Elementary knowledge of safety and explosion protection

1.1 Characteristics of explosion

A phenomenon, in which substances are converted from one state into another and massive energy and sounds are instantaneously released, is referred to as explosion. Internal characteristics of explosion: When a substance explodes, the massive generated gases and energy are suddenly released and sharply converted within a finite volume, and they are built up within the finite volume within a very short period of time, to lead to high pressure and high temperature. External characteristics of explosion: Under the action of pressure effects, the exploded medium impacts the peripheral objects with sharp and abrupt pressure, or leads to mechanical destructive effects. Acoustic susceptance effects may be generated by peripheral objects and media due to vibration.

1.2 Explosion conditions

Explosion may take place only when the following 3 conditions are available:

- Steam or haze of flammable gas or inflammable liquid exists;
- Oxygen (air)

The above-mentioned gases are mixed with air or oxygen in definite proportions, and form an explosive gas mixture with a concentration falling within the explosion limit.

- Ignition sources

Ignition energy enough for igniting the mixture is available, such as sparkles generated by friction and impaction, electric arc or hot surfaces.

Table 28: Explosion limits of some flammable gases and oil products

Inflammable gas	Explosion concentration limit/% (volume)		Name of oil product	Explosion concentration limit/% (volume)	
	Lower limit	Upper limit		Lower limit	Upper limit
Methane	4.9	15	Solvent oil	1.4	6.0
Ethane	3.22	12.45	Aviation kerosene	1.4	7.5
Propane	2.1	9.5	Kerosene	0.8	6.5
Butane	1.5	8.5	Automobile gasoline	1.0	8.0
Natural gas	1.1	16	Kerosene	0.6	6.5

1.3 Explosion protection measures

The coexisting of three essential conditions preventing the chemical explosion of flammable substances is the elementary theory of explosion protection and the

essence of all technical measures taken to prevent chemical explosion of flammable substances. The bottom-most thinking is to replace the flammable substance or oxygen with non flammable substances, or reduce their quantity in so far as possible such that they cannot form explosive mixture. The hazard area shall be additionally ventilated by setting up blowers or applying some architectural changes.

Measures:

- Reduce the concentration of explosive substances by additional ventilation
- Use casings full of inert substances
- Take detection measures such that an alarm may be given in time once the specified range is exceeded, and the system may be cut off.
- As per the grades of explosion hazard areas and grades and grouping of explosion gas mixture, adopt electrical equipment of corresponding types, or adopt electrical equipment the corresponding items of which are higher than those mentioned above.

1.4 Division of explosion hazard areas

Division of gas-explosion hazard areas

Grade-0 area (abbreviated as "area 0"): It refers to an environment where explosive gas mixture may occur continuously or chronically, or occur frequently for a spell under normal condition.

Grade-1 area (abbreviated as "area 1"): It refers to an environment where explosive gas mixture may occur periodically or occasionally under normal condition

Grade-2 area (abbreviated as "area 2"): It refers to an environment where explosive gas mixture may not occur under normal condition, or only occur for a spell.

1.5 Explosionproof electrical equipement

- Types of explosion protection

Isolation type (Ex d): An explosion isolation casing is adopted to envelope the components, and the casing may withstand the internal explosion pressure and prevent the flames from spreading outward.

Increased safety type (Ex e): No electric arcs, sparkles or high temperature, which may ignite the explosive mixture, occur under normal operating conditions, and some suitable structural measures may be taken so as to improve its safety.

Intrinsic safe type (Ex i): No sparkles or heating effects generated in normal operation or faulty state under standard experiment conditions may ignite the explosive mixture (Ex i) .

Pressurized type (Ex p): A casing, which may maintain the pressure of non-explosion gas inside electrical equipment at a level higher than that of the peripheral explosive gas, is adopted so as to prevent the external explosion gas from entering into the casing.

Oil immersed type (Ex o): It indicates that all or some live parts are immersed in oil such that it cannot ignite the explosive mixture above the oil level or around the casing.

Sand filled type (Ex q): The casing is filled with non-inflammable particulate material, such that the electric arcs and sparkles generated inside the casing, and the superheating temperature of casing walls or surfaces of particulate material cannot ignite the explosive mixture around the casing.

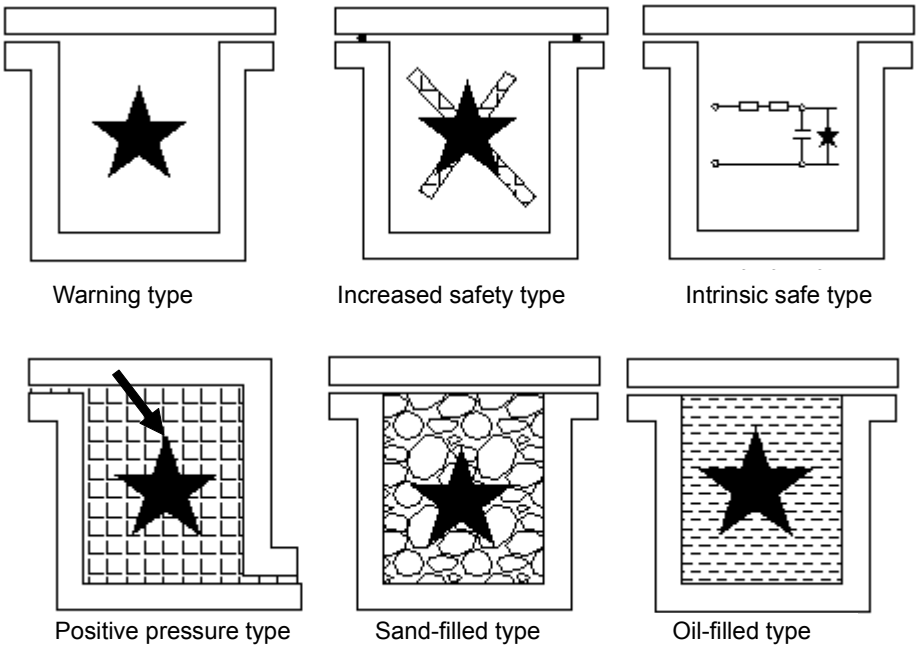

Fig. 9.5 Simplified diagram of the types of explosion protection

1.6 Basic principle of division of hazard areas of gas station

- Basic principles of classification of hazard areas

The grades of explosion hazard areas shall be defined as per the current national standard *GB50058 Design specifications for electrical installations in environment with explosion and fire hazards*. The division of hazardous areas shall be performed as per the principle of "Distinguish the hazard sources, conduct detailed global analysis, and perform division rationally", such that the locations with hidden explosion hazards or potential hazards may be authentically rated as hazardous area, and the locations whose hazard level may be reduced by measures may be rated as low-level hazard areas or safety areas. Since gasoline is a type of inflammable liquid, and its vapor may be mixed with air and the mixture may easily develop into explosive gas mixture that falls within type-II explosive mixture; therefore, the filling stations shall be rated as environmental explosive-gas hazard areas. As per GB50058-92, the explosive-gas environment of gas stations shall be zoned in accordance with the occurrence frequency and duration time of explosive gas mixture.

Area 0: It refers to a type of environment where explosive gas mixture occurs continuously or chronically. For example, inside the fixed-type storage tanks that are presently adopted by most of the gas stations, the space not filled up with inert gas above the inside-tank liquid surface may be rated as area 0;

Area 1: It refers to a type of environment where explosive gas mixture occur possibly during normal operation, such as the locations where flammable substances may possibly leak due to product drawing-off or cap opening/closing when necessary during normal operation, for instance a space (of 1.5m in radius) around the exhaust outlet of a tank centering round the vent;

Area 2: It refers to an environment where explosive gas mixture may impossibly occur under normal condition, or only occur for a spell, such as the locations where flammable substances may possibly leak due to erosion and aging etc.

- Principle of releaase source grading and division of ventilation types:

The release sources shall be divided into 3 grades as per the release frequency, duration time and quantities of inflammable substances, namely, the continuous release sources, grade-1 release sources and grade-2 release sources.

Continuous release source: It refers to the release sources that are estimated to have chronicle release or short-time frequent release, including the space between inflammable liquid surface and tank deck inside a fixed-roof storage tank. The surface of inflammable liquid directly exposed to the atmosphere of oil-water separator, and the open vent holes and other ports that frequently or chronically release inflammable liquid into the atmosphere.

Grade-1 release sources: It refers to the release sources estimated to conduct occasional release during normal operation (the sealed positions of pumps, compressors and valves that may release inflammable substances during normal operation, drainage systems that are installed on vessels containing inflammable fluid and may release inflammable substances to the atmosphere, and sampling points that may release inflammable substance to the atmosphere during normal operation).

Grade-2 release sources: It refers to the release sources that may not conduct release under normal operation, or only conduct occasional short-time release (sealing positions of pumps, compressors and valves that may not release inflammable substances during normal operation), flanges, junction pieces and conduit joints that may not emit released substances during normal operation, relief valves, vent holes and other orifices that may not release substances into the atmosphere during normal operation, and sampling points that may not release inflammable substances to the atmosphere during normal operation.

There may be release sources provided with the characteristics of two (2) or three (3) of the three (3) grades i.e. continuous release source, grade-1 release source and grade-2 release source at some sites, and they may be referred to as multistage release sources.

The root factors for determining the types of hazard areas are exactly to distinguish the release sources and determine the grades of release sources. The division of hazard areas of explosive gas environment shall be determined as per the grades of release sources and the draft conditions, and shall conform to the following provisions:

Firstly, divide the areas as per the levels of release sources:

The areas where continuous release source exists may be rated as area 0;

The areas where grade-1 release source exists may be rated as area 1;

The areas where grade-2 release source exists may be rated as area 2.

Secondly, adjust the area division as per draft conditions:

(1) When the site is well-ventilated, the grade of explosive hazard area shall be lowered. When the site is poorly ventilated, the grade of explosive hazard area shall be raised.

(2) When local mechanical ventilation is more effective on reducing the concentration of explosive gas mixture than natural ventilation and general mechanical ventilation, local ventilation may be adopted to lower the grades of explosion hazard areas.

(3) For the obstacles, potholes and corner pockets, the grades of explosion hazard area shall be locally raised.

(4) Obstacles such as dyke or wall may be used to restrict the diffusion of explosive gas mixture heavier than air to reduce the range of explosion hazard areas.

- Possible release sources of gas stations

The places or locations where substances capable of forming explosive mixture may be released are referred to as release sources.

Before analysis is conducted, we shall learn about the overall layout of a gas station. In other words, the layout chart of gas station building, facilities and

peripheral facilities shall be surveyed and mapped first. Presently, most gas stations are composed of underground horizontal storage tanks, gasoline filling islands (fuel dispensers), oil unloading yard and station building (power distribution room, office rooms etc.). The fueling system is composed of fuel tanks, fuel dispensers and fuel pipelines. Therefore, mainly three facilities of a gas station may give rise to release sources, namely filling tank (including oil filling opening), fuel dispensers and fuel pipelines (including gate valves etc.).

(1) Possible release sources of filling tank

Presently, most gas stations are equipped with underground horizontal fixed-type storage tanks the possible release sources of which include: manhole seal, exhaust outlet (guided to atmosphere at a height higher than 4m), oil inlet (led to oil unloading yard through steel pipe) and oil outlet (led to delivery port of fuel dispenser through steel pipe). Relative specific gravity of fuel vapor and air is greater than 2.5, and the fuel vapor may easily be built up on the ground and may be diffused from relatively a low place to quite distant places. Therefore, the division of hazard areas of inflammable substance (heavier than air) storage tanks and buried gasoline storage tanks shall conform to the following provisions.

① The space above in-tank oil surface may be rated as area 0.

② For the inner space of manhole (valve) pit, the spherical space of 1.5m (0.75m) in radius centered on the breather pipe orifice and the spherical space of 0.5m in radius centered on the sealed oil unloading port shall be rated as area 1.

③ The cylindrical space 1m above the ground surface and less than 1.5m away from the external rim of the manhole (valve) pit, the spherical space of 3m (2m) in radius centered on the breather pipe orifice, and the spherical space (extending to the ground surface) of 1.5m in radius centered on the sealed oil unloading port shall be rated as area 2.

④ (Note: For the explosion hazard areas of breather pipe of gasoline tank equipped with oil-unloading vapor recovery system, the bracketed figures shall be adopted)

⑤ If the periphery of storage tanks is provided with a border dike, the range ranging from outer wall of storage tanks to the border dike and with a height equal to the dike top height shall be rated as area 2.

⑥ Oil unloading yard: The space of 1.5m in radius centered on the oil filling opening of fuel tank (oil unloading port of tank truck) shall be rated as area 1.

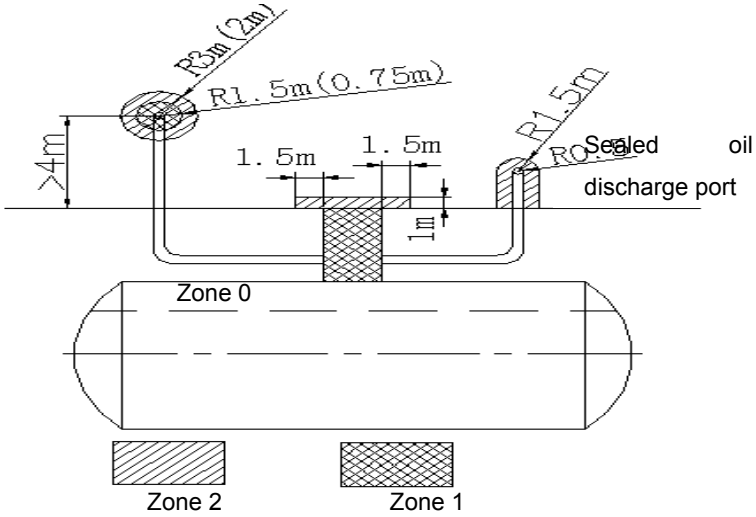

Fig. 9.6.1 Division of explosion hazard zones of underground horizontal tank

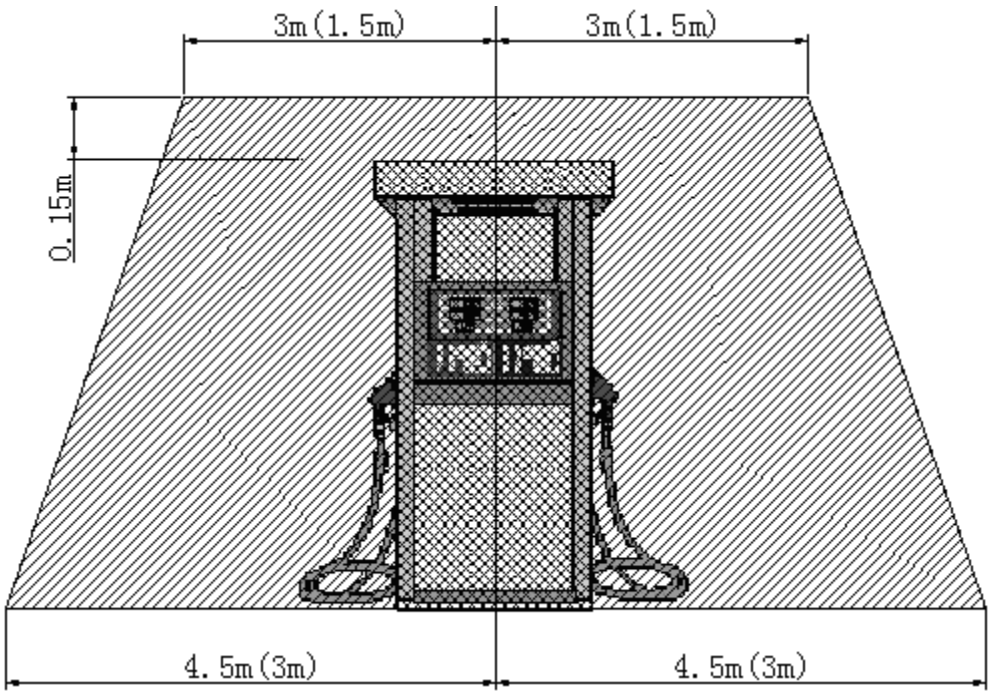

Fig. 9.6.2 Division of explosion hazard zones of fuel dispenser

(2) Possible release sources of fuel dispensers

Fuel may possibly leak from a fuel dispenser either under normal operating conditions (including fueling waiting state) or in fault status. Major positions where leakage may possibly occur and the causes are listed below:

① During normal operation

As shown by the operating principle of a fuel dispenser, the oil-gas separator may implement continuous venting and release fuel vapor when the dispenser works in its fueling state. The liquid oil accumulated to a definite amount inside the oil-gas separator may return to the low-pressure chamber when the oil drain valve float inside the normal-pressure chamber floats up. However, liquid oil inside the normal-pressure chamber may be subjected to outward venting due to spontaneous evaporation exactly during that period of time. When the dispenser is conducting fueling, oil-gas may be released from the oil-supply head due to nozzle fueling; when fueling is over, residual fuel inside the nozzle may be subjected to spontaneous evaporation, and the residual fuel inside the hose may leak through the nozzle mouth.

② Fault status
The joint packing of oil suction pipe and lower flange is untight; the sealing

elements of pump or oil-gas separator are aged; bearing sleeves of oil pumps or flow meters are worn, or reinforced seal is worn; built-in fuel transfer line is broken due to erosion or vibration; oil-gas separator is faulty and oil flows out of vent-pipe; oil leaks from the commissure of the mechanical parts; and oil leakage occurs because the nozzle cannot be self-sealed.

As per the above analysis, the interior release sources of a fuel dispenser are determined as follows:

Continuous-grade release source: nil

Grade-1 release sources: exhaust outlet of oil-gas separator and oil filling opening of nozzle, which are chronically opened in fueling state;

Grade-2 release sources: the sealed positions, commissures and pipeline adapting/connecting positions of fuel dispenser pump, oil-gas separator, flow meter, solenoid valve, sight glass and bellows oil inlet, which are estimated not to release fuel in non-fueling state.

Therefore, the division of explosion hazard areas of gasoline dispensers shall conform to the following provisions:

① The space inside fuel dispenser case may be rated as area 1.

② The truncated cone space, which takes the fuel-dispenser center line as center line, takes the ground area of 4.5m (3m) in radius as bottom surface, and takes the plane 0.15m above the top of fuel dispenser and of 3m (1.5m) in radius as top surface, may be rated as area 2.

(Note: For the explosion hazard areas of fuel dispenser equipped with fueling vapor recovery system, the bracketed figures shall be adopted)

(3) Possible release sources of fuel delivery pipeline

When any pipelines, components or mouthpieces of the whole hydraulic system (from tank oil taking to oil receiving vessel) of a fuel dispenser are leaking, malfunctioned or even are broken, there bound to be discharged fuel that may be then vaporized, and they may be rated as grade-2 release sources. Therefore, the cylindrical space of 1.5m in radius and taking the pipeline axial as its axial may be rated as area 2.

- Division of hazardous areas of gas station

To sum up, for division of hazardous areas of a gas station, the layout charts, elevation views and the relative positions shall be surveyed and mapped as per the positions of the tanks (including the oil unloading yard), fuel dispensers, fuel pipeline (including the gate valves), station building and switching house (including the diesel engine room), and then the layout charts and elevation views of areas 1 and 2 shall be plotted as per the positions of release sources described above. It is worth notice that the pits and trenches beneath the floor of explosion hazard areas of gasoline facilities shall be rated as area 1. Finally, explosion-proof electrical equipment applicable to the hazard areas shall be selected.