great influence on the safety management. For example, causes of one accident can help the place with same problems quickly get corrected and substantially reduce accidents.

8.2.6 Regulations' Effects on Security Administration

There are a set of laws and regulations on safe administration both in China and Sweden, such as S*afe Production Act*, and *Supervision Regulations on Special equipments* in China，and *the Work Environment Act* in Sweden. By contrast, Swedish law and regulations have obvious characters: a) Renewal, amendment and amalgamation of Provisions. New knowledge concerning risks and changes make the development of Provisions an ongoing task. b) The Provisions are written by specialists. To maintain their specialist competence, they have to keep abreast of research and development in their respective fields, as well as keeping in close touch with the inspectors. c) Proposals are circulated for comment. When Provisions have been drafted, the draft version is circulated for comment to the labor market parties, industrial organizations, certain national authorities and others concerned. Generally a number of alterations are made to the draft version after this circulation process. They generally enter into force six months after adoption.

Regulations play an important role in safe administration. Regulations can standardize the behavior, correct those behaviors out of the safety, and punish those who violate the laws and disciplines, so as to attain the goal of safety. The features of Swedish treaties indicate that the treaty will continue to reflect the reality of the security risks. Amending the treaty is to enhance its pertinence and practicability, which will affect significantly reducing the repeatability of accidents.

8.3 Society Factors in the Age of Globalization Affects Safety Administration

The age of globalization is featured with the globalization of products, markets and the convergence of the rules. Under that situation, the society factors, such as the government administration, market economy, information technology, education and regulations, have a significant impact on safety administration. Now, this chapter will simply analyze the influence on the six processes of elevators from part of these social factors.

8.3.1 Society Factors Affect Manufacture Process

Market economy is a main influential society factor on the manufacture processes. Market economy demands enterprises compete under Globalization, it means that components and parts of elevators can be produced in large quantities in different countries, and security authentication synchronously has been primary requirement for products to enter into world market. An enterprise, enabling the large-scale production of components, can centralize more energy into improving the competition of research and development, the safe identity, and effective management to ensure products always at top level in the world and guarantee enterprises gain more market share and more profit.

8.3.2 Society Factors Affect Installation Process

Regulations and educations are the main influential society factors on the installation process. The convergence of regulations is a major characteristic of globalization.

Workers must be trained and managed according to uniform criterion to improve their techniques. Moreover，the globalization also provides an opportunity for high-level experts to communicate the advanced experience. Therefore, these two social resources play key roles in ensuring the security of installation process under globalization era.

8.3.3 Society Factors Affect Maintenance Process

Regulations and information technology are the main influential society factors on the maintenance process. For the differences in notions，different users in one country will have different request on elevators maintenance. So, uniform standard under globalization age has unitive binding to maintenance process. And in the era of globalization, computers and Internet are becoming more popular, which provides technical support for the creation of information reflection in maintenance process. The information, whether elevators are within maintenance period and problem records during maintenance, can be checked through network. Overall and standardized administration will ensure elevators more security.

8.3.4 Society Factors Affect Operation Process

Education and information technology are the main influential society factors on the operation process. The quality of users is the most significant factor and the users play most important role of safety issues. In the age of globalization, with the development of education, the users of elevators realize more the influence from elevators safety on the safety of themselves. Thus these users will self-consciously correct their insecure behaviors, require maintenances for the issues of operation, and demand property managers to deal with the hidden troubles in time. Furthermore, information technology provides a base for the creation of overall security operation system of elevators. Once it comes to emergencies, emergency rescue departments, management departments, and maintenance departments cooperate closely to minimize the losses of accidents.

8.3.5 Society Factors Affect Inspection Process

Regulations and information technology are the main influential society factors on the inspection process. Criterion is the evidence of inspection. In globalization era，uniform criterion units evidences of inspection. It is a way to take entrusted detection approaches to implement security administration. The advanced information technology units every part of the inspection process as a system. Detection part can be identified at any moment through network.

8.3.6 Society Factors Affect Supervision Process

Government administration and regulations are the main influential society factors on the supervision process. Globalization demands more for the adaptability of security codes, and requires government weakness in administrational function. Currently, there are several leading standards of elevators as followings: the standards of EU, United States and Japan. The standards of China are based primarily on the basis of EU standards. Under globalization era, these regulations will also be standardized. Government administration of safety is only on the basis of regulations.

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Appendix 1:

Questionnaire 1: **the Weight of Security Administrational Processes of Elevator**

Target	Processes	Degree of Importance (total 100%)
Safety	Manufacture(design)	
	Installation(alteration, repair)	
	Maintenance	
	Operation	
	Inspection	
	Supervision	

Appendix 2:

Questionnaire 1: **影响电梯安全管理过程的权重分布调查问卷**

总体目标	电梯安全管理过程	因素的权重分布
电梯的整体安全性	设计和制造	
	安装、维修、改造	
	保养	
	使用	
	检验	
	监察	

注：请每位专家对电梯安全管理的六个过程确定权重分配，权重相加应为 100%。

Appendix 3:

Questionnaire 2(English version):

Main Factors Affecting Elevators Safety Assessment

Goal	Administration process	Factors	Selected Factors
Safety	Manufacture (design)	Management level	
		Personnel quality	
		Technology	
		Production quality	
		R & D investment	
		Equipments	
	Installation (repair, alteration)	Scenery management	
		Inspection technology	
		Inspection equipments	
		Personnel quality	
		Technique criterion	
		Quality assurance operation	
	Maintenance	Quality assurance operation	
		Personnel quality	
		Technique criterion	
		Emergency rescue	
		Service attitude	
		Information system	
	Operation	Accidents rate	
		Personnel quality	
		Technique criterion	
		Emergency rescue	
		Remote monitoring	
		Property management	
	Inspection	Checkers quality	
		Quality assurance	
		Technique criterion	
		Apparatus	
		Information system	
		Management level	
	Supervision	Legislation and execution	
		Organization	
		Management level	
		Personnel quality	
		Finance	
		Information system	

Appendix 4:

Questionnaire 2: **影响电梯安全管理各环节的主要因素调查问卷**

总体目标	电梯监察过程	影响的因素	选择主要因素
电梯的整体安全性	设计和制造	企业的管理水平	
		设计制造人员的素质	
		技术的先进性	
		生产质量控制	
		研发及生产经费投入	
		设备仪器投入	
	安装、维修、改造	现场管理水平	
		检验技术水平	
		检测设备的先进性	
		人员的素质	
		安全技术规范与标准	
		质保体系运作	
	保养	质保体系运作	
		人员的素质	
		安全技术规范	
		应急救护措施	
		服务态度	
		信息反馈机制	
	使用	故障发生率	
		人员的素质	
		安全技术规范	
		应急救护预案	
		远程监控	
		物业的管理水平	

电梯的整体安全性	检验	质保体系	
		人员的素质	
		安全技术规范	
		检验设备的先进性	
		信息反馈机制	
		检验的管理水平	
	监察	法规规章制定与执行	
		机构与人员	
		管理水平	
		人员的素质	
		财政投入	
		信息的沟通	

注：请每位专家在确定的六个影响因素中选定四个主要因素。

Appendix 5:

Questionnaire 3: **Weight Distribution of Factors of Elevators Safety Assessment**

(English version)

Goal	Administration process	Factors	Selected Factors
Safety	Manufacture (design)	Equipments	
		Personnel quality	
		Technology	
		Production quality	
	Installation (repair, alteration)	Scenery management	
		Inspection technology	
		Quality assurance operation	
		Personnel quality	
	Maintenance	Quality assurance operation	
		Personnel quality	
		Service attitude	
		Emergency rescue	
	Operation	Personnel quality	
		Emergency rescue	
		Remote monitoring	
		Property management	
	Inspection	Checkers quality	
		Quality assurance	
		Technique criterion	
		Apparatus	
	Supervision	Legislation and execution	
		Organization	
		Finance	
		Information system	

Appendix 6:

Questionnaire 3: **电梯安全管理环节主要因素权重分配调查问卷**

总体目标	电梯监察过程	影响的因素	每个选择因素的权重分布
电梯的整体安全性	设计和制造	技术先进性	
		人员的素质	
		生产质量控制	
		设备仪器投入	
	安装、维修、改造	现场管理水平	
		人员的素质	
		质保体系运作	
		检验技术水平	
	保养	质保体系运作	
		人员的素质	
		应急救援	
		服务态度	
电梯的整体安全性	使用	物业的管理水平	
		人员的素质	
		远程监控	
		应急救护预案	
	检验	检验设备的先进性	
		人员的素质	
		安全技术规范	
		质保体系	
	监察	立法与执行	
		机构与人员	
		财政投入	
		信息的沟通	

注：对选定的四个主要因素确定权重分配，四个因素的权重相加应为 100%。

Appendix 7:

Questionnaire 4(English version): **Elevators Safety Evaluation**

Goal	Processes	Factors	Evaluation				
			V1	V2	V3	V4	V5
Safety	Manufacture (design)	Technology					
		Personnel quality					
		Production quality					
		Equipments					
	Installation (repair, alteration)	Scenery management					
		Personnel quality					
		Quality assurance Operation					
		Inspection technology					
	Maintenance	Quality assurance Operation					
		Personnel quality					
		Emergency rescue					
		Service attitude					
	Operation	Property management					
		Remote monitoring					
		Operators quality					
		Emergency program					
	Inspection	Apparatus					
		Checkers quality					
		Quality assurance					
		Technique criterion					
	Supervision	Legislation and Execution					
		Organization					
		Information					
		Finance					

Appendix 8:

Questionnaire 4: **电梯安全评价表**

目标	评价因素	评价子因素	评价情况				
			好	较好	一般	较差	差
	制造（设计）	技术先进性					
		人员素质					
		生产质量控制					
		设备仪器投入					
	安装（改造、维修）	现场管理水平					
		人员素质					
		质保体系运作					
		检验技术水平					
	保养	质保体系运作					
安全		人员素质					
		应急救援					
		服务态度					
	使用	物业管理水平					
		远程监控					
		使用人员素质					
		应急救援预案					
	检验	检测仪器					
		人员素质					
		质保体系					
		应急救援预案					
	监察	立法与执法					
		机构和人员					
		信息沟通					
		财政投入					

Appendix 9:

Table 5-3: Special Equipments Accidents in China

Special equipments	Year	Total accident	Extraordinary accident	Serious accident	Death	Wounded	Economic loss (0000)
Boiler	2004	23	0	23	12	38	125.45
Self-made boiler	2003	35	1	34	20	32	218.2
	Ratio	23%	100%	21%	50%	81%	-59%
	2004	43	2	41	30	58	88.8
Pressure vessel	2003	40	2	38	38	55	86.6
	Rate	13%	100%	8%	0%	27%	1186%
	2004	45	4	41	38	70	1113.28
Cylinder	2003	30	0	30	23	41	380.1
	Rate	10%	0	7%	-17%	63%	-58%
	2004	33	1	32	19	87	158.8
Pressure pipe	2003	36	2	34	28	91	178.1
	Rate	-58%	-50%	-59%	-46%	-69%	65%
	2004	15	1	14	15	28	293.3
Elevator	2003	16	4	12	33	33	102.9
	Rate	231%	-100%	342%	18%	-45%	30%
	2004	53	0	53	39	18	133.8
Crane	2003	52	1	51	46	10	200.6
	Rate	-15%	0	-15%	-13%	60%	236%
	2004	44	1	43	40	16	673.5
Housing crane	2003	125	10	115	146	106	1270.4
	Rate	-81.6%	-70%	-82%	-77%	-43%	-65%
	2004	23	3	20	34	60	441.7

Motor vehicles	2003	0	0	0	0	0	0
	Rate	0	0	0	0	0	0
	2004	8	0	8	7	3	47.8
Entertainment facility	2003	15	0	15	16	1	115.5
	Rate	-93%	0	-93%	-100%	0	-96%
	2004	1	0	1	0	1	5
Passenger ropeway	2003	3	0	3	1	3	0
	Rate	-67%	0	-67%	-100%	-100%	0
	2004	1	0	1	1	0	10
General comparison	2003	0	0	0	0	0	0
	Rate	0	0	0	0	0	0
	2004	289	12	277	235	379	3091.43

(Note: Since incomplete data of boilers, automobile plant in 2003, that makes some comparative data and the general comparison impossible).

Appendix 10:

the Calculation Process of Weight

The 10 experts were invited to evaluate the above three factors, by their importance order, with respective score 3,2,1. The sum of scores on each factor made by experts is the final score for each factor. The final score of each factor is divided by the sum of final scores for the three factors, namely, that is the weight of each factor on the evaluation factors. Actually, weight distribution is an implicit expression of technology management on knowledge and experience. But the experts could not give explicit solution to the weight distribution process. In fact, the weight distribution process of experts shows their rich work experience and abundant profession knowledge. The following collection is experts' scores and weight of each factor. See Table 6-2.

Table 6-2：Experts' Scores

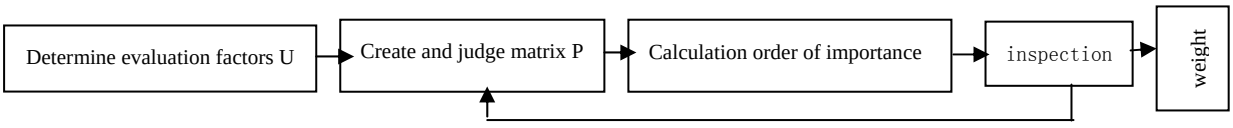
Factor	E1	E2	E 3	E 4	E 5	E 6	E 7	E 8	E 9	E10	Result
U1	2	3	3	2	2	1	3	2	3	1	0.36
U2	1	2	1	1	3	2	2	3	1	2	0.30
U3	3	1	2	3	1	3	1	1	2	3	0.34

To validate the accuracy of first level method, the sub-level, hierarchical analysis method, is taken. When necessary, the adjustment of the relevant data will make weight distribution more reasonable.

Here to introduce hierarchical analysis method. The process of identifying weight of three factors: a) to determine the evaluation factor unit: U, consisted of U1, U2, U3; b) to identify one objective as evaluation target A, determine relative importance of three factors and construct matrix P (called A-U matrix); c) to calculate the order of

importance. By matrix A-U, corresponding eigenvectors can be calculated through latent root calculation method. And those eigenvectors are the importance weights of all evaluation factors. D) to make a further verification on the importance weight, and adjust if necessary, then recheck till it reaching a reasonable range. See Figure 6-1: verification process.

Figure 6-1：Verification Process



Here is the detailed calculation process：

Step one：Determine evaluation factors U：

U=（U1，U2，U3），

Step two：Create and judge matrix P：

Take A as a goal；u_i as evaluation factor; u_{ij} as relevant importance of u_i to u_j，（I=1,2,……n; j=1,2……n），u_i can be marked according to the Table 6-3.

Table 6-3 Relevant Importance Mark

mark	Content
1	Means u_i as important as u_j.
3	Means u_i importance than u_j.
5	Means u_i more importance than u_j.
7	Means u_i much more important than u_j.
9	Means u_i absolutely more important than u_j.
2，4，6，8	If mark needs being subdivided, 2，4，6，and 8 can be inserted between 1，3，5，7，9.
Reciprocal	Means getting u_{ij} when comparison happened between u_i and u_j. Means getting $u_{ji}=1/u_{ij}$ when comparison between u_j and u_i.

Taking U1 as a comparison object，to determine U21、U31；

Taking U2 as a comparison object，to determine U12、U32；

Taking U3 as a comparison object，to determine U13、U23；

Based on the meaning of above symbols，it can be conclude matrix P，also named matrix A-U. Then,

$$P=\begin{pmatrix} U11 & U12 & U13 \\ U21 & U22 & U23 \\ U31 & U32 & U33 \end{pmatrix}$$

Step three: Determine the importance order of calculation.

On matrix A-U, corresponding eigenvectors can be calculated through latent root calculation method and these eigenvectors are the importance weights of all evaluation factors. Calculation method of Matrix A-U is as following:

a．to calculate product of factors in each line of matrix

$M_i=\prod_{j=1}^{n}u_{ij}$，（$i$，$j$=1，2，……$n$）

b．to calculate nth root of $M_i:\overline{W_i}$

$\overline{W_i}=\sqrt[n]{M_i}$

c．to normalize vector $\overline{W}=\left[\overline{W_1},\overline{W_2},\ldots\overline{W_n}\right]^T$

$$W_i=\overline{W_i}\Big/\sum_{j=1}^{n}\overline{W_j}$$

then $W=(W_1,W_2,\ldots,W_n)^T$ being eigenvector of Matrix A-U.

d．to calculate most latent root: $\lambda_{\max}$

$$\lambda_{\max}=\sum_{i=1}^{n}\frac{(PW)_i}{nW_i}=\frac{1}{n}\sum_{i=1}^{n}\frac{(PW)_i}{W_i}$$

$(PW)_i$ means ith element of PW.

$$PW = \begin{pmatrix} (PW)1 \\ (PW)2 \\ \bullet \\ (PW)i \end{pmatrix} = \begin{pmatrix} u11 & u12 & \cdots u1n \\ u21 & u22 & \cdots u2n \\ & \cdot & \\ un1 & un2 & \cdots unn \end{pmatrix} * \begin{pmatrix} W1 \\ W2 \\ \cdot \\ Wi \end{pmatrix}$$

Step four：Verification

The above eigenvectors are weight, which will be verified whether they are reasonable or not. The test formula, CR=CI/RI, can be taken to test consistency of matrix. CR is called random consistency ratio of matrix.

CI, named ecumenic coincidence indicator, is calculated as follows：

$$CI=\frac{1}{n-1}(\lambda_{max}-n)$$

RI is average coincidence indicator of matrix. See Table 6-4.

Table 6-4：Average coincidence indicator of matrix

N	1	2	3	4	5	6	7	8	9
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45

If CR<0.1, then it means matrix satisfaction coincident.

Verification process is as following：

First, based on the analysis of scores made by 10 experts, the importance of U1 to U2 is 1，U1 to U3 is 3，U2 to U3 is 5，then the matrix is：

$$P=\begin{Bmatrix} 1, 1, 3 \\ 1, 1, 5 \\ \frac{1}{3}, \frac{1}{5}, 1 \end{Bmatrix}$$

Eigenvector $\{1.442，1.710，0.405\}^T$ is normalized to get normalized eigenvector: $W=\{0.405,0.481,0.114\}^T$

$$PW = \begin{Bmatrix} 1, 1, 3 \\ 1, 1, 5 \\ \frac{1}{3}, \frac{1}{5}, 1 \end{Bmatrix} * \{0.405, 0.481, 0.114\}^T = \{1.228, 1.456, 0.345\}^T$$

λ_{max} = (1.228/0.405+1.456/0.481+0.345/0.114)/3 = 3.028

Following the above method, the other results are: λ_{max} =3.028 with its eigenvector {0.405，0.481，0.114}， CI=$\frac{1}{n-1}(\lambda_{max} - n)$ =0.014<0.1 means matrix satisfaction coincident.

Second, weight analysis on sub-level factors. U1 is an example and similarly, matrix is concluded：

$$P = \begin{Bmatrix} 1, 1, 3, 5 \\ 1, 1, 5, 3 \\ \frac{1}{3}, \frac{1}{5}, 1, 3 \\ \frac{1}{5}, \frac{1}{3}, \frac{1}{3}, 1 \end{Bmatrix}$$

Based on the above method, the result can be drawn：λ_{max} =4.2213，among which eigenvector is{0.394，0.394，0.134，0.078}，CI=0.074<0.1，means matrix satisfaction coincident.

The remaining parts can be calculated with the above method. If the result is CI>0.1, it is necessary to adjust the importance of evaluation factors. Professionals are invited to work out the corresponding program to make calculation more convenient and efficient. Experts firstly adjust the importance parameters, secondly computers calculate it and finally the program does not end until the result brings CI<0.1.

Conclusion: The weight of three evaluation factors calculated with hierarchical analysis method is basically coincident with the result of mathematic average method.