Safety Management for the City Gas Industry

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Theory and Practice in China

By

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PREFACE

As a high-quality energy source, city gas provides great convenience for people's daily life and industries, but it also poses dangers and accidents. Gas safety management involves many fields such as engineering, planning, design, construction, supervision, inspection, operation, maintenance and emergency response. It is not only relevant to those working in the industry, but also the billions of gas consumers.

This book sorts out the important laws and regulations on safe production in force in China, and discusses the safety issues of city gas from a management perspective. It summarises China's practices and experiences in the city gas safety management, which will be of great benefit to the training of relevant enterprises, institutions and professionals across the globe.

There are seven chapters in this book, namely: (1) characteristics and accident hazards of city gas; (2) essential laws and regulations on safe production; (3) enterprise safety management and safety culture; (4) hazard identification and safety evaluation; (5) emergency plan management; (6) accident precaution and management; (7) safe operation and safe use.

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CHAPTER 1

CHARACTERISTICS AND ACCIDENT HAZARDS OF CITY GAS

1.1 Types of City Gas

Gas generally refers to the gas used as a fuel, considering safety and economics. City gas must meet the quality requirements and supply to residential or commercial buildings or industrial enterprises as fuel.

We can classify gas according to its source or mode of production, or from the application's point of view, according to the calorific value of gas or combustion characteristics.

According to the source and mode of production, gas can be broadly classified as natural gas (including coalbed methane), manufactured gas, liquefied petroleum gas and biogas (artificial biogas). Natural gas, manufactured gas, and liquefied petroleum gas can be used as city gas sources. Due to its low calorific value and high carbon dioxide content; however, there are good application prospects as a clean energy alternative to straw and coal in rural areas. In recent years, the research and application of biogas processing and purification technology have been encouraged and supported by the policy in China, and we have used biogas as a vehicle fuel and regional energy in practice.

With the accelerating urbanisation process and the demand for clean energy, new gaseous fuels will continue to enter the urban energy system in various forms. The scope of city gas is also expanding.

1.1.1 Classification by source

1) Natural gas

Natural gas is commonly a gaseous fossil fuel, a mixture of hydrocarbon and non-hydrocarbon gases naturally occurring in the formation. It is a gaseous fossil fuel mainly composed of methane.

Natural gas is extracted from the earth at high pressure and easily transported over long distances. Natural gas has a high calorific value and is quickly and efficiently combusted, making it an excellent and economical natural resource.

We can generally classify natural gas according to its deposits or gas composition characteristics. The composition of natural gas varies depending on the origin, deposit structure, extraction season, and other factors. According to the features of the mineral deposits, conventional natural gas is mainly divided into three categories: gas field gas, condensate field gas, and oil-associated gas.

The gas field is the abbreviation of the natural gas field, which refers to the area rich in natural gas. Gas field gas presents a homogeneous gas phase in the stratum, and when it is extracted, it is called gas-phase natural gas. Its main component is methane, with a content of about 80% ~90%. It also contains small amounts of carbon dioxide, hydrogen sulphide, nitrogen, and trace amounts of helium, neon, argon, and other gases.

Condensate field gas refers to natural gas containing small amounts of light petroleum fractions (gasoline and kerosene components). After the gas is extracted, it is generally depressurised and cooled to separate the two phases of gas and liquid, transported, distributed, and used separately. The methane content of condensate field gas is about 75%.

Petroleum-associated gas refers to the natural gas that coexists with petroleum and is extracted with fat. Petroleum-associated gas is divided into gas cap gas and dissolved gas. Gas cap gas is insoluble in oil and is generally not extracted to maintain the necessary well pressure during the oil extraction process. Liquefied gas refers to the gas dissolved in grease obtained from oil extraction. The main components of petroleum-associated gas are methane, ethane, propane and butane, with small amounts of pentane and heavy hydrocarbons. The gas to oil ratio (gas m^3/crude oil ton) is generally between 20～500 m^3/t.

2) Manufactured gas

Artificially produced gas refers to the gaseous fuel produced by processing solid or liquid combustible materials. Generally, the gaseous fuel made from coal or coke is called coal gas, and the gaseous fuel made from petroleum and its by-products (heavy oil) is called oil gas.

Manufactured gas can be divided into many categories according to the raw materials, production and processing methods, and equipment.

When solid fuels (such as coal) are heated in isolation from the air, they decompose to the products such as combustible gases (dried distillate gas), liquids (coal tar), and solids (semi-coke or coke). This chemical process of solid fuels is known as dry distillation. The gas that escapes from the dry distillation of coal-based fuels is called dry distillation gas.

The process of converting solid fuels (such as coal or coke) into combustible gases through chemical reactions by interacting the solid fuels (such as air, oxygen, water vapour) with gasifying agents (such as air, oxygen, water vapour) at high temperatures is called gasification of solid fuels. The resulting gaseous fuel is called gasified gas.

Oil gas is a gas fuel made by cracking petroleum and by-products (heavy oil, light oil, naphtha) at high temperatures. The calorific value of high-temperature cracked gas with the participation of catalyst can be close to that of the distillate gas.

3) Liquefied petroleum gas

Liquefied petroleum gas (LPG) is a by-product of the oil extraction and processing process, and its main components are propane, propylene, butane, and butene. According to the number of carbon atoms in its molecules, it is often called C_3, C_4.

LPG is pressurised at room temperature or cooled down to atmospheric pressure to become liquid for easy storage and transportation as a mixture of hydrocarbons. Liquefied petroleum gas is a widely used type of gas source, which can be easily re-gasified into a gaseous state by depressurisation or warming.

According to its origin, liquefied petroleum gas is mainly divided into two. One is the natural petroleum gas, coming from the oil or gas field exploitation process, and the other is the refinery LPG from the refiner.

4) Other gas

With the development of science and technology and the gas mentioned above, some other gaseous fuels have been gradually developed and utilised, e.g., coalbed methane and mine gas, shale gas, methoxymethane, light hydrocarbon mixed gas, natural gas hydrates, and biogas.

Coalbed methane and mine gas are combustible gases associated with coal generation and metamorphosis.

Coalbed methane, also called coalfield gas, is a combustible gas produced in coal formation and gathered in a specific geological structure. Its main component is methane, but it also contains carbon dioxide, hydrogen, and a small amount of oxygen, ethane, ethylene, carbon monoxide, nitrogen and hydrogen sulphide, and other gases.

Mine gas is an explosive mixture of coalbed methane and air. During the coal mining process, when the coal seam is extracted and free space is formed in the shaft, the coal seam gas escapes from the coal seam and rock and moves into the distance, where it mixes with the air to create mine gas. Its main components are methane (30% ～55%), nitrogen (30% ～55%), oxygen, carbon dioxide.

Shale gas is an unconventional natural gas stored in organic-rich mud shale and its interlayer, mainly composed of methane. It exists in a free or adsorped state. Although shale gas is difficult to exploit, it is a promising unconventional gas resource with abundant reserves on the ground.

Natural gas hydrate, also known as *combustible ice*, is an ice-like crystalline material formed by natural gas and water under high pressure and low temperature in deep-sea sediments or permafrost of land areas. For its ice-like appearance and ignitability, it is also called *combustible ice*. Combustible ice has a high resource density and is widely distributed worldwide, making it precious.

Biogas is a combustible gas produced by the action of microbes (fermentation) under certain conditions of temperature, humidity, and acidity by isolating the air (such as a biogas digester) from some organic materials (such as straw, weeds, leaves, human and animal manure, municipal garbage, domestic sewage, and other wastes). It contains 60% ~70% carbon dioxide, hydrogen sulphide, nitrogen, and carbon monoxide, with a slight odour and a low calorific value of 20～25 MJ/m^3。

1.1.2 Classification by combustion characteristics

With the gas industry's development, more gas sources with broader variation in composition, resulting in changes in combustion characteristics, enter the city gas market. For gas distribution and appliance manufacturing companies to have a common guideline to follow, they must be classified

by gas source and its related combustion characteristics. The Chinese national standard GB/T 13611-2018 *Classification and essential attributes of city gas* are based on the high calorific value of gas and combustion heat load index (Wobbe index) to classify the city gas, as shown in Table 1-1.

The category and characteristic index of city gas (15°C, 101.325 kPa, dry) shall comply with the provisions of Table 1-1.

Table 1-1: Types of city gas and characteristic indicators

Category		High Wobbe index W_S /(MJ/m^3)		Gross Calorific Value H_S /(MJ/m^3)	
		Standard	Scope	Standard	Scope
Manufactured gas	3R	13.92	12.65~14.81	11.10	9.99~12.21
	4R	17.53	16.23~19.03	12.69	11.42~13.96
	5R	21.57	19.81~23.17	15.31	13.78~16.85
	6R	25.70	23.85~27.95	17.06	15.36~18.77
	7R	31.00	28.57~33.12	18.38	16.54~20.21
Natural gas	3T	13.30	12.42~14.41	12.91	11.62~14.20
	4T	17.16	15.77~18.56	16.41	14.77~18.05
	10T	41.52	39.06~44.84	32.24	31.97~35.46
	12T	50.72	45.66~54.77	37.78	31.97~43.57
Liquefied petroleum gas (LPG)	19Y	76.84	72.86~87.33	95.65	88.52~126.21
	22Y	87.33	72.86~87.33	125.81	88.52~126.21
	20Y	79.59	72.86~87.33	103.19	88.52~126.21
Mixture of LPG & air	12YK	50.70	45.71~57.29	59.85	53.87~65.84
Dimethyl ether (DME)	12E	47.45	46.98~47.45	58.87	59.27~59.87
Biogas	6Z	23.14	21.66~25.17	22.22	20.00~24.44

Note 1: The gas category, expressed as the high wobble index value of the gas in its original unit of kcal/m^3, divided by 1000 and rounded to the nearest whole number, e.g., 12T, so the high Wobble index value of the gas is approximately 12,000 kcal/m^3.

Note 2: 3T and 4T are mine gas or a mixed gas of air and light hydrocarbon, with combustion characteristics similar to natural gas.

Note 3: 10T and 12T natural gas includes dry well gas, oilfield gas, coalbed methane, shale gas, substitute natural gas, and biogas.

[a] Dimethyl ether gas should be used as a single source and not be blended.

1.2 Quality Requirements for City Gas

1.2.1 Basic requirements for city gas

High-quality gas should be supplied to the densely populated cities and towns as a matter of priority to meet energy conservation and environmental protection requirements. As a city gas source, it should meet the basic needs.

1) High calorific value

High energy density lowers the investment level in the transmission and distribution system. Only under particular circumstances, after technical and economic comparison reasonable, the use of the lower calorific value of gas as a city gas source is allowed. The calorific value of city gas should be more significant than 14.7 MJ/m^3.

2) Low toxicity

To prevent gas leaks from causing poisoning and ensure gas safety, we must strictly control the content of carbon monoxide and other toxic ingredients in city gas.

3) Low impurity content

The impurities and harmful components often affect the safety of the gas supply in the gas. Contaminants can cause equipment malfunctions in gas systems, instrument failures, pipeline blockages, improper use of gas appliances, and even accidents.

1.2.2 Effects of impurities and hazardous substances in gas

The impurities and harmful substances contained in the gas have a non-negligible impact on the safety of the city gas supply. The common contaminants and their possible hazards are as follows.

1) Tar and dust

The tar and ash content in dry distillation gas often accumulates in the valves and equipment, resulting in loose valve closure and blockage of pipes and gas equipment.

2) Sulphide

The sulfide in gas is mainly hydrogen sulfide. Besides, there are also small amounts of mercaptans (CH_3SH, C_2H_5SH) and carbon disulfide (CS_2). In natural gas, hydrogen sulfide is the main sulfide. Hydrogen sulfide is a colourless, rotten egg-smelling gas that burns to produce sulfur dioxide. Hydrogen sulfide and sulfur dioxide are both harmful gases.

3) Naphthalene

The content of naphthalene in coal gas is relatively high. At low temperature, gaseous naphthalene will precipitate in a crystalline state, attached to the wall of the pipe, so that the flow section of the tube becomes smaller or even blocked.

4) Ammonia

Ammonia has a corrosive effect on gas pipes, equipment, and appliances and generates nitrogen oxides (NO_x) and other harmful gases during combustion. However, ammonia has a neutralising effect on the acidic substances produced by sulfide, so the presence of a small amount of ammonia in the gas will help protect metal pipes and equipment.

5) Carbon monoxide

Carbon monoxide is a colourless, odourless, highly toxic, combustible gas. Generally, carbon monoxide content in city gas is less than 10% (volumetric component).

6) Nitrogen oxide

Nitrogen oxides are easily polymerised with double-bonded hydrocarbons to form gaseous colloids that can adhere to gas transmission equipment and gas appliances and cause malfunctions. When the concentration of nitrogen oxides in the air reaches 0.01%, it stimulates human respiratory organs, and prolonged exposure can endanger life.

7) Water

Water must be removed from natural gas before it enters long-distance pipelines. The local accumulation of water and other impurities can reduce the pipeline's capacity. Under high pressure, the water in natural gas also readily forms hydrides with the hydrocarbons inside. Acidic gases such as hydrogen sulfide and carbon dioxide dissolve in water, increasing the corrosion of metal pipes and equipment. The transmission and distribution system has to be improved in drainage facilities and pipelines' maintenance to transport water-bearing gas.

1.2.3 Quality requirements for city gas

1) Natural gas

The quality standard of natural gas shall conform to GB 17820-2018 Class I or Class II gas provisions in Table 1-2.

Table 1-2: Technical specifications of natural gas (GB17820-2018)

Items	Class I	Class II
High calorific value (MJ/m^3) ≥	34.0	31.4
Total sulphur (in terms of sulphur)(mg/m^3) ≤	20	100
Hydrogen sulfide(mg/m^3) ≤	6	20
Molar fraction of carbon dioxide (%) ≤	3.0	4.0

* The standard reference condition used in this standard is 102.325 kPa at 20°C.

2) Manufactured gas

The quality of manufactured gas should be under the provisions of GB/T 13612 in Table 1-3.

Table 1-3: Quality standards for manufactured gas

Items	Quality indicators	Impurity limits
Low calorific value [a] (MJ/m^3)		
Class I [b]	＞14	GB/T 12206
Class II [b]	＞10	GB/T 12206
Gas Properties Index (GPI) [c] fluctuation range compliance	GB/T 13611	
Impurities		
Tar & dust /(mg/m^3)	＜10	GB/T 12208
Hydrogen sulfide /(mg/m^3)	＜20	GB/T 12211
Ammonia /(mg/m^3)	＜50	GB/T 12210
Naphthalene[d] /(mg/m^3)	＜$50\times10^2/P$ (winter) ＜$100\times10^2/P$(summer)	GB/T 12209.1
Oxygen content[e] (volumetric fraction) /%		GB/T 10410.1 or chemical analysis methods
Class I	＜2	
Class II	＜1	
Carbon monoxide content [f] (volumetric fraction) /%	＜10	GB/T 10410.1 or chemical analysis methods

Note: a. This standard gas volume (m^3) refers to the book at 101.325 kPa at 15°C.
b. The gas of Category I is dry distilled coal gas. Category II is coal gasified gas, oil gasified gas (including liquefied petroleum gas and natural gas reforming).
c. Combustion characteristic index: Wobbe Index (W), combustion potential (CP);
d. Naphthalene system refers to naphthalene and its congeners α-methylnaphthalene and β-methylnaphthalene. When the absolute pressure (P) at the pipeline transmission point (P) is less than 202.65 kPa, the pressure (P) factor may be excluded from the calculation.
e. Oxygen content refers to the indicator required for the production process in a gas plant.
f. The carbon monoxide content shall be less than 20% by volume for the gas of Class II or Class I adulterated with Class II gas.

3) Liquefied Petroleum Gas

The content of sulphur, moisture, ethane, and ethylene in LPG should be confined. The amount of residual liquid (C_5 and above) should be under control, as C_5 and above components cannot be vaporised naturally at room temperature.

The quality standards for LPG as industrial and civil fuel are different from those for vehicles. Table 1-4 from GB 11174-2011 shows the quality standards for LPG as industrial and residential fuel.

Table 1-4: LPG quality standards

Items	Quality standard			Test method
	Commercial propane	Commercial propane-butane mixture	Commercial butane	
Density (15℃) /(kg/m^2)	report			SH/T 0221
Vapor pressure (37.8℃) ≤	1430	1380	485	GB/T 12576
Component%				
C_3 hydrocarbon fraction (volume fraction)/% ≥	95	—	—	SY0230
C_4 and higher hydrocarbon fractions (volume fraction) /% ≤	2.5	—	—	
(C_3+C_4) hydrocarbon fraction (volume fraction)/% ≥	—	95	95	
C4 and above hydrocarbon fraction (v/v)/% ≤	—	3.0	2.0	
Residue				
Evaporation residue/(ml/100ml)≤	0.05			SY7509
Oil stain observation	-			
Copper sheet corrosion (40°C, 1h)/grade ≤	1			SY0232
Total sulfur content/(mg/m^3)≤	343			SY0222
Hydrogen sulphide (subject to one of the following requirements)				
Lead acetate	None			SY0125
Chromatography /(mg/m^3) ≤	10			SY0231
Free water	None			visual assessmen*

* In case of dispute, visually check the presence of free water using SY0221 instruments and test conditions.

1.2.4 Odorisation

Gas is a flammable and explosive hazardous product. Therefore, it is required that the gas must have a distinctive, detectable, and warning odour. When a gas leakage occurs during customer use, it should be detectable by smell. The fragrance should be added to the gas, which is odourless or has a low odour. Gas concentration detection devices should also be installed on industrial and commercial users' premises to detect the presence of a gas leak.

Gas delivered to the city via long-distance pipelines is generally odorised at the city gate station.

The odorising agent should have the following characteristics.

1) The odorant should not be harmful to humans, pipes, or materials in touch within the usual concentration range.

2) The distinctive odour should be persistent, unpleasant, and distinctly different from ordinary gas odours.

3) Appropriate volatility.

4) Burning completely and the combustion products should not be harmful to the human respiratory system and should not rust or injure materials in regular contact with the combustion products.

5) Not chemically reacts with the components of the gas.

6) The degree of dissolution in water should not be greater than 2.5% (mass composition).

7) Low cost.

In China, the commonly used odorants are mainly tetrahydrothiophene (THT), ethyl mercaptan (EM). Also, non-alcoholic odorants are in use.

1.3 Forms and Features of the City Gas Supply System

The city gas supply system mainly has two forms: pipeline and bottled supply.

The supply system of the city gas pipeline is generally composed of gate stations, gas pipeline networks, gas storage facilities, pressure regulating devices, management facilities, monitoring systems. The received gas is delivered to the user through the transmission and distribution pipe network. The gas source is mainly natural gas or manufactured gas. Also, in some

areas, liquefied petroleum gas (LPG) mixed with air (i.e., the substitute natural gas) is supplied to users in the form of the pipeline.

The gas sources of the bottled supply system include liquefied petroleum gas (LPG) and liquefied natural gas (LNG), using special metal cylinders for commercial and residential uses.

1.3.1 Gas pipeline supply systems

Gas pipeline supply is the main form of city gas supply, with the following main features.

1) Multiple pressure levels

China" city gas pipelines are divided into seven levels according to their design pressure P (MPa), and the design pressure grading standards for pipelines are shown in Table 1-5.

Table 1-5: The design pressure of the city gas pipeline (gauge pressure)

Items		Pressure *P* (MPa)
High-pressure gas piping	A	$2.5<P\leq4.0$
	B	$1.6<P\leq2.5$
Sub-high pressure gas piping	A	$0.8<P\leq1.6$
	B	$0.4<P\leq0.8$
Medium pressure gas piping	A	$0.2<P\leq0.4$
	B	$0.01\leq P\leq0.2$
Low-pressure gas piping		$P<0.01$

Depending on the size of the city, the gas supply system can be a single-stage or multi-stage system to meet transmission and user pressure requirements. Gas power (thermal) plants, large industrial users, boiler houses usually require high or medium pressure gas; commercial and residential users generally use medium and low-pressure gas devices.

2) Wide range of pipe laying

Depending on the city planning and the distribution of gas users, city gas pipes are laid along streets and alleys. Underground gas pipes are usually laid on sidewalks, in green belts, on slow lanes, and under fast lanes. Customer gas pipes are laid on the facade of buildings and inside buildings.

3) Meet with the customers of different types and sizes

The gas supplied by pipeline can meet residential, commercial, industrial, heating and air conditioning, thermal power plants, and other users. The supply capability is guaranteed, and the gas supply is stable and safe.

4) System complexity

The gas system belongs to the city's infrastructure. There are many types and large quantities of equipment and facilities in the system, and the construction period is different. Therefore, systematic management is needed to ensure its integrity and safety.

1.3.2 Bottled supply systems

Bottled supply refers primarily to the LPG cylinder supply, which can be used alone or supplement the pipeline supply system. The features of the bottled supply system are listed below.

1) System scale and the investment controllability

The bottled supply plant's storage, filling scale, and investment can be adjusted and controlled as needed. The cylinders and transport vehicles can be purchased and used in phases. The supply area can be set and adjusted flexibly.

2) Low demands

Most residential household users use a single bottle gas supply, while commercial and small boiler plants and industrial users can use double bottles or groups of bottles for gas supply. It is not recommended to use the bottled gas supply for significant gas demand.

3) Safety and economy of the cylinders' transportation

As for the transportation of cylinders, the economy, safety, and other related factors should all be considered determining the transport modes and transport distance reasonably. The relevant departments shall develop and approve a transport safety management system.

1.4 Gas Accidents and Hazards

Every coin has two sides. As high-quality energy, the city gas brings us the convenience of production and life, but it also means danger when the gas system is abnormal.

In the gas production, storage, transportation and use process, once severe accidents, e.g., damaging leaks, fire and explosion occur, it will force the production system temporarily or longer-term to be interrupted and cause casualties and property losses, owing to the process continuity, high automation degree, technology complexity and the equipment variety.

Accidents have increased sharply with the continuous expansion of gas production and consumption, especially for natural gas. The consequences of accidents have become more and more serious, restricting the gas industry's development to some extent.

1.4.1 Features of gas accidents

Gas accidents have both general features and particularities.

1) Universality

There are wide ranges of gas pipelines and facilities in the city, and gas accidents may occur in and around any place with gas pipelines or gas facilities.

2) Emergency

City gas accidents generally occur suddenly. The damage to gas equipment or gas pipelines, including external damage by third parties, occurs typically without warning. Gas leaks often occur without people noticing.

3) Unpredictability

Some accidents can be predicted based on environmental and other factors. For instance, air and road traffic accidents may occur more frequently in bad weather. However, city gas accidents generally have little to do with factors such as climate and may appear in any season and under any weather conditions. Therefore, gas accidents are usually unpredictable and challenging to prepare for in advance.

4) Large influence range

When a gas accident occurs, not only does it affect the production, delivery, and use of gas, but certain surrounding areas are often affected by accidents as well. For example, if a gas explosion occurs in a residential building, it may cause the entire building to be damaged and affected. Once a gas explosion occurring in the residential building has caused damage to the building, it has to be dismantled as a whole after the explosion accident. Gas pipeline leaks may cause gas outages in a region of several kilometres.

5) Serious consequences

Many gas accidents can cause fires and explosions, resulting in injuries and property damage.

6) Secondary damage

In an earthquake, landslide, stratigraphic change, and flooding, damage to gas facilities may cause secondary damage. In many earthquakes, fires started after gas lines broke or leaked, which caused more severe damage than the earthquake itself and made it difficult to rescue people after the disaster.

1.4.2 Gas hazard and hazard analysis

1) Flammability and toxicity

The flammable and explosive characteristics of gas make it possible to meet air near the leakage point and mix to form combustible gas once the gas leaks. When it encounters fire, high temperature, electromagnetic radiation, radio and microwave, and other ignition sources, it may cause fire and explosion.

City gas must be purified before it reaches the town and must meet the requirements of the relevant standards. The toxicity of city gas is low, but it can still cause suffocation or poisoning at high concentrations. In particular, the manufactured gas contains colourless, odourless, highly toxic carbon monoxide (CO). Although the CO content is limited in the city gas quality requirements, the consequences of poisoning may still be serious when the leakage is significant.

2) Volatility and diffusivity

City gas leaks into the air and then spreads. High-pressure gas is ejected at high velocity from the pipe or equipment opening and spreads rapidly in the

air. If the gas cloud does not encounter the fire source, the harm will decrease with the gradual diffusion of the gas cloud and the decrease of pressure and concentration. However, fire and explosion accidents will occur if ignited, causing casualties and property losses.

When LPG leaks, the vapour cloud diffuses close to the ground, which is not accessible to volatilise and is easily ignited by ground ignition sources. When a large amount of LPG leaks, in the process of rapid gasification of LPG, it will quickly absorb the heat around it and form a low-temperature state locally, which may cause frostbite of personnel or failure of equipment and valve closure.

CNG, i.e., compressed natural gas and LPG, increased rapidly in Chinese cities and towns. Its characteristics of high pressure and low temperature make it more dangerous. A large leak of LPG calls for specialised response and disposal.

3) Flue gas hazards

When the gas combusts completely, the combustion products consist mainly of carbon dioxide (CO_2) and water. Once the gas cannot burn entirely, the flue gas contains CO. If it cannot be discharged in time and collects in a small space, it may cause suffocation or even death. Most poisonings and fatalities are because the indoor air was consumed, and the flue gas after combustion gathers indoor. It causes harm under the combined anoxic and toxic action.

4) Occupational hazards

City gas is a low-toxic gas that does not cause occupational hazards for employees under normal circumstances. However, in the places of gas production, storage and LPG filling, emergency repair of leakage accidents, attention should be paid to the protection of employees according to the monitoring of gas concentration.

The carbon monoxide levels and allowable operating hours in the work area are shown in Table 1-6. The relationship between airborne hydrogen sulphide (H_2S) concentrations and organism reflection is shown in Table 1-7.