

The Vulnerability Formation Mechanism and Control Strategy of the Oil and Gas Pipeline City

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Abstract. Most of the pipelines of oil and gas pipelines in our country have been for more than 25 years. These pipes are buried underground and was difficult to daily test. In addition, it was vulnerable to environmental, corrosion and natural disasters ,So there is a hidden nature of accidents. The rapid development of urbanization, population accumulation, dense building and insufficient safety range are all the reasons for the frequent accidents of oil and gas pipelines. Therefore, to appraise and know the safe condition of the city various regions oil and gas pipelines is vital significant.In order to ensure the safety of oil and gas pipeline city, this paper defines the connotation of oil and gas pipeline city vulnerability according to the previous research on vulnerability. Then from three perspectives of environment ,structure and behavior, based on the analytical paradigm of “structure—vulnerability conduct—performance” about oil and gas, the influential indicators of vulnerable oil and gas pipelines were analysed ,the vulnerability mechanism framework of Oil and gas pipeline city was also constructed. Finally ,the paper proposed the regulating strategy of the vulnerability of the oil and gas pipeline city to decrease its vulnerability index, which can be realize the city's vulnerability evaluation and provides new ideas for the sustainable development of the city.

1. Introduction

Oil and gas pipelines in China were expected to increase to meet growing demand. Oil and gas pipelines in our country have undergone four stages initial development (1958-1969), rapid development (1970-1987), steady development (1988-1995) , accelerated development(1996 - present)[1].Most oil and gas pipelines in China were more than 25 years, there exist many safety problems such as leakage of products, sick operation and serious corrosion etc. Separately, it can't be repaired or replaced in time. The average rate of oil and gas pipeline accidents in China was 3 times per 1000 km/year, well above the US 0.5 times per 1000 km/year and Europe's(0.25 times per 1000 km/year), public information shows. Incomplete statistics show that there have been more than 1000 oil and gas accidents in China since 1995[2]. As soon as the oil and gas pipeline leaked or broke, it will cause significant fire accident and even malignant consequences such as explosion, poisoning, environmental pollution, especially in densely populated areas, serious casualties and great economic losses tend to appear. In 2002,Six people were killed and five injured in a blast which was attributed to



the build up of gas in Daqing. In 2006, A "1.20" explosion in the gas station of the Fujia gas station in the southwestern oil and gas field was led to a bad result: 10 deaths, 3 serious injured and 47 slight injured. "The great accident of the 11.22 Donghuang oil pipelines" in 2013, which killed 62 people and 136 was injured.

As a new term for the study of security, vulnerability is an important bridge between disaster and risk research and also is an important comprehensive indicator of system security[3]. Based on many dangers to the surrounding cities of oil and gas pipelines, it is of practical significance to study the formation mechanism of oil and gas pipelines city vulnerability to the possibility of scientific prevention and reduce the occurrence of disaster.

2. Oil and gas pipelines vulnerability

The term of vulnerability was applied to the field of geosciences and natural disaster research at the beginning, which was interpreted as the extent of loss caused by some elements of risk disasters[4]. In the 1990s, vulnerability was associated with resilience, marginality, sensitivity, and adaptability[5-7]. The concept of vulnerability has different expressions in different research fields, but there are certain commonalities: the instability of the system itself. Internal characteristic of the system was the most important and direct factor affecting the fragility. External interference can affect the size of vulnerability by the internal characteristics of system, and then be reflected in the sensitivity and response of the system to the interference. Vulnerability not only reflects the current state of the system, but also includes the risk problem, which presents the spatial and temporal pattern of vulnerability.

As to the analysis above, vulnerability was reviewed as a status property in this paper, that is, the oil and gas pipeline city system exhibits a high degree of sensitivity under the external disturbance and lacks of response capability, cause the system to the extent of damage. The vulnerability of the system is usually inversely correlated to security. The vulnerability of the system went down when security on it was improved. Subject to its sensitivity and instability, under the effect of disturbance of different factors, the oil and gas pipelines city system shows a high degree of complexity.

3. Formation mechanism of oil and gas pipelines city

Factors affecting the vulnerability of oil and gas pipelines city can be divided into three levels: environment, structure and behavior, and its vulnerability is changed by the interaction between direct, indirect or influencing factors. The vulnerability of oil and gas pipelines in this paper was a negative performance. City, the industrial chain or the formation of the capital structure tend to have a long time, formed its unique structure of rigid. This feature in the face of the urban resource constraints, the adverse effects such as changes in oil and gas pipelines, will show its effect, which reflects the side effects of oil and gas pipelines city. Taking oil and gas pipelines as a system, a combination of society, economy and resources environment have reflected its exposure, sensitivity and adaptability, etc. In addition, the sensitivity is the property of the oil and gas pipelines city itself, which is determined by its internal structure. The size reflects the response of the oil and gas pipeline city system to the internal and external changes, which may be positive or negative. The response capacity was reflected in oil and gas pipelines city system, that displayed against a variety of characteristics of the adverse impact when the internal or external disturbance occurred. The changes that system faced were concealment or controllable, and cope with these changes rely mainly on the function of the system itself. Besides, not only the adaptation of the oil and gas pipeline city system to external changes included, but also the variability of the external changes, namely active coping and reactive coping[8,9]. The adaptive value is greater, the stronger the adaptability of the system, the less vulnerable the system is. Resilience refers to the bear, adaptation, or the ability to recover the system after the internal or external disturbance happens, that is, the time and energy required for the system to recover from the disaster. The model of formation mechanism of oil and gas pipelines city vulnerability was constructed, as shown in Fig.1.

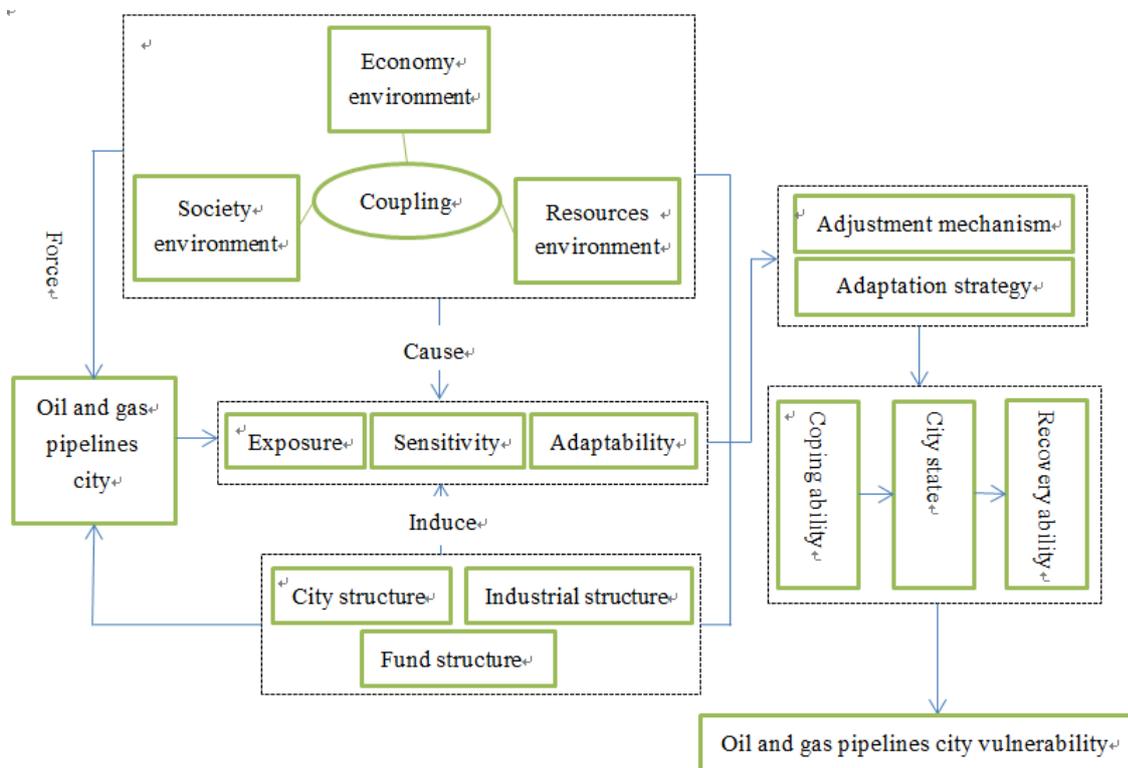


Figure 1. The model of formation mechanism of oil and gas pipelines city vulnerability

3.1 City vulnerability

- Economic factors: Mainly reflects the economic strength of the oil and gas pipeline city, and directly related with the coping ability. The higher the level of economic and social development, the stronger the economic strength, oil and gas pipeline city on the internal or external interference resistance is stronger.
- Society factors: The impact of social factors on vulnerability includes population density, age structure, population quality and other population factors, medical and health conditions, culture and education and other public services were also considered. In general, for areas where the density of the city is large, the more likely it is to lead to unexpected losses, the higher the sensitivity, the lower the safety.
- Resources environment factors: In the process of urbanization, Economic growth is bound to sacrifice environmental quality for a certain price. Environmental pollution problems in resource-constrained settings have increasing prominent.
- Oil and gas pipelines factors: Oil and gas pipelines vulnerability often manifest as the complexity of its surroundings. Moreover, it was susceptible to population density, soil geological conditions and so on. The characters of centralized distribution, large amount and medium kinds will increase the vulnerability of the oil and gas pipeline system.

3.2. The vulnerability of emergency capability

The emergency capability has a critical role to play in the occurrence of disasters, that is the “anti-sensitivity” of the system. On the whole, coping capacity presents two states in the event of a disaster: one is the vulnerability of oil and gas pipelines. By taking measures to decrease the potential of oil and gas pipelines, reduce the exposure of oil and gas pipelines or minimize damage. Another is city vulnerability. Using the coping capacity to weaken the vulnerability factor, that is, to enhance the ability of the city itself to counter the adverse effects, and then to reduce the vulnerability of the system being evaluated.

4. The control measures and suggestions of vulnerability on oil and gas pipelines city

- 1) Increase the awareness of security knowledge
- 2) Leaking, once happening to pipeline, will easily lead to fire or explosion and cause damage to the surrounding environment, especially in complex areas such as population and buildings concentrated regions. Therefore, it is important for residents to realize the harmfulness of pipelines and raise their safety concerns. Try to avoid some adversely behaviors to the pipes, including the third-party damage, unlawful tying, etc. Besides that, we can use the strength of the residents to supervise construction enterprises so as to reduce error operation, which can help decrease the vulnerability of system effectively.
- 3) Establish linkage mechanism for government, enterprises and community
- 4) "11 • 22 Donghuang oil pipelines leakage explosion" was identified as accident caused by negligence. Based on this, it is necessary to establish a co-management mechanism that guided by the government, and enterprises, community participated in. On the one hand, to strengthen the national safety production-related laws or regulations while the government as the main force. On the other hand, enterprises and community residents are brought into the management area to form a system of mutual supervision.
- 5) Adjust industrial structure and implement sustainable management
- 6) Taking the oil and gas pipelines city as a system, raise the proportion of the tertiary industry to reduce the negative effects on the environment caused by lower industrial structure. Correctly handle the relationship between the inside and outside of the system, and to predict the potential changes in the system and possible consequences happen. To coordinate the economic and environmental development through the implementation of sustainable management, so as to improve the safety of the oil and gas pipelines city.

5. Conclusion

- 1) Based on the concept of vulnerability related concepts in different fields, the concept of vulnerability of oil and gas pipelines is proposed. In this paper, vulnerability was reviewed as a status property, that is, the oil and gas pipeline city system exhibits a high degree of sensitivity under the external disturbance and lacks of response capability, cause the system to the extent of damage.
- 2) Vulnerability is the inherent attribute of oil and gas pipeline city. From the perspective of the concept of oil and gas pipelines vulnerability, this paper divided it into two parts: city vulnerability and emergency capability vulnerability. Then the model of formation mechanism of oil and gas pipelines city vulnerability was constructed and analyzed.
- 3) The paper put forward the control measures and suggestions of vulnerability on oil and gas pipelines city, which can help to identify the root of vulnerability and find the weak links of the evaluation system. It will provide scientific theoretical basis for the oil and gas pipeline safety management to ensure the safety of the oil and gas pipelines.

References

- [1] Yao W, Jiang C L and Cong J H 2010 *J. Comprehensive safety risk precontrol of the pipelines. China Petroleum Enterprise.* **(12)**.89-93
- [2] Qi A H 2009 *J. The present situation and problem analysis of oil and gas pipeline transportation in China. International Petroleum Economics.* **17(12)**,57-59
- [3] Zhao X W, Chai J S 2011 *J. Study on indicators of vulnerability assessment for city buried gas pipeline system. Journal of Safety Science & Technology.* **7(7)**,92-96.
- [4] Timmerman P 1981 *J. Vulnerability, Resilience and the Collapse of Society. A Review of Models and Possible Climatic Applications. Institute for Environmental Studies, University of Toronto*
- [5] Huang L L, Yao A L and Xian T 2014 *J. Research on risk assessment method of oil & gas pipeline with consideration of vulnerability. China Safety Science Journal.* **24(7)**.93-99

- [6] Krellenberg K, Link F and Welz J 2014 *J. Supporting local adaptation: The contribution of socio-environmental fragmentation to urban vulnerability. Applied Geography.* **55(12)**.61-70
- [7] Gallopín G C 2003. Handbook for Estimating the SocioEconomic and Environmental Effects of Disasters. *Economic Commission for Latin America and the Caribbean.* Mexico.45-56
- [8] Yohe G, Tol R.S J 2001 *J. Indicators for social and economic coping capacity- moving toward a working definition of adaptive capacity. Global Environmental Change.* **12(1)**.25-40
- [9] Feng L I 2013 *J. The Frangibility of Tourism Economy: Definition, Formation Mechanism and Frame Analysis. East China Economic Management.* **27(03)**.76-81