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Analysis and Improvement of Grounding Problems in the Petrochemical Industry

Wang Weili[1,a,*], Liang Haibo[1,b]

[1]*College of Mechanical and Electrical Engineering, Southwest Petroleum University, Chengdu, Sichuan Province, 610599, China*
[a]*wangweili533@163.com*, [b]*secondbo@126.com*
[*]*Corresponding author*

Abstract: *Within the petrochemical industry, the degree of specification of electrical grounding can seriously affect product safety. Based on device grounding and safety design standards, this paper forms final recommendations for grounding installation and selection at production sites by exploring and considering corrosion conditions and media properties. Based on the grounding and safety design standards of the device, this paper discusses the installation and selection of grounding at the production site and forms the final recommendations by considering the corrosion conditions and media properties in order to improve the design and construction, so as to achieve the purpose of anti-electricity, anti-static and safe operation.*

Keywords: *lightning protection; anti-static; instrumentation; grounding*

1. Introduction

Electrical grounding refers to the exposed parts of electrical equipment and devices being connected to the ground through conductors, and static electricity and supply current are introduced to the ground, which is the basic guarantee for safe use and stable operation of the device. Correct grounding is required for the normal operation of electrical equipment and instruments, and is also a meaningful way to ensure personal safety and reduce electrostatic hazards. However, for different types of electrical grounding protection in practical applications, there are problems such as non-standard grounding installation, unclear type selection, and complex electrical grounding construction in different environments. In order to avoid electrical explosion caused by non-standard installation and mismatched type selection of devices on the production site, this paper summarizes the common electrical grounding problems through safety design standards and application status, and analyzes the existing common problems in depth and gives suggestions or measures.

2. Grounding Classification and Role

Device grounding package oil is mainly composed of alkanes, naphthene and other hydrocarbon mixtures. The materials in petrochemical enterprises' high-temperature and high-pressure production processes are extremely volatile. The volatile matter is flammable and explosive, which has caused unpredictable consequences for life and property, and has caused adverse impacts on the environment and society. By analyzing the causes of accidents, it is found that lightning and the static electricity are the main factors triggering fire or explosion accidents. The degree of standardization of lightning and static protection measures can seriously affect product safety. However, due to the diversity of industries, safety design standards are not always the same. The electrical grounding in accordance with the industrial safety design standards, can effectively avoid the safety hazards caused by static electricity, including lightning protection grounding, anti-static grounding, instrument protection grounding, etc. Because electrical grounding involves different safety design standards, construction personnel cannot achieve absolute specifications under different grounding standards and grounding types. Furthermore, as the service time of the device increases, there is a problem of "low, old, and bad" in the field grounding.

2.1 Lightning Protection Grounding

Lightning protection grounding is divided into external and internal lightning protection grounding.

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External lightning protection mainly refers to the electromagnetic effect of lightning and side lightning on the building and the impact on the internal equipment of the building. Currently, the external lightning protection is mainly through the foundation grounding body, lightning rod, equipotential, lightning arrester, etc., to provide the necessary conditions for internal equipment induction lightning protection. External lightning protection measures will significantly reduce the electromagnetic effect of lightning strikes on buildings. On the other hand, internal lightning protection prevents equipment from lightning induction and lightning wave intrusion. In the petrochemical industry, technical measures such as shielding, grounding, equipotential treatment, and installation of shunt voltage limiting devices are adopted to control and reduce the impact of lightning induction and lightning wave intrusion on equipment.

2.2 Anti-static Grounding

In the petrochemical industry, the harm of static electricity is widespread. The generation of static electricity can cause equipment and instrumentation malfunction, affect the service life of equipment, and generate electrostatic sparks to cause electrical explosions. Due to the volatilization of a large number of hydrocarbon gases in the production process of the petrochemical industry, effective anti-static measures must be taken. Through grounding, objects with static electricity or objects that may generate static electricity will form an electrical circuit with the earth through the electrostatic conductor, and the electric shock current will be safely led to the earth.

2.3 Working Grounding

Instruments and equipment are mostly connected with other parts in the production process. Ensuring the measurement and control accuracy is the key to the allocation in the production process. The stable supply of current will impact the measurement and control accuracy of instrument equipment. Working grounding measures can maintain the system's potential stability and reduce the harm of overvoltage caused by the high-voltage system channeling into the low-voltage system.

2.4 Protective Grounding

Due to the extremely high measurement accuracy and strong current power supply, the body shell is not charged under normal operation. When the fault occurs, the power supply fire line and the shell short circuit to form a charged body. Through the protective grounding measures, the body shell and the ground between the formation of a suitable conductive connection, weakening the ground and the body shell potential difference.

3. Problem Analysis and Improvement

There are many existing standards and specifications for electrical groundings, such as SY/T 7385-2017, SH/T 3081-2019, GB 15599-2009, GB 50093-2013, GB/T 50892-2013, SY/T 5984-2020, GB 50183-2004, Q/SY TZ 0282-2019, SY/T5984-2020 and other industry standards. Petrochemical enterprises generally design and construct electrical grounding for working areas according to lightning protection grounding, anti-static grounding, working grounding and protective grounding requirements. However, due to the neglect of grounding devices, grounding equipment models, media properties, corrosive environment and other issues by on-site personnel, the grounding installation is not standardized and the grounding selection is not reasonable, leading to the failure to effectively solve the safety problems in the working area.

3.1. Common Grounding

According to GB 15599-2009, SY/T 7385-2017, SH/T 3081-2019 and other standards and specifications, lightning protection grounding in buildings should share a set of grounding devices with AC working grounding, DC working grounding and safety protection grounding. For instrumentation grounding, the field instrumentation metal housing, metal protection box, and metal junction box that needs to be implemented for protective grounding should be connected to the grounding network and other metal components nearby [1]. Under the condition of common grounding, the anti-static grounding of production facilities should share the grounding device with electrical protection grounding, information system grounding, and lightning protection grounding system other than an independent

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lightning arrester grounding system [2]. If lightning protection grounding is available, anti-static grounding is not required. Common grounding will reduce the generation of redundant grounding lines, reduce the tedious work of construction personnel, and obtain higher detection efficiency through existing detection methods.

3.2. Instrument Grounding

According to GB 50093-2013 and GB/T 50892-2013 and other standards and specifications, through the analysis of the power supply voltage of instrument grounding and the field use of instrument grounding in an explosive hazardous environment, the appropriate grounding measures are selected. Enclosures of field instruments with power supply voltage higher than 36 V shall be protected and grounded. For instruments with power supply voltage not higher than 36 V, if there are no special requirements in the design, protective grounding can be omitted [3] [4]. The metal shell, frame, instrument cable tray, cable protection tube, etc. of all instruments and equipment in an explosive hazardous environment shall be grounded. Non-explosive hazardous environments and instruments with power supply voltage of 36 V and below may not be grounded for protection [5].

3.3. Flange bridging

In petrochemical enterprises producing metal pipelines conveying flammable and explosive substances, metal pipe flanges very easy to generate static electricity. In this regard, the static electricity generated at the metal pipe flange shall be eliminated by the flange static electricity bridging measures. Further analysis is made by using transition resistance, ferrule and bolt at the connection under the metal pipe flange bridging measures. When the transition resistance of elbows, valves, flanges and other connections of long metal objects is greater than 0.03 Ω, the connection shall be connected by metal wire to realize flange static bridging; When the metal pipe flange is fastened with metal bolts or clips, it is not necessary to install additional static connecting wire [6]; Flanges connected by not less than 5 bolts may not be bridged under non-corrosive environment [7].

When connecting metal pipes, valves and flanges with flanges, it is necessary to consider the changes of electrostatic bridging measures under different corrosion conditions or media properties.

3.3.1. Under corrosive conditions

Before installing flange bolts or clamps, oil or rust should be removed from the contact surface; the anti-loosening nut needs to be added during installation. The flange and other joints need to be measured at the transition resistance for the design by electrostatic grounding of metal pipes. When the transition resistance exceeds 0.03 Ω, the wire should be made electrostatic cross-connection [8].

3.3.2. Non-corrosive conditions

At the metal flange under non-corrosive conditions, more than five metal bolts or clips are required to make fixed connections to the confined metal flange. When the above situation is completed, the conductive contact between the bolts or clips needs to be tested. As shown in Table 1, when the transition resistance at the connection is greater than 0.03 Ω, it is necessary to use 16 mm^2 copper core flexible stranded wire or flexible copper braided wire for static bridging measures. General conditions may not be installed separately with electrostatic jumper wire electrostatic elimination measures.

3.3.3. Media properties

When metal pipelines transport natural gas, liquefied petroleum gas, light hydrocarbon and condensate, and the flange plate at the flange is connected with less than 5 bolts, 16 mm^2 copper core flexible stranded wire or flexible copper braided wire shall be used for static bridging, and a margin of not less than 100 mm shall be reserved at the flange jumper.

3.3.4. Flange bridging standardization under corrosive environment and medium properties

In the non-corrosive environment, no less than 5 bolts are required to be bridged; In addition, the fixed position of flange plate with more than 5 bolts shall be bridged; When the resistance is greater than 0.03 Ω, no matter how many bolts are to be bridged. In corrosive environment, or when transporting natural gas, liquefied petroleum gas, light hydrocarbon and condensate, and less than 5 bolts, bridging shall be made; When there are no less than 5 bolts or no more than 0.03 ohm, it's okay of no bridging; For more than 4 bolts in corrosive environment, it is recommended to regularly check and replace the gasket to ensure good contact. For metal pipes with transition resistance greater than 0.03 Ω at the flange

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connection, static bridging measures shall be used to ensure their safety.

Table 1: Minimum specifications of the static grounding branch line and connecting line

Device type	Grounding branch line	Connecting line
Fixed device	16 mm^2 multi-strand copper core wire; 8 mm galvanized round steel; 12 mm x 4 mm galvanized flat steel	6 mm^2 copper core flexible stranded wire or flexible copper braided wire
Mobile device	16 mm^2 copper core flexible stranded wire or rubber sheathed copper core flexible cable	
Vibration or frequently moving device	6 mm^2 copper core flexible stranded wire	

3.4. Grounding selection

3.4.1. Lightning protection and grounding selection

Combined with safety standards, lightning protection, and grounding measures for vessels, pipelines, and loading and unloading facilities, a unified specification selection is made considering steel materials and use specifications. The rigid conductor download of the lightning protection grounding device shall be made of galvanized flat steel, with a thickness of flat steel, not less than 4 mm and a width of not less than 40 mm. In order to meet the safety standards and construction convenience, the grounding trunk line shall be uniformly 50 mm × 5 mm galvanized flat steel [9].

When lightning protection and grounding measures are used for vessels, pipelines and loading and unloading facilities, the disconnection card for transition connection shall be designed. The disconnect card shall be placed between the down lead and the grounding body, and 0.3-1 m from the ground; The upper and lower ends of the break clamp shall be fully welded and overlapped, and the overlapping length shall be twice the width of the flat steel; It shall be fastened with M12 stainless steel bolts with lock nuts or spring washers, and the overlapping length shall not be less than twice of the flat steel; The connecting metal surface shall be dedusted and degreased. After the disconnection card and lightning protection grounding measures are completed, the grounding resistance shall be less than 10 Ω [10].

3.4.2. Anti-static grounding selection

Combined with the safety standards and anti-static grounding measures, the steel material and use specifications shall be considered to make a unified standard selection. As shown in Table 1 and Table 2, the sectional area of the flat steel of the ground grounding trunk line shall not be less than 100 mm^2, and the thickness shall not be less than 4 mm; The sectional area of the flat steel of the underground grounding trunk line is not less than 160 mm^2, and the thickness is not less than 4 mm [11]; The anti-static grounding down lead of containers, pipelines and loading and unloading facilities should be made of galvanized flat steel with thickness not less than 4 mm and width not less than 25 mm.

The classification and application of electrostatic grounding measures for earth covering equipment and fixed equipment should be further considered. The shell of fixed equipment, such as a tower, container, pump, heat exchanger, filter, etc., shall be grounded by static electricity. If it is soil-covered equipment, static electricity grounding may not be done. After the completion of electrostatic grounding measures, the resistance value of anti-static grounding devices such as pumps, filters, and buffers connected to the pipeline shall be less than 100 Ω.

Table 2: Minimum specifications of steel for electrostatic grounding trunk and grounding body

Name		Unit	Above Ground	Underground
Flat steel	Cross-sectional area	mm^2	100	160
	Thickness	mm	4	4
Round steel	Diameter	mm	12	14
Angle steel	Specification	mm	/	50 x 5
Steel Pipe	Diameter	mm	/	50
	Thickness	mm	/	3.5

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3.4.3. Standardize the size of the grounding selection.

In order to prevent construction and installation errors and disordered selection, combined with lightning protection, grounding, anti-static grounding and other measures and safety standards, the size of all grounding devices can be unified in engineering application: the size of the grounding down lead is 40 mm * 4 mm, the size of the ground and underground trunk line is 50 mm * 5 mm, the grounding resistance is 4 Ω, and the size of the disconnect clamp locknut is M12. Furthermore, the application of different grounding measures and standards by construction personnel should be simplified to improve the anti-static and anti-static efficiency.

4. Conclusion

In this paper, various relevant grounding standards, such as national, industrial, and enterprise standards, are analyzed, the common grounding problems are systematically summarized, and suggestions for improvement are put forward. Firstly, the common grounding device is analyzed to improve the understanding of common grounding in construction design; Unifying the grounding model of device equipment can completely avoid mistakes in model selection. Finally, it can be determined whether the flange needs to be bridged according to the properties of the medium and whether it is a corrosive environment so as to avoid the phenomenon of random bridging everywhere on the site. It is helpful for the petrochemical industry to avoid potential safety hazards caused by electrical grounding in production, and ensure the safety of personnel and reliable operation of equipment. Improving electrical grounding capacity will play a positive role in the safety of personnel, the stable operation of equipment, and the safety protection of well sites or enterprises. The analysis of various grounding standards in this paper will quickly strengthen staff's understanding of electrical grounding technology and standardization of relevant standards and fully guarantee the safe production of petrochemical enterprises.

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