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Research on Improved Technology of Portal Frame of Overhead Line in High-Voltage Substation

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Abstract. In the Saudi Master Gas System Expansion project, the portal frame of the overhead line of the high-voltage substation was reformed. The safety and stability of the laying of the high-voltage cable was guaranteed through the optimized design of the supporting structure and the production of the high-voltage cable head. Good practical results have been obtained, the construction quality and period have been guaranteed. It provides a guiding and operational statement for the improved technology of portal frame of overhead line in high-voltage substation.

Keywords. High-voltage cable, portal frame, improved technology.

1. Introduction

The power supply of the company's MGS (Master Gas System) Expansion project in Saudi Arabia is designed to be supplied by the off-site high-voltage line. After the installation of newly built GIS equipment in the project is completed, the portal frame of the overhead line of the high-voltage substation should be reformed to meet the conditions of power supply from the off-site high-voltage line in the later stage of the project. In view of the particularity of the work of construction, to facilitate subsequent similar renovation project smooth implementation, so the detailed research in the most appropriate portal improved, which contains the GIS to high-voltage substations overhead line between the portal cable laying, high-voltage cable head production, test and installation and final system test, debug, etc.

2. Technical Principle

The portal frame improved process adopts steel plate or channel steel to make the roller support structure for high-voltage cable laying. According to the layout of the roller support structure for high-voltage cable laying, the frame structure is combined. The high-voltage cable roller is placed on the cable roller support structure through the roller, and the high-voltage cable laying is carried out by the tractor, which can be safely and quickly laid for all kinds of specifications and models of high-voltage cable.

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This process avoids the traditional high-voltage cable laying using crane migration, which is easy to cause the high-voltage cable roller to turn over when mechanical traction is large, thus causing the phenomenon of high-voltage cable scratch or damage. In addition, the high-voltage cable joints production process is improved to ensure the construction quality of the terminal joint and the safety and stability in the later operation process.

3. Key Points of Technology

3.1. Preparation

Check the delivery record of all materials and ensure that the materials used for installation are qualified. High-voltage cable laying roller support structure is finished

Cable joints production acceptance. Before making the high voltage cable joints, do the insulation test or DC voltage withstand test on the high voltage cable, and ensure that the insulation layer of the cable is not damaged.

Prepare machinery, tools, equipment and materials used in construction, and unpack the equipment when it arrives on site. At the same time, prepare various installation and hoisting tools to ensure that the tools are safe, reliable, and easy to use.

Check the electrical circuits, control and protection devices are reasonably configured. *T*hey must be safe and reliable.

3.2. Laying of High-voltage Cables

Before laying the high-voltage cable, it must be confirmed that the inspection of the directly buried cable trench is completed, and the buried depth of the cable trench meets the requirements of the specification. The cable layout path has been checked according to the design drawings and specifications.

Install pulley on laying path. A pulley shall be installed at a horizontal spacing of 3m to 5m, and pulleys shall be installed on both sides of the bending section. This can avoid cable damage.

The high-voltage cable rotor is placed on the high-voltage cable roller support structure, which can avoid the cable rotor roller from the turntable when the traction force is too large. A closed buckle cover of the same radius shall be used above the turntable. One side of the buckle cover adopts the way of connecting shaft, and the other side adopts the fixed pin (refer to figure 1 high-voltage cable roller support structure drawing). When the cable rotor is completely located on the turntable, fasten the upper buckle cover to avoid the cable rotor from the roller during cable laying.

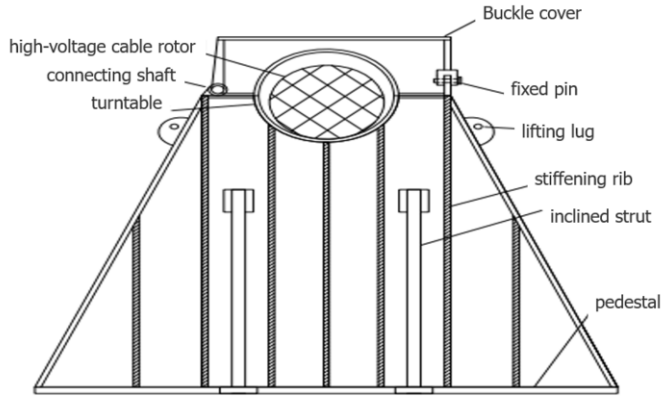

Figure 1. High-voltage cable roller support structure drawing.

Laying of high-voltage cables with traction equipment. During laying, enough manpower should be configured to adjust the cable laying pulley, and observe the status of high-voltage cable roller support structure to avoid cable surface damage caused by excessive traction force.

3.3. The current Transformer（CT） and High Voltage Cable Terminal are Installed in Place

Check item by item according to the requirements of the current transformer manufacturer's manual. The porcelain sleeve has no crack or damage, the explosion-proof film has no leakage, the primary joint terminal board is in good condition, the metal shell has no rust, the porcelain skirt is clean and has good hydrophobicity.

The special sling is set on the crane hook, and the lifting arm is moved slowly above the center of gravity of the CT. Four shackles are set on the special lifting ring of the CT, and the hook is slowly raised, so that the sling is put in the right position and subject to slight force. A brown rope is used at the bottom of the current transformer as the positioning wind rope to prevent the porcelain sleeve from being damaged during lifting.

The crane commander will instruct the hook to lift slowly. When the current transformer is lifted 100mm from the ground, it should check whether the special sling, crane brake and the lifting center of the transformer are offset or not. If any abnormality is found, the crane should pull back to the transformer for readjust before continuing to lift, and adjust the direction of the wind rope in time. Then, the hook can be lowered slowly and suspended when it is about 100mm away from the steel structure. After finding the installation hole diagonally with two guide rods, the hook can continue to fall into position and tighten the four installation bolts. Remove the special lifting strap and remove the lifting arm above the current transformer as soon as possible.

Check that the connection position of the grounding terminal of the current transformer shell and the original grounding connection piece should be consistent.

The current transformer joint shall be installed by lifting vehicle. Under the command of the heavy industry, the connecting wires on both sides shall be hoisted up slowly with ropes respectively. The installation personnel shall check whether the length of the wire is consistent with the original. Check that the bond surface of the

transformer is not cracked, apply conductive grease on the surface, and tighten the four bolts.

3.4. Manufacture, Test and Installation Of High-Voltage Cable Joints

When making the high-voltage cable joints, it is necessary to do shielding test on the whole cable to ensure that the cable is intact, and measure the reserved length of the cable to ensure that the joints can be fully inserted into the transformer conductor. Peel off the outermost PVC insulation layer of the cable as required (Refer to figure 2. stripping outer layers of high-voltage cables) and straighten cables with hand hoist and saw off excess cables. When moving the cable, do not drag to damage the cable protective layer. If the cable outer layer is damaged, the subsequent high-voltage cable test will fail.

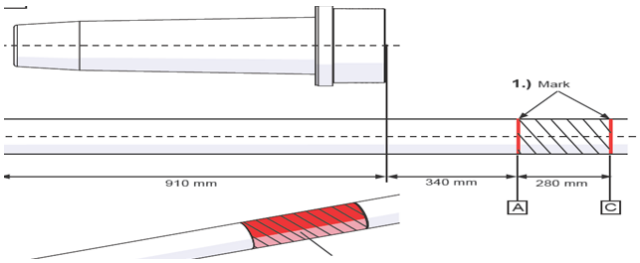

Figure 2. Stripping outer layers of high-voltage cables drawing.

Use 80 mesh sandpaper to thoroughly polish the area where the insulation layer has been peeled off to ensure a smooth and burr free surface. Peel off the third layer of corrugated steel armoured sheathing and remove the sealing tape in the cable inner layer. Use a professional tool to cut the steel sheathed sheath to avoid scratching the cable protective layer. Pay attention to the cutting depth to avoid cutting through the next layer, the steel thorns of the cutting surface should be polished smooth with a file.

Install the heating sleeve of the cable with the steel armoured sheathing stripped off, heat it to 80 degrees, keep it warm for three hours, fix and straighten it with steel angle after heating, and remove steel angle after cooling to the ambient temperature. Heating straightening can eliminate part of insulation thermal shrinkage and reduce the impact on joint size. The internal stress of insulation is improved so as to ensure the good performance of cable.

Remove 95mm of plastic insulation layer from the front end of the cable to expose the cable core. The insulated end is usually cut into a cone to form a 45degree cutting Angle (Refer to figure 3. connection of the insulated end) to ensure that the wound sealing tape is well sealed with the insulating layer. Polish the insulation layer with sanded paper and apply silicon grease inside the insulation layer and stress cone. In this way, the tangential field strength along the 45degree section can be weakened and the possibility of current breaking through the joint is reduced, thus improving the joint performance.

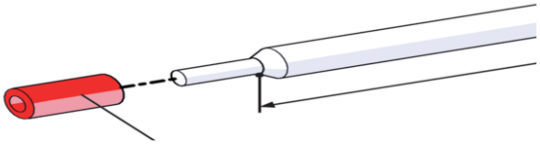

Figure 3. Connection of the insulated end.

In order to ensure the sealing effect, when installing the cable gland (O ring), a rubber ring should be filled between the connection and the steel sheath to ensure the stability of the installation. After installing cable gland, protect the insulation tubes to prevent them from bumping (Refer to figure 4. details of installing O rings).

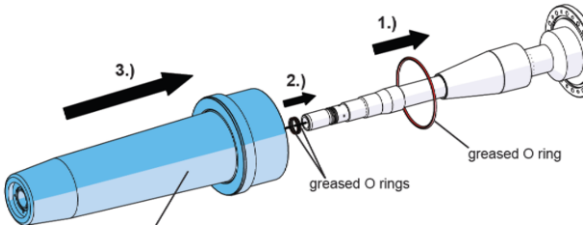

Figure 4. Details of installing cable gland

Fix terminal head and ground. The terminal heads are inserted into the conductor of the transformer. Place the sealing ring at the adapter connection and secure it with bolts. Ensure that the entire container of the terminal head is sealed and charged. Each point below the cable terminal head needs to be fixed on the bracket with cable clips to prevent vibration, so as not to affect the sealing of the terminal head.

Connect the bottom flange to the oil injection pump and inject oil into the insulating porcelain to the specified position. This process provides necessary environment for subsequent high- pressure test. The high voltage cable of each terminal joint is provided with a corresponding ground box from which the cable is led to the flange below the insulation sleeve. Finally, according to the cable path to do cable bridge support.

3.5. Final Test

3.5.1. Before High-Voltage Withstand Test.

The voltage transformer on the GIS should be disconnected or removed. The arrester on the GIS should be disconnected. All secondary windings of current transformer on GIS should be short-circuited and grounded before testing.

3.5.2. Conductor Housing Voltage Test.

The test voltage of GIS magnetic induction line is applied between the conductor and the shell through the busbar at the porcelain bottle casing, one phase at a time, and the other two phases are short-connected with the earthing shell.

3.5.3. Circuit Breaker Fracture Withstand Voltage Test.

The three phases are short-connected on both sides of the fracture, and the test voltage is applied from the porcelain bottle casing, and the test voltage is applied at least once for each component.

The test is divided into equipment capacitance measurement, test current and test capacity estimation.

All components are in accordance with the test procedures, if the test voltage does not flashover or breakdown, and there is no significant change in insulation resistance before and after the test, the voltage test is considered qualified. If breakdown discharge occurs during the test, the following treatment schemes shall be adopted:

- Repeat the test, if the equipment can withstand the specified test voltage, it is considered that the discharge self-recovery, voltage test through;
- If the repeated test fails, the equipment shall be disassembled or returned to the factory, the discharge interval shall be opened, the insulation damage shall be carefully checked, the necessary repair measures shall be taken, and the specified voltage withstand test shall be carried out.

4. Key Safety Measures

Hoisting machines and tools shall be operated under the command of professional operators. During hoisting, the wire rope and lifting lug shall be firmly connected.

The high-voltage cable rotor is placed on the high-voltage cable roller support structure. In order to prevent the cable roller from breaking away from the turntable due to excessive traction during the laying of high-voltage cables, the upper cover is fastened to avoid the roller disconnection of the cable rotor during the laying of cables.

During the high voltage withstand test, the guardian must supervise and intercom must be configured. In the process of pressurization, the guardian should convey the instructions clearly and accurately, and the operator should be focused to prevent the occurrence of abnormal conditions. When abnormal conditions occur, the test should be stopped immediately. The operator should first disconnect the power supply and discharge, and the high-voltage part of the booster equipment can be checked only after disconnecting and grounding. The test can continue after the operator finds out the cause.

5. Conclusion

The technological transformation of overhead line portal frame construction in high voltage substation ensures that no wear or damage occurs during laying of high voltage cables. At the same time, in the high voltage cable joint production process method improvement, including peeling outer layer, grinding and cleaning insulation layer, cable heating sleeve installation, sealing *cable gland*, insulation sleeve installation, fixed terminal head and grounding and other key steps, to ensure the smooth implementation of cable terminal joint construction. This improved process has achieved good practical effect in the MGS Expansion project, verified the feasibility of the process and the safety and stability of follow-up devices.

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