

# Preliminary study on risk assessment of tunnel gas disaster

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## **Abstract**

Since more and more tunnels passing through coal-bearing strata, gas accidents are on the rise accompanying the construction and development of basic communication in our country. Therefore, it is so urgent to study gas disaster risk assessment system which conform the characteristics of tunnel engineering. Based on the research of gas tunnel in our country, a relatively perfect gas disaster risk assessment system of tunnel has been set up through the study on the influencing factors of gas disaster, including geological factors, gas factors and human factors. This system is composed of three parts described above: gas tunnel classification evaluation, gas tunnel engineering risk assessment, and tunnel face risk assessment. Therefore, it can make a prompt and accurate assessment of gas disaster in any phase, such as route selection, designation, construction, and take appropriate engineering control measures.

**Key words:** Tunnel Engineering; Gas Disaster; Risk Assessment System; Method and Indicators.

## **1. Introduces:**

China is a mountainous country, 75% of the land is mountainous and hills, so it is inevitable to need to build a lot of tunnel when transportation routes through the mountains. As the economy develops, demanding of people to traffic situation increasingly high, and with the development and construction of high-grade highways, high-speed railway will arise more and more tunnel. With the construction of tunnel, we inevitable to encounter tunnel through the coal formation or occurrence gas, such as Yichang-Wanzhou Railway Yesanguan tunnel, Hefei-Wuhan Railway Hongshiyuan tunnel, Guangan-Huayingshan high-speed Huayingshan tunnel and Dujangyan- Wenchuan high-speed Zipingpu Tunnel are gas tunnel what built in recent years, these tunnel have all encountered gas danger in the construction process such as gas suffocation, fire, explosion and gas outburst danger<sup>[1] [2] [3]</sup>.

With the gas disasters continuously increasing in gas tunnel construction, people more and more awareness of the importance of prevention and reducing gas disaster, and urgent need for effective method and means of disaster risk assessment for gas tunnel. basis on the current understanding of the gas disaster, if we can control and management the related information timely and systematic, and implementation effective forecast

before the possible occurred dangerous, relying on the existing control measures we have full grasp to complete elimination of the tunnel gas disaster occurred. Therefore, the accurate prediction and determine to risk of tunnel gas hazard and to improve the high gas tunnel construction technology and management level is the key to prevent the gas explosion in coal and gas outburst, and is the indemnification of the tunnel construction safety.

In present, the problem of tunnel gas disaster risk assessment work is not carried out, or not in all-around development, and the related theory system is not perfect. Therefore, we carried out the risk assessment system theory and method of gas tunnel risk assessment actively to avoid gas explosion and gas outburst accident, protect life and property of the people will have very important practical significance, especially with the construction on railway, highway projects in western mountain of China, it is very urgent of gas tunnel risk evaluation and research.

## **2. Risk Assessment of Gas Tunnel:**

### **2.1 Research Status of Gas Tunnel Risk Assessment:**

There are not many gas tunnel construction of the last century in China, so did not carry out the research about the reasonable definition standards of the gas tunnel, monitoring method, construction safety techniques of the normal precautions and emergency measures, so the gas tunnel hazard evaluation is still in its infancy currently, and research emphasis on coal and gas outburst risk assessment, the outburst indicators often reference the coal system research. According to the existing gas tunnel, its data indicate that different from often happens coal and gas outburst hazard of coal mine system, combustion and explosion hazards account vast majority of gas hazard in tunnels, so there is distance between the available work level and the gas tunnel risk assessment.

The "Technical Code for Railway Tunnel with Gas" (TB10120-2002) is given in a number of stipulates about gas tunnel hazard assessment<sup>[4]</sup>, its definition of gas tunnel and the gas tunnel classification and partition is somewhat similar to the gas tunnel risk assessment (Figure 1).

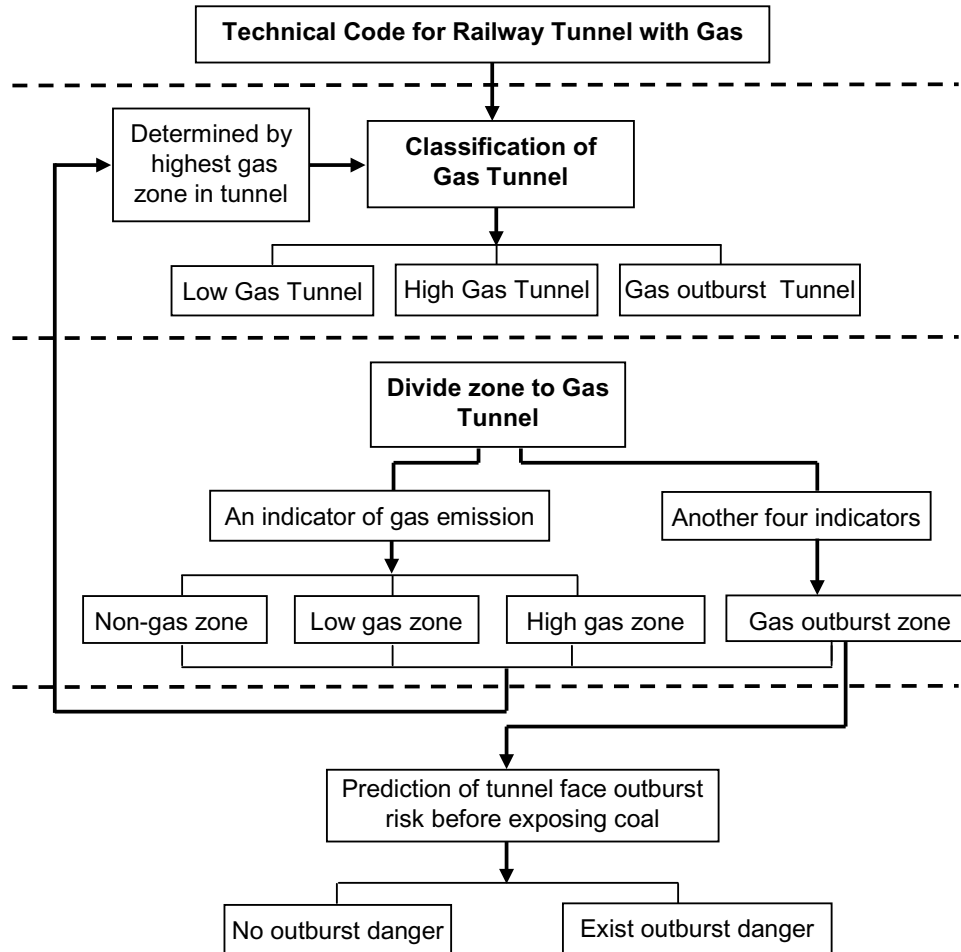


Figure 1 Gas tunnel classification and partitioning of technical code

In this paper, based on "Technical Code for Railway Tunnel with Gas", a preliminary study on risk assessment of tunnel gas disaster is carry out, combined with large number of gas tunnel engineering of China, and has proposed tunnel gas disaster risk assessment system.

## 2.2 Risk Assessment Content of Gas Tunnel:

Underground tunnel project is a linear project, in a small space under the ground, and once occurred a gas disaster (mainly are gas explosion), the most workers in the tunnel will die at the scene, machinery and equipment will be severely damaged. That is once occurred a gas disaster, the affected body (people and equipment) damage rating is the largest and nearly to 100%. So we can summarize the content of the risk assessment of gas tunnel in this paper as: at the various stages of construction of the tunnel, according to obtained information and engineering requirements to make the corresponding gas disaster risk assessment, evaluation possibility of gas disaster (fire, explosion,

asphyxiation, highlighting, etc.), to provide a scientific basis for the next phase of work, thus ensuring the works safety and construction progress and provide a good operating environment when complete the tunnel construction.

### **3. Risk Assessment System of Gas Tunnel:**

The completion and use of any tunnel need to go through the planning and selection, survey and design and construction phases, we can obtain different information about each phase, and need to encountered different problems, then to get the results vary. Based on the content of gas tunnel risk assessment, gas tunnel risk assessment system is working for different work stages of risk assessment, and this system is composed of three parts described above: gas tunnel classification evaluation of planning and selection phase, gas tunnel construction risk assessment of design and construction phase, and tunnel face outburst risk assessment of the gas tunnel face exposing coal phase (Figure 2).

#### **3.1 Classification Evaluation of Gas Tunnel:**

The gas content is higher, the concentration is large, and more easily to occur gas accidents, thus the degree of danger is greater. Gas tunnel classification evaluation of the early planning and selection phase stages is a qualitative classification to the whole tunnel will construction, and is the first step in risk assessment system. It means take the tunnel as a point, and carry out grade evaluation on this point, according to the most favorable conditions for gas occurrence in tunnel (the highest gas content condition) to evaluate the level of the gas tunnel.

According to the principles and methods of geological engineering theory, a concise gas tunnel classification evaluation method has been set up, mainly based on geological macro-scopic estimation. The method takes distributed gas zone, buried depth of tunnel, and geological structure, seam thickness, the degree of exposed groundwater in tunnel site areas as evaluation indexes, and adheres to general evaluation method factors to carry out the classification.

Classification evaluation of gas tunnel is actually based on the amount of gas content in tunnel evaluate to the occur possibility of gas disaster of proposed tunnel, which corresponds to classification of gas tunnel of "Technical Code for Railway Tunnel with Gas" (Figure 1). At this point only departure from the background conditions of geological environment and their combinations on the role of control the gas phenomenon, static study possibility measurement of occur gas disaster in tunnel site which is a relatively stable disaster occur situation, regardless of the future will be encountered impact of human activities. From the physical sense, the occur possibility of

tunnel gas disaster is a probabilistic value, its evaluation results does not have a clear time scale, and not concerned about the current tunnel accumulation gas in which stage also. When we talked about the proposed tunnel of gas with a high degree of disaster, in general corresponding to "special geological setting determines somewhere occur gas disaster easily" of the traditional engineering geology field.

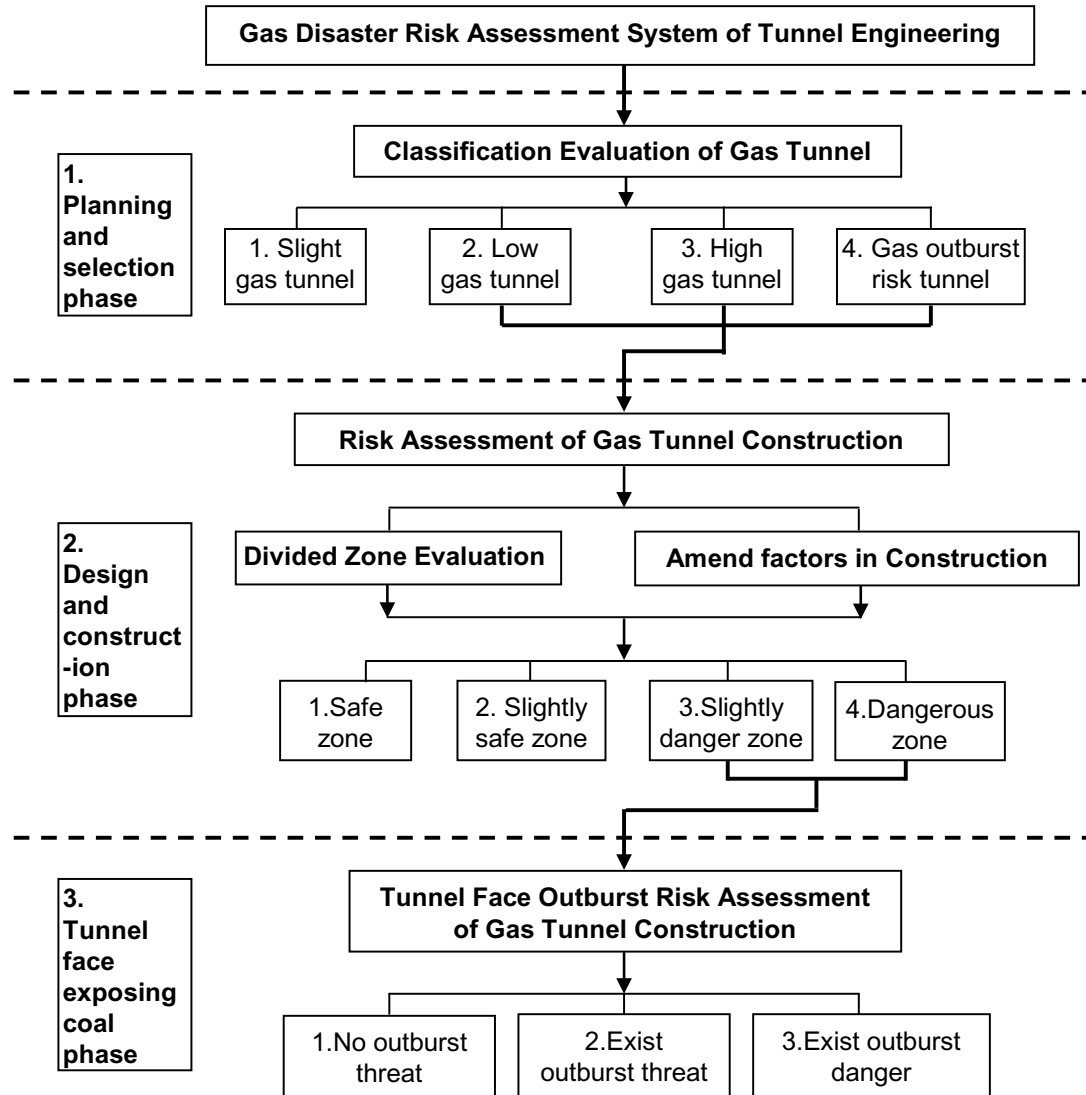


Figure 2 Tunnel gas disaster risk assessment system

### 3.2 Risk Assessment of Gas Tunnel Construction:

Based on the classification evaluation of gas tunnel then can carry out the gas tunnel construction risk assessment of design and construction phase, the classification evaluation results are four grades with slight gas tunnel, low gas tunnel, high gas tunnel and the gas outburst risk tunnel, and the construction risk assessment execute evaluation for the later three levels.

Considering relatively numerous materials in design and relatively more demanding of projects, meanwhile, due to classification evaluation method, and referring to gas tunnel railway technical specifications of 2002 version, a suitable gas disaster engineering risk assessment method should be established. Gas tunnel engineering risk assessment is composed of two parts: division evaluation and risk assessment, and amend by superposition construction factors. Division evaluation is a risk assessment of each division under natural geological conditions, meanwhile, the background value and basis of construction risk assessment, which includes six evaluation indexes: gas emission, pressure, geological structure, the type of coal structure, groundwater conditions, and depth between working zone and the coal. Different prevention and control measures, gas management, construction experience, and technical level may bring out different level of risk. Those four factors can be taken as amending factor; methods of assessment can be divided into comprehensive evaluation method of general factors, fuzzy comprehensive evaluation method, and extension evaluation method.

To note here is that, to the tunnel construction survey, design and construction stage, tunnel site has conducted considerable exploration and testing work, we have more detailed information of tunnel geological environment, the risk assessment is in terms of different sections of the tunnel at this time, that evaluate the section of the tunnel linear project, and it corresponds to the gas tunnel divide section of "Technical Code for Railway Tunnel with Gas" (Figure 1). Compared with early classification evaluation of gas tunnel, the risk assessment index are more detailed and more accurate of risk assessment of gas tunnel construction, can more specific guidance to the next construction step, type of evaluation from the point evaluation turn into a line evaluation.

### **3.3. Tunnel Face Outburst Risk Assessment of Gas Tunnel Construction**

Risk assessment of gas tunnel construction results also are four grades with the safe zone, relatively safe zone, the more dangerous zone and danger zone, it need to carry out the evaluation of tunnel face outburst risk when tunnel construct in the gas layer (usually coal strata), that is uncovering coal stage in the more dangerous zone and danger zone, it evaluate the possibility of occurred potential hazards in tunnel face coal and gas outburst.

Outburst risk assessment base on the latest information of tunnel construction, taking the maximum buried depth, geological structure, dynamic phenomenon in advance borehole drilling, maximum gas pressure, maximum initial velocity of gas emission in borehole, and coal structure as the outburst risk evaluation indexed, by discriminating each of them to conduct the predictive assessment. Execute specialized evaluation on outburst disaster of directly harm the construction workers in tunnel face, on the one hand is amend the risk assessment of gas tunnel construction, on the other hand is forecast the possibility of

tunnel face outburst when construction and provide safety protection for the tunnel continue construction<sup>[1] [5]</sup>.

#### **4. Conclusions:**

Gas tunnel classification evaluation, gas tunnel construction risk assessment and tunnel face outburst risk assessment are both connections and differences, they are not essentially different on evaluation methods, but consider different element at different stages. The gas hazard assessment of different tunnel construction stages is only consider the gas disaster natural attributes, does not explore the characteristics of their disaster, so the research associated with it is belong to the traditional engineering geology scope.

The complete gas disaster risk assessment system, applicable to tunnel engineering, is composed of three parts described above: gas tunnel classification evaluation, gas tunnel engineering risk assessment, and tunnel face risk assessment. Therefore, it can make a prompt and accurate assessment of gas disaster in any phase, such as route selection, designation, construction, and take appropriate engineering control measures. The evaluation system is consistent with the construction procedures, but also demonstrated the scientific research idea from the macro to the micro. But how to accurately select the evaluation indicators and assessment methods of tunnel gas disaster risk assessment system remains to be further study.

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