Ranking the Social-impact Factors for Major Security Emergency of Oil and Gas Pipelines in Urban

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***Abstract*—Oil and gas pipelines are the lifeline of the national economy. However, statistical data shows that oil and gas pipelines are high potentiality of dangers in urban areas, which usually bring disastrous consequences to the city. People should not only take measures to reduce the possibility of major security emergencies from occurring, but also should try to improve the controllability of the social-impact of security emergencies.**

Hence, the purpose of this study is to explore the social-impact factors of oil and gas pipeline security emergencies in urban areas. By employing the Analytic Hierarchy Process (AHP) approach, this study ranks the relevant factors, and then puts forward the control strategies to reduce the social-impact. The result shows that the factors have different weights. Factors ranking can improve the speed and quality of decision-making, therefore strengthening emergency management by providing quicker feedback to security control center; thus reducing the social-impact diffusion and potential disaster losses. In addition, it can provide a reference for the construction of the control mechanism or integrated information platform of security emergency for public administration departments, oil and gas production enterprises and other social organizations.

I. INTRODUCTION

In recent years security emergencies caused serious consequences to the safety and health of daily civilian life. Therefore, safety and security has become the focus of attention of different governments, research institutions, social groups and ordinary people at all levels. As the main artery of modern industry and city life, oil and gas pipelines are the lifeline of the national economy. However, a growing number of oil and gas pipelines are laid underground or beneath residential buildings, passing through broad regions, and the laying environment is very complex; moreover, the flammable and explosive substances flowing through the pipelines are under high pressure, making pipelines a potentiality for disaster. This is especially dangerous in densely populated urban areas characterized by wide infrastructure developments and large scale of housings. Any leakage, combustion or explosion of oil or gas presents a great threat to the people in the area, with disastrous consequences. Since oil and gas products are stored on non-closed ground facilities and transported in long distances by pipelines with insufficient security protection measures, we are often exposed to various risky situations [1].

The Bhopal disaster in 1984, the Piper Alpha disaster in 1988[2], and the BP Texas City refinery disaster in 2005[3] are painful reminders of the potential consequences. Unfortunately, many accidents still have occurred in oil and gas industry because of human error [3]. For instance, the BP Macondo exploration well suddenly exploded on April 20, 2010, 11 workers died and the explosion caused a massive oil spill into the Gulf of Mexico [4]. Several other accidents have occurred in recent years, such as the GAIL Andhra Pradesh gas pipeline explosion, Taiwan Kaohsiung gas explosion, and Sinopec Qingdao oil pipeline explosion. At least 44 people were killed and 166 others injured in the Qingdao explosion. There is obviously a necessity to strengthen the prevention and control of disastrous accidents in the operation process of oil and gas pipelines.

Although scholars are working hard to study and explore more effective security management measures, however, the unpredictability of the natural, technical or artificial factors, in particular, the operational anomalies of human beings are inevitable in high risk environments [5]. Of Course, it is impossible to completely avoid security incidents, and there is no place where it is absolutely safe at any time. In addition, a general security emergency of oil and gas at the beginning usually occurs only in the local area, which has a limited impact on society. However, due to improper security management, untimely emergency response, distorted and exaggerated reports from the media, or other reasons, the general security emergency can become a major security emergency, which is likely to escalate further [6]. Therefore, it is very necessary to explore a quick response mechanism and some treatment methods after an emergency occurs, and study the influencing factors of emergency spread and consequence, as well as the diffusion model of its social-impact, thereby reduce the vulnerability of the object-affected, and enhance the ability of emergency response system. This way, once a security emergency of oil and gas pipelines occurs in urban areas, emergency response organization is able to take a quick response mechanism and input response resources to give a positive response, in order to reduce casualties, economic losses and environmental damages to the minimum. This study is mainly to explore the factors affecting the social-impact of security emergencies and rank these factors, then put forward the control strategies. The results can provide a valuable reference for the development of integrated information platform on security management and the construction of security emergency control mechanism for public administration departments, oil and gas production enterprises and other social organizations.

Following this introduction, this article has the following structure. Section 2 is literature review that provides the theoretical fundament for support of this study; Section 3 states methodology; Section 4 presents data analysis, the results and discussion; Section 5 provides conclusions and offers relevant suggestions for enterprises, public sector, and universities and research institutions.

II. THEORETICAL BACKGROUD

A. Emergency and Safety Management of Oil & Gas Fields

The safety of oil and gas pipelines is one of the key areas of safety management. Haque[7] investigated the most-hazard prone areas in the world, including East and South Asia, and the Pacific Islands, and substantiated the fact that many variables (socio-economic and demographic) have a significant impact on disaster-related deaths and injuries in those regions. During the recent decades, many countries in Asia, Africa, and Latin America experienced rapid economic growth, but coincided with a trend of considerable increase in deaths and injuries [8]. Over the past few years, a number of oil and gas explosions occurred, and these further aroused everyone's attention to safety production or safety management. Therefore, the current challenge to the oil and gas industry is to implement risk mitigation activities, e.g., safety management and environment protection[9]. Of course, safety management should be based on the assumption that the circumstances producing major accidents can, in a certain extent, be predicted and controlled[10].

"Emergency" is a relative time-space conjuncture, the state of danger or a situation requiring serious immediate attention, and how the attention is given largely depends upon coping capacity of a system[11]. Pat Lagadec[12]further pointed out that ability to deal with crisis largely depends on the structures that have been developed before the crisis. The purpose of safety management is to control risks and maintain an acceptable level of safety throughout the life-cycle of an organization. However, the term "safety management" has no clear-cut definition, OECD[13]and Kettunen et al.[14]thought that safety management is a concept describing the systematic management processes dealing with organization safety, this is the relatively consistent point of view. That is to say, safety management usually stands for a series of activities to control a particular hazardous operation or process, and is an integration of all elements, functions and processes of an organization that might directly or indirectly affect its safety[14].

Over the last decade, due to a combination of organizational, technical, and cultural deficiencies, a number of unprecedented process incidents occurred in the process sector, therefore Process Safety Management (PSM) has become a subject of great interest for enterprises, governments, and professional associations. Indeed, a review of the literature reveals that PSM issues focus on the following, such as organizational safety culture, PSM performance measurement, employee training, and knowledge management, and so on[2]. In terms of safety management measures, Rizwan M et al.[15]regarded a Permit-To-Work (PTW) system as a key component of an oil and gas company's safety management system, for the PTW system ensures that every work is planned and carried out in a safe manner, and proven that PTW system is a best-practice method to ensure safety on dangerous worksites. In addition, PSM also is a systematic approach to major security emergency management, and is widely used in oil and gas industry[4].

In safety management, it is very important to create a good safety culture. One of the key elements of a good safety culture is the perceived risk, which refers to people' s beliefs, attitudes, judgments and feelings about unsafe situation, within the wider context of social and cultural values. Furthermore, good emergency response measures have a significant impact on the personnel's perception of risk[16]. Mearns K and Flin R[17]explored and pointed out that some social and cognitive factors would contribute to safe/unsafe behavior in hazardous work environments. For this purpose, BP had presented a challenging goal of "no accidents, no harm to people" in recent years and had achieved encouraging results in personal safety performance[4].

In industrial safety management, the risk (R) is most commonly assumed as a function of the probability of occurrence (p) and the severity of the potential damage (s) caused by a given hazard, R=f(p, s). Effective safety management depends on how the risk involved in organization's activities is assessed and how related decisions to reduce and control such risk are taken[18]. Of course, there is no such thing as zero risk. Therefore, the available proven approaches are to actively reduce both the probability of occurrence and the scale of consequence. One approach is to construct robust comprehensive Safety Management Systems (SMS) that contain prevention, reduction, control, and mitigation, being based on thorough life-cycle risk assessment [19]. Rizwan M et al.[15] held the same opinion, and put forward Job Hazard Analysis (JHA), which is the process of identifying and correcting the hazards or potential accidents in each step of a process or operation.

In order to strengthen safety management of oil and gas, not only should the industry have seamless awareness on possible emergency situations, but the storing and transporting infrastructures must also maintain a high level of security conditions to effectively deter any threats and risks[20]. Moreover, owing to the fact that petroleum products are highly flammable and explosive, oil and gas facilities become potential targets for terrorists and some disgruntled employees[1].For example, in 2012, a LNG cargo vessel also became a major target of pirate attack off the coast of Oman[21]. In short, the oil and gas industry must build a specific control systems to ensure a high reliability of operation, since any tiny mistake can lead to serious and costly security accidents or disasters[22].

B. Vulnerability and its Mitigation

Vulnerability management is a new perspective to from which to study the security emergency management of oil and gas fields. Vulnerability is one of the important concepts in security or disaster management, it refers to the possible losses caused by an accident or a disaster, and it reflects the sensitivity of the object-affected to the damage or disaster losses. Vulnerability was primarily focused on the study in the field of geology, at present, it is more and more applied in the research of Environment, Health, Safety (EHS) problem. Evaluating the vulnerability of object-affected and further reducing their vulnerability is key in the related research. The occurrence of emergency is determined by the vulnerability of the object-affected and the inducing factors in the environment. Environmental neglect and destruction for the sake of socio-economic development has increased various inducing factors, resulting in a variety of frequently occurring major emergencies. Although the theoretical research and practical exploration in regional disaster reduction, urban public security and other fields have been significantly increased, there is still great room for improvement for the basic research on major security emergency, especially the study on vulnerability that is the essential factors affecting the social-impact diffusion of emergency. Because the vulnerability of object-affected and the human factors have a great relation, moreover human factors, in essence, are the imbalance between people and environment, this imbalance can be improved to a great extent by management activities, therefore, the study on the vulnerability management of object-affected has great significances to the security management of oil and gas pipelines.

Gabor T and Griffith T K[23] early gave “vulnerability” a complete definition, they considered that vulnerability refers to the threat to not only the properties and the ecological situation of a community, but also the general state of emergency preparedness at any given point. However, until now vulnerability has no universally accepted single definition. The early definition of vulnerability focused primarily on the loss-propensity. The Intergovernmental Panel on Climate Change (IPCC) describes vulnerability as a function of many variables, including climate variation to which a system is exposed, its sensitivity, and its adaptive capacity[24]. Berry L J[25] thought that vulnerability is a pre-existing condition or state that is defined by a set of negative attributes, which cause people or communities’ susceptibility to loss. Adger W N[26] also held a similar opinion, he thought that vulnerability is the state of susceptibility to harm that is associated with environmental and social change when a system is exposed. The progression of vulnerability goes through four steps: root causes, dynamic pressures, unsafe conditions, disasters[27]. Bohle H G et al.[28] pointed out that vulnerability contains three dimensions, including exposure, potentiality and capacity. Sociologists tend to view vulnerability as a set of socio-economic factors that determine people’s ability to deal with stress or change[29], and certain properties of a system will make it show up different vulnerabilities to different types of hazard[30]. Timmerman P(1981) used vulnerability as a term describing the degree to which a system, or part of a system may react adversely to the occurrence of a hazardous event[31]. Downing T E[32]gave a similar definition, he thought that vulnerability is the susceptible degree of an exposure unit to harm, and the ability to cope, recover, or fundamentally adapt.

The avoidance or mitigation of hazards and disasters was closely correlated with minimizing vulnerabilities, however, only in recent years the importance of vulnerability reduction was initially recognized, specifically in the developing world[11]. Over the past 10 years the literature on vulnerability has grown enormously. Vulnerability as a dynamic and complex process, focuses on not only past and actual conditions, but also possible conditions in the process and the future. So the challenge is how to define indicators that are used to assess, measure, and synthesize information on vulnerability[33]. In many literature, corresponding to vulnerability, the researchers use “resilience” as a term representing the measure of a system's capacity to adapt and recover from the occurrence of a hazardous event, without changes in its fundamental structure and function[32]. In oil and gas field, the vulnerability of object -affected or emergency response system is mainly social vulnerability. Furthermore, social vulnerability is distinguished from biophysical vulnerability, and the relationship between social vulnerability and resilience of a human system depends critically on the nature of the emergency faced[34].

C. Human Error

Human factors are the factors that lead to the occurrence of emergency and influence emergency consequence. The cause of emergency often comes from the unsafe state of object and the anomaly of the environment in which the object is. Among them, the human factors are the main factors that make the environment be abnormal. In spite of the sustained development in technology, human safety awareness and management tools have been continuously enhanced, but we have to admit that human ability is limited, and the behavior and attitude of people is difficult to control, so human error is always difficult to avoid. It is regrettable that there is an increasing trend of accidents caused by human error in recent years. Although its overall contribution to the problems may be small, 70-80% of problems are related with human error. The Australian Incident Monitoring Study (AIMS) reported that, if human factors were included, system-based deficiency or organizational factors were implicated in 97% of all incidents[35].

Hong Zhang et al. [36] analyzed the human error characteristics of 59 major drilling blowout accidents in China from 1970 to 2006, and found that the direct cause of the accidents by human error was accounted for 93.53 %. Therefore, in order to reduce the occurrence of accidents or emergencies, the measures should be taken to overcome human error. Among them, the human error is mainly reflected in the management mistakes, which cause the organization to have defects in the management systems, the behavior criteria and the organization atmosphere, and so on. And then the management mistakes make the organization members emerge anomalies in the personal physical, psychological and other aspects, and eventually become the human error that induces accidents or emergencies.

The field of safety management has been certainly studied since the publication of Peterson's book in 1978. For example, theoretical concepts like safety culture and resilience engineering were introduced into the scope of safety management. A key objective of safety management is to control employee behavior, because of the basic assumptions that human errors are a prime cause of accidents[5]. Reason J[37] pointed out that individual unsafe acts are hard to predict and control, whereas the organizational and contextual factors that give rise to these unsafe acts are present before the occurrence of an accident. And errors are symptomatic of both human fallibility and underlying organizational failings. Organizational problems, in contrast, are both diagnosable and manageable.

D. Social-impact of Security Emergency

The security emergency of oil and gas pipelines in urban areas impacts on people's production and livelihood, or brings a threat to people's lives, or even causes death, so it will become one focus of people's attention. Because society is a complex network of relationships, and has its own unique characteristics and operating mechanism, once major security emergency of oil and gas pipelines occurs, the social-impact will appear simultaneously. At this time, it is very important to effectively control the diffusion of social-impact. If the social-impact is not effectively controlled, it will make the consequences expand, even lead to a series of chain reaction, resulting in more serious consequences. Obviously, it is very necessary to explore the main influencing factors, pathways and mechanisms of the social-impact diffusion of emergency, and to enhance the ability of the management and control of security emergency.

Social-impact is a complex social process, which is affected by many factors. To sum up, there are two major types of factors that affect the range and speed of the social-impact diffusion for security emergency of oil and gas pipelines, including social factors and technical factors. In terms of social factors, they include economic, cultural, ethnic, religious, etc., that is to say, they are non-technical factors that can impact on the social-impact diffusion, and their essence is the social public psychological factors. Technical factors are the media that can transmit emergency information, for example, network, television, newspaper, radio, oral, etc.. With the rapid development of communication technology, information dissemination technology based on internet, e.g., Facebook, Twitter, Weibo, Wechat, is one of the most important dissemination technology, for they can achieve real-time online communication, and can have no boundaries. Comparatively speaking, the technical factors are more easily monitored and controlled, but the social factors are involved in the public social psychology, and so they are difficult to observe and evaluate. From the dimension of time, there are horizontal factors and vertical factors in social-impact, thereinto the horizontal factors refer to the degree of correlation between adjacent areas, the vertical factors are mainly related to historical lessons, training, education and other content.

An important content of the study on social-impact is the prediction of the damage. For example, one way of predicting the windstorm damage on buildings is by consulting experts in the field of wind engineering and structural engineering. The experts predict the nature and extent of building damages based on several factors that can reflect significant features of the buildings, e.g., surrounding environments, geographic location, construction types, building materials, and so on. At the same time, the experience knowledge gained from onsite damage investigation over the past years is still another major factor that is used during experts predicting[38]. With regard to the factors affecting the social-impact diffusion of emergency, ZHU Jiangbin[39] thought that the analysis can be carried out through the following three dimensions, including the properties and strength of emergency, the vulnerability of object-affected, the vulnerability of response system.

III. METHODOLOGY

A. Research Framework

This study aims to explore the factors affecting social-impact for major security emergency of oil and gas pipelines in urban areas, and the research framework is based on the literature of security management, vulnerability and human error in section 2 and experts discuss the result. Based on the process diagram of human vulnerability to NTEEs (nature-triggered environmental extremes)[11], and the social-impact diffusion model of major security emergency in oil and gas production companies[6], this study gives some improvement and introduces new elements, and puts forward an improved model from the perspective of city security and public security management, to explore the factors of social-impact for major security emergency of oil and gas pipelines in urban areas, as shown in **Figure 1**.

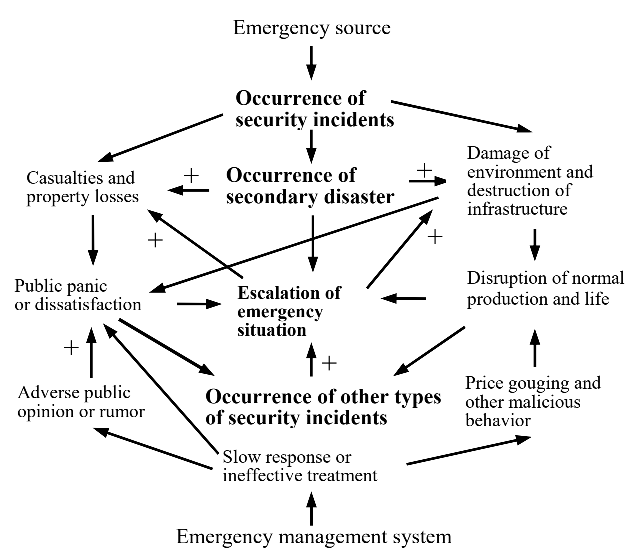

Fig. 1 Diffusion Model of Social-impact for Security Emergency of Oil and Gas Pipelines

On the basis of the above framework, the key point of this study is made clearly. In other words, focusing on the pathway of security emergency diffusion, this study explores the key vulnerability points of object-affected and the weight of various influencing factors, thereupon then puts forward some suggestions on strengthening the management of social-impact diffusion for major security emergency of oil and gas pipelines.

B. Questionnaire Design and Hierarchy Structure

Many items are involved in the social-impact factors for security emergency of oil and gas pipelines in urban areas. In terms of vulnerability, Haque and Burton [11]researched and pointed out, the process of human vulnerability to NTEEs involves six aspects, such as nature, hazards, risk, vulnerability, social /human systems, mitigation, and every aspects can be further subdivided, e.g. , social /human systems include risk awareness, perception, adjustment behavior, response, and so on. In order to measure the benefits of the investment in safety measures for pipelines, Guzman and Asgari[9] proposed a framework which contains variables such as threat and consequence, probability of accidents, vulnerability, failure modes, percentages of risk reduction and mitigation costs. Moreover, Ghettas S[2] studied on the evaluation of process safety management effectiveness in oil and gas field, and designed an abundant and comprehensive questionnaire, which consisted of 15 dimensions, e.g., process safety management indicators, process safety documents management, employees participation, top management commitment, continuous learning, organizational resilience, process maintenance activities, safety systems, safety drills, et al., and each aspect is subdivided into a number of specific items. This study designed the final questionnaire, by taking the above questionnaire as reference and integrating the knowledge gained from above literatures.

The questionnaire designed for this study comprises two parts. The first part of the questionnaire includes demographic information, such as gender, age, education, job position and working years, etc.. The second part is primary questionnaire of Analytic Hierarchy Process (AHP), which decomposes the decision-making problem into a hierarchy of criteria. The goal, factor constructs and criteria of AHP structure are established by the project team with the group brainstorming method, the constructs and criteria are derived from the literature search, social surveys, and interviews with experts. Under the goal of the social-impact factors for security emergency of oil and gas pipelines in urban areas, there are 5 factor constructs, and 5 or 6 terms of criteria are included in each of the constructs.

Based on literature review and interviews with experts in different fields, the study used group decision-making model and group brainstorming to list the most objective criteria, and consulted the views of school professors and industry experts, then summarized 27 criteria, such as *Cause of emergency incident*, *Types of emergency incident*, *Severity of emergency incident*, and so on. The 27 criteria were then summarized into 5 factor constructs, including *Emergency category*, *Local basic situation*, *Local social environment*, *Emergency response system*, *Emergency treatment*. As shown in **Figure 2**, hierarchy structure consists of 3 levels, Level 0 is the goal of the analysis, Level 1 is multi-criteria that consist of 5 criteria, that is to say there are 5 factor constructs. Level 2 is sub-criteria, in total 27 items.

For the survey, the questionnaire is to make pair wise comparisons between each factors pair. The results of the comparison, which was obtained from the responses of the experts, were described in term of integer values from 1 (equal importance) to 9 (extreme importance) ,where higher number means the chosen factor is considered more important in greater degree than another factor being compared with.

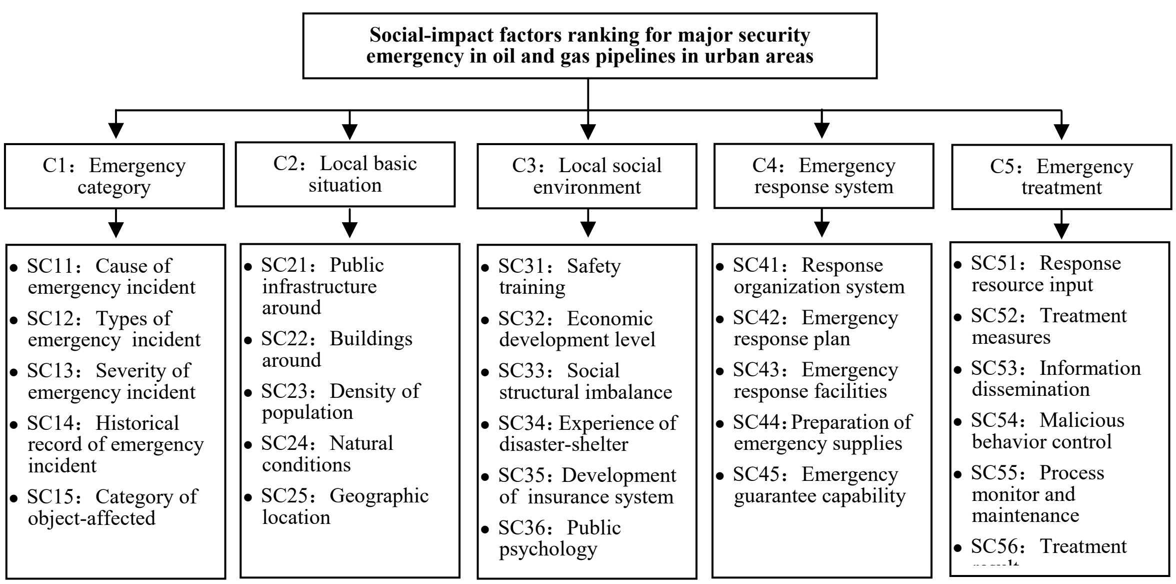

Fig. 2 the Hierarchy Structure of the Analysis

C. Sampling Design and Demographic Information

This study used a quantitative approach to measure the factors affecting the social-impact. The data were collected by a structured questionnaire from 60 security experts working in different fields, through traditional paper questionnaires. Those experts were consisted of 20 scholars or researchers who work in universities or research institutions, 20 industry experts who all have direct duties related to the EHS and some hold positions at middle-level or high-level of the EHS department (e.g., technical or engineering, security management, human resources, etc.) with key roles in enterprises, 20 supervisors or policymakers who work in the security management department of government. A total of 60 questionnaires were distributed and all were returned. Eliminating 5 invalid forms, the real effective rate was 91.7% with 55 questionnaires (academia, enterprise sector and public sector experts' questionnaires are 20, 17, 18 respectively).

TABLE 1 DEMOGRAPHIC INFORMATION OF EXPERTS

		Freq.	Percentage (%)	Cumulative percent (%)
Gender	Male	40	73.0	73.0
	Female	15	27.0	100.0
Age	25-29	10	18.2	18.2
	30-39	17	30.9	49.1
	40-49	15	27.3	76.4
	50-59	13	23.6	100.0
	60 above	0	0	100.0
The level of Education	Bachelor	19	34.5	34.5
	Master	25	45.4	79.9
	Doctor	11	20.1	100.0
Job position	Executives	3	5.5	5.5
	Middle Management	12	21.8	27.3
	Supervisors	14	25.4	52.7
	Researcher/ Scholar	16	29.1	81.8
	Policymaker	10	18.2	100.0
Year of working experience	5-10 years	20	36.4	36.4
	11-20 years	17	30.9	67.3
	above 20 years	18	32.7	100.0
Classification of work units	College /University	15	27.3	27.3
	Research institution	5	9.1	36.4
	Enterprise	17	30.9	67.3
	Public sector	18	32.7	100.0

Demographic information was collected in several aspects. The summary of 55 valid questionnaire samples is shown in **Table 1**. The data indicate that 73.0% of the experts are male (15males), all of them have a working experience of 5-30 years in the security management sector, and their ages range from 25 to 60. In addition, 65.5% of them obtained a Ph.D or a master's degree in China and abroad, and 11 of them have Ph.D degree. The experts are in different positions, including policymaker, researcher/scholar, supervisors, middle management, executives. Therefore, the data from these experts have better reliability.

D. Data Analysis Procedure

It is widely accepted that analysis method of the sample is one of quantitative method. This is chosen as the best method to draw conclusions utilizing techniques that emphasize validity and reliability. In this respect, the risk assessment is one of the most critical tasks in the security management. The study uses Analytic Hierarchy Process (AHP) to evaluate the factors of security emergency in oil and gas pipelines. AHP is one of the multiple criteria decision-making method that was originally developed by Thomas L.Saaty[40]. AHP is mainly used for decision-making problems, such as setting priorities, predicting outcomes, risk assessment, choosing a best alternative, allocating resources, designing systems, optimization, and so on[41]. Cagno et.al[18] also pointed out that AHP is used as a risk assessment approach to directly and holistically estimate factors and theirs risks. In short, today AHP can provide measures of judgment consistency, and is a simple and practical approach, in the field of multi-objective or multi-criteria decision-making.

IV. RESULTS AND DISCUSSION

Using AHP approach, it has been shown how all important factors can be treated holistically (as a result of synthesis process), rather than independently, within the process to elicit expert opinion[18].This analysis using 60 experts (evenly distributed in universities and research institutions, enterprises, public sectors) will increase the validity and reliability of the results, and add to our knowledge of the factors affecting social-impact of oil and gas pipelines and how it may affect diffusion.

A. Consistency Check

The ranking of factors affecting the social-impact for security emergency of oil and gas pipelines in urban areas is the research object of this study. For this purpose, AHP approach was used to calculate the weight of the factor constructs and the criteria, and designed pair-wise comparison questionnaires, then invited five professor level experts in the field to do a survey for the content of the questionnaire, then we put forward some suggestions for revision. On this basis, experts were selected to conduct a questionnaire survey. In order to reduce the difference in field distribution, this study selected a considerable number of respondents in three fields, that is to say, the respondents from universities and research institutions, enterprises and public sectors were1:1:1, that is, 20 people respectively. After sorting the questionnaires, the software *Choice Expert* was used to calculate the weight of each factor construct and criterion. In order to ensure that subjective judgment of the respondents in the questionnaires has the logical consistency, the study used consistency checks (the Consistency Index CI$\leqq$0.1). In this study, each factor construct CI $\leqq$ 0.05, each criterion CI $\leqq$0.01, the inconsistency is acceptable. In addition, for further analyzing that whether there are differences in the criterion weight, after calculating the weight judged by the experts in different fields, this study synthesized the weight value of the criteria in arithmetic mean method, and analyzed the differences among different respondent groups.

B. Comparison of Factor Constructs

The analysis found that, among the factors affecting the social-impact for major security emergency of oil and gas pipelines in urban areas, as a whole the experts in different fields valued the factor construct *Emergency response system* the most, the average weight is 0.299. The factor construct *Emergency treatment* (0.256) is the second, the rest in turn are *Emergency category* (0.194), *Local social environment* (0.130), *Local basic situatio*n (0.121), as shown in **Table 2**. This results show that once a security emergency occurs, it would have become an established fact, so people would pay more attention to emergency response system and the treatment of security emergency, rather than the emergency itself. This is in accordance with the actual situation.

However, because the focus of the experts in various fields is different, there are also differences in the judgment result of the importance of the five factor constructs. Nevertheless, for the least important construct, the views of the experts in three fields are consistent, all thought that the construct *Local basic situation* is least important, only the evaluation of the weight value is different, and weight value is lower, 0.124, 0.125 and 0.114 respectively. However, for the most important factor construct, the experts in three fields hold different views. Among them, the views of enterprises and public sectors experts are consistent, they all thought that the construct *Emergency response system* is the most important, respectively valuation as 0.265 and 0.366, but the experts in universities and research institutions considered that *Emergency treatment* (0.285) is the most important, which is consistent with the responsibility or work content of the experts in enterprises, public sectors, and universities and research institutions.

TABLE 2 WEIGHT COMPARISON OF FACTOR CONSTRUCTS

Factor construct	Total	Academia	Enterprises	Public sectors
Emergency category	0.194	0.193	0.247	0.142
Local basic situation	0.121	0.124	0.125	0.114
Local social environment	0.130	0.130	0.127	0.134
Emergency response system	0.299	0.265	0.265	0.366
Emergency treatment	0.256	0.285	0.234	0.248

C. Comparison of Criteria and Synthesis

From the perspective of individual factor constructs, the weight of criteria in each factor construct is different, as shown in **Table 3**. In the factor construct *Emergency category*, the criteria *Severity of emergency incident* (0.306) and *Cause of emergency incident* (0.294) are in the top 2, and *Category of object-affected* (0.108) is the least important. That is to say, once a security emergency occurs, people would pay more attention to the casualties and the damages caused by the emergency, and would like to know the real cause of the emergency. This is also in accordance with the actual situation.

TABLE 3 WEIGHT OF CRITERION IN EACH FACTOR CONSTRUCT

Factor construct	Criterion	Weight
Emergency category	Cause of emergency incident	0.294 (2)
	Types of emergency incident	0.182 (3)
	Severity of emergency incident	0.306 (1)
	Historical record of emergency incident	0.110 (4)
	Category of object-affected	0.108 (5)
Local basic situation	Public infrastructure around	0.262 (2)
	Buildings around	0.157 (4)
	Density of population	0.294 (1)
	Natural conditions	0.116 (5)
	Geographic location	0.172 (3)
Local social environment	Safety training	0.233 (1)
	Economic development level	0.139 (4)
	Social structural imbalance	0.117 (6)
	Experience of disaster-shelter	0.181 (3)
	Development of insurance system	0.201 (2)
	Public psychology	0.129 (5)
Emergency response system	Response organization system	0.242 (1)
	Emergency response plan	0.216 (2)
	Emergency response facilities	0.177 (5)
	Preparation of emergency supplies	0.180 (4)
	Emergency guarantee capability	0.185 (3)
Emergency treatment	Response resource input	0.160 (3)
	Treatment measures	0.232 (1)
	Information dissemination	0.149 (5)
	Malicious behavior control	0.167 (2)
	Process monitor and maintenance	0.138 (6)
	Treatment result	0.152 (4)

Note: Figure in brackets "( )"indicates the ranking order of importance, e.g., (1) is NO.1 importance.

In the factor construct *Local basic situation*, the criterion *Density of population* (0.294) is the most important, and *Public infrastructure around* (0.262) is in the second, and *Natural conditions* (0.116) is the least important. The density of population is directly related to the possibility of casualties as well as the size of the disaster, and the public infrastructure around is related to the vital interests of the public, so people pay more attention to them.

In the factor construct *Local social environment*, the criterion *Safety training*(0.233) is the most important, and *Development of insurance system* (0.201) is in the second, and *Social structural imbalance* (0.117) is the least important. The results further indicate that a good safety training and a perfect insurance system are very important for people affected by the security emergency. Relatively speaking, social structural imbalance and public psychology are not so important.

In the factor construct *Emergency response system*, the weight of each criterion is comparative equilibrium. Among them, the criteria *Response organization system* (0.242) and *Emergency response plan* (0.216) are in the top 2, and *Emergency response facilities* (0.177) is the least important, but the gap is not as big as other construct. That is to say, each criterion in the construct is all relatively important. This is the reason that this construct is the most important one in all five factor constructs.

In the factor construct *Emergency treatment*, the criterion *Treatment measures* (0.232) is the most important, and *Process monitor and maintenance* (0.138) is the least important. However, except for the most important criterion, those weight value of the others are relatively close, which also indicates that each criterion has considerable importance, and has an important influence on social-impact for major security emergency of oil and gas pipelines in urban areas.

From the perspective of all factor constructs (shown in **Table 4**), on the whole, the criterion *Response organization system* in the factor construct *Emergency response system* is got the greatest attention, the average weight value is 0.072, *Emergency response plan* (0.064) in *Emergency response system* and *Cause of emergency incident* (0.060) in *Emergency category* take second place. *Treatment measures* (0.059) in *Emergency treatment*, *Emergency guarantee capability* (0.056) in *Emergency response system,* S*everity of emergency incident* (0.055) in *Emergency category, Preparation of emergency supplies* (0.054) and *Emergency response facilities* (0.052) in *Emergency response system* are also got higher attention. As mentioned before, all experts in various fields do agree that the emergency response system has an important influence on the social-impact for major security emergency of oil and gas pipelines in urban areas. The assessment is very consistent with the actual situation, for emergency response system is directly related to the result of emergency treatment, also has a direct impact on the public confidence. In comparison, *Natural conditions* (0.014) in *Local basic situation* and *Social structural imbalance* (0.015) in *Local social environment* are the least important. **Table 4** shows the sort of factors affecting social-impact for security emergency of oil and gas pipelines in urban areas. This makes known that the experts in different fields give more concern to emergency response system, especially to the construction of response organization system and the emergency plan, than security emergency itself or local basic situation and local social environment. Of course, the cause and the severity of security emergency also have been highly concerned, the measures of emergency treatment are in the same way. In summary, the weight of the criteria that are not directly related to the emergency response system or the emergency treatment are given a lower value.

By expert investigation and AHP approach, this study summarizes a set of criteria of the factors affecting the social-impact for major security emergency of oil and gas pipelines in urban areas, and the results will provide a reference for the development of integrated information platform on security management and the construction of control mechanism of security emergency for public administration departments, oil and gas production enterprises and other social organizations.

TABLE 4 SYNTHESIS WEIGHT OF CRITERION IN ALL FACTOR CONSTRUCTS

Factor construct	Criterion	Synthesis weight	Mean of weight in construct
Emergency category	Cause of emergency incident	0.060(3)	0.039 (3)
	Types of emergency incident	0.035(15)	
	Severity of emergency incident	0.055(6)	
	Historical record of emergency incident	0.023(20)	
	Category of object-affected	0.021(21)	
Local basic situation	Public infrastructure around	0.032(16)	0.024 (4)
	Buildings around	0.019(23)	
	Density of population	0.035(14)	
	Natural conditions	0.014(27)	
	Geographic location	0.021(22)	
Local social environment	Safety training	0.030(17)	0.022 (5)
	Economic development level	0.018(24)	
	Social structural imbalance	0.015(26)	
	Experience of disaster-shelter	0.024(19)	
	Development of insurance system	0.026(18)	
	Public psychology	0.017(25)	
Emergency response system	Response organization system	0.072(1)	0.060 (1)
	Emergency response plan	0.064(2)	
	Emergency response facilities	0.052(8)	
	Preparation of emergency supplies	0.054(7)	
	Emergency guarantee capability	0.056(5)	
Emergency treatment	Response resource input	0.041(10)	0.043 (2)
	Treatment measures	0.059(4)	
	Information dissemination	0.038(12)	
	Malicious behavior control	0.043(9)	
	Process monitor and maintenance	0.036(13)	
	Treatment result	0.040(11)	

Note: Figure in brackets "( )"ndicates the ranking order of importance, e.g., (1) is NO.1 importance.

V. CONCLUSION AND SUGGESTION

This study aims to explore the factors affecting the social-impact for major security emergency of oil and gas pipelines in urban areas and its ranking of importance, by the investigation and analysis of five factor constructs, including *Emergency category*, *Local basic situation*, *Local social environment*, *Emergency response system*, *Emergency treatment*. Although the experts in different fields have different evaluations for each factor construct, they have a relatively consistent view on the most or more important factor constructs. The results show that the construction of emergency response system is the most important, more so than security emergency itself and the emergency treatment. This further illustrates the strong public demand for public security and a sound emergency response system. The existing construction of public security system is still not satisfactory, even if the whole society were to build a good security culture, which would prevent the occurrence of an important number of incidents[2]. Of course, the experts in different fields also gave a higher weight value to some criteria, such as *Treatment measures*, *Malicious behavior control*, *Response resource input* in the factor construct *Emergency treatment*, and *Cause of emergency incident* and *Severity of emergency incident* in the factor construct *Emergency category*. The results demonstrate that once a security emergency occurs, the public sectors should take the most effective way to solve it as soon as possible, and to control the speed and possibility of its social-impact diffusion in a limited range, consequently minimize the loss caused by the emergency.

In terms of criteria, there is an obvious difference in the importance of 27 items. *Response organization system, Emergency response plan, Cause of emergency incident, Treatment measures*, and *Emergency guarantee capability* are in the top 5. *Severity of emergency incident* is only ranked 6th. The results tell us that once a security emergency occurs, people should pay high attention to how to actively deal with the emergency effectively and as much as possible to reduce the casualties, but could not merely focus on the severity of emergency. At this point, effectively dealing with the emergency is more meaningful than debating on the emergency itself.

The oil and gas pipelines are a very special carrier in urban areas, where the security emergency system is directly affecting public security and social impact. We should not only need do everything possible to reduce the possibility of security emergency of oil and gas pipelines in urban areas, but also must do all we can to reduce the damage caused by the security emergency. This study suggests that it is very necessary to construct a top-down multilevel emergency response system, ensure the allocation of all kinds of resources in place, and establish the synergy mechanism between the emergency subsystem at all levels.

Based on the results, the 27 criteria and their ranking of importance can be taken as a valuable reference, and to construct such a top-down multilevel emergency response system, including but not limited to the integrated information platform on security management and the security emergency control mechanism. In particular, the factors ranking in the front row should be paid more attention to. Once a security emergency occurs, the information platform or security control center will be able to get all kinds of valuable information through the response system, so the response organization system can make a comprehensive and objective judgments, and make decisions quickly, by analyzing the severity, cause, types of security emergency, density of population, public infrastructure around, etc.. Furthermore, the response organization system can assess the possible scope of the social-impact diffusion and the key control elements, find out the main areas of weakness and the key points of emergency control, clear the core tasks of emergency response, and then make an effective emergency response plan, input the necessary response resources, and take effective treatment measures. In short, the results can improve the decision accuracy and response speed, to avoid the escalation of emergency situation or reduce the occurrence of secondary disaster, consequently control the social-impact diffusion.

Obviously, basing on the construction of an effective control mechanism of social-impact, the response organization system can improve the speed and quality of decision-making and quickly feedback to security control center or integrated information platform on security management, and then the response organization system can strengthen emergency management. In addition, it is also helpful to the research and application of security management technology, which will be useful for emergency response. Therefore, the results will be helpful to reduce the cost of emergency treatment, and reduce the loss caused by a security emergency.

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