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DEVELPOMENT OF DRY TYPE OUTDOOR TERMINATION FOR 66 - 110KV XLPE CABLE

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ABSTRACT

The typical outdoor termination for XLPE cables is composed of a porcelain bushing or composite bushing filled with insulating oil.(1) The authors have developed a dry-type outdoor termination for 66–110kV XLPE cables without using a porcelain bushing or insulating oil, consisting of electric field shielding epoxy and a metal rod covered with silicone rubber casing molded on the surface.(2) The termination uses few parts and can be quickly installed in the field. Initial and long-term tests for the termination were conducted in accordance with the JEC standard. All samples met the performance requirements.
This paper describes the design of the outdoor termination for 66–110kV XLPE cables and the results of the tests, as well as the development of the higher voltage class outdoor termination.

KEYWORDS

outdoor termination, dry type, XLPE cable,
cold-shrinkable-joint

1. INTRODUCTION

The outdoor termination for XLPE cables is usually composed of a porcelain bushing filled with insulating oil, which makes it very heavy and the direction of installation is restricted. To solve those problems, we have developed a completely dry-type outdoor termination with silicone rubber casing without using insulating oil. The termination without a porcelain bushing is light, and the absence of insulating oil permits the bushing to be freely installed at any desired angle. The assembly is very simple because XLPE cables are connected to the terminal with a rubber block. This paper reports the results of various tests of this dry-type outdoor termination.

2. STRUCTURE AND FEATURE

Figure 1 shows the structure of the dry-type outdoor termination for 66–110kV class cables, which has the following features.

- The epoxy unit with metal rod is covered with a silicone rubber casing.
- Completely dry-type solid insulation structure
- Easy handling and lightweight (about 90kg)
- Free installation angle and environment-friendly
- No need for special tools or skills

Connection of termination and XLPE cable conductor with rubber block

3. ELECTRICAL DESIGN

The insulation of the outdoor termination was designed in accordance with JEC3408 and IEC60840. Figure 2 shows an example of the equivalent potential distribution. The electric field control mechanism was optimized by the electric field design. There is no part that will be affected by the stress of epoxy or silicone rubber.

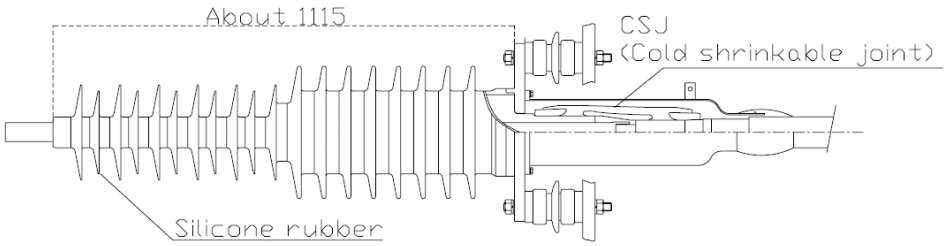

Figure 1. Structure of dry-type outdoor termination for 66–110kV class cables

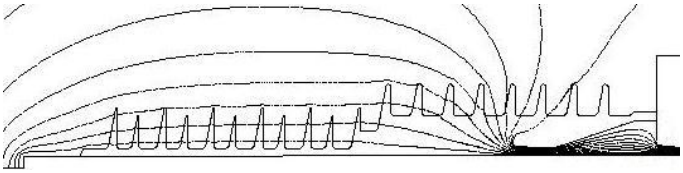

Figure 2. Potential distribution for out-door termination

4. ASSEMBLY PROCEDURES

Figure 3 shows the procedure for assembling the outdoor termination. The protection tube and rubber block are put over the XLPE cable. The termination unit and cable conductor are connected by compressing the connector. After the rubber block is moved to the jointing center, the spiral core is pulled out to mount the rubber block on the cable insulator. Then the shielding layer is formed on the rubber block and covered with the protection tube. This outdoor termination does not need special tools or skills for assembly.

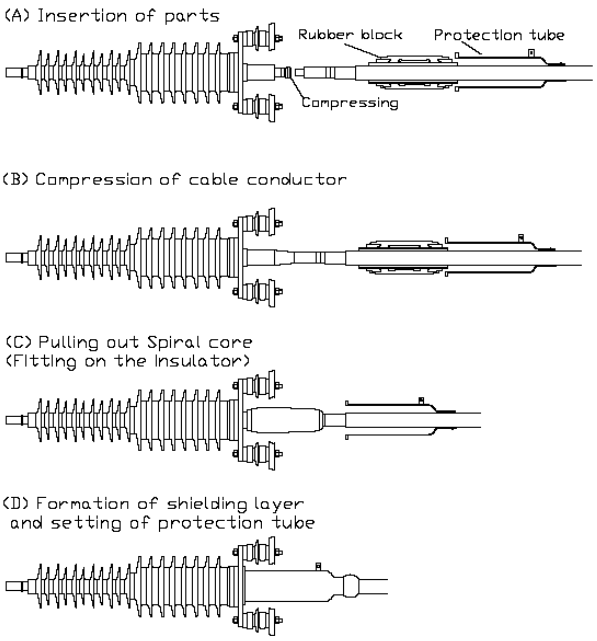

Figure 3. Assembling procedure for outdoor termination

The features of this outdoor termination assembly are shown below.

- The cable processing length is very short.
- The outer semi-conductive layer can be removed with a handy tool within a few minutes.
- The interfacial property between cable insulation and rubber block was studied carefully, and it was confirmed that removing the outer semi-conductive layer by hand or by a handy tool ensures excellent interfacial property.
- Only a few parts are required and assembling is easy. (Termination unit, Rubber block, and Protection tube)
- Quality control in the field is easy, because the terminal unit and rubber block are inspected in advance at the factory.

Figure.4 Appearance of dry-type outdoor termination

5.COLD-SHRINKABLE-JOINT (CSJ)

The cold-shrinkable-joint (CSJ) is a silicone rubber one-piece unit molded at a factory. The CSJ is composed of a stress-relief high voltage electrode, insulation layer, stress-relief cone, and outer semi-conductive layer. It is expanded in the factory in excess of the outer diameter of the cable jacket by a spiral core to shorten the total joint length. The CSJ is assembled simply by pulling the spiral core out of the rubber sleeve. Special tools and skills are not required because it can be shrink-fitted at room temperature without any tool.(3) The outdoor termination can be easily assembled by using this CSJ technology.

6. ELECTRICAL PERFORMANCE TEST

6.1 Initial performance

The termination was tested to check its initial electrical performance based on JEC3408 and IEC60840. The outdoor termination was connected with the 1000mm^2 XLPE cable. Table 1 shows the test results. The result of the initial characteristics test was excellent in terms of the performance required of IEC 110kV class and JEC 77kV class terminations.

Table 1 Result of initial characteristics tests

Items	Condition	Results
AC withstand voltage test	150kV/1hr (JEC3408)	Good
	160kV/30minutes (IEC60840)	Good
AC breakdown Voltage test		250kV ↑
Lightning impulse withstand voltage test	±550kV/3-shots (JEC3408)	Good
	±550kV/10-shots (IEC60840)	Good
Lightning impulse breakdown voltage test		±610kV ↑

6.2 Long-term performance

A long-term loading cycle test was carried out for six months based on JEC3408 to confirm the long-term stability. Two outdoor terminations were arranged in the long-term test circuit. The loading condition was controlled at the conductor temperature of a dummy XLPE cable. The long-term test was executed in two stages: in the first stage, the type-test was carried out for one month, then in the second stage, a PQ-test was carried out for six months. Table 2 shows the test results, and Figures 5 and 6 show the long-term test conditions.

Table 2 Results of long-term tests

Stage	Items	Condition	Results
1st	Applied voltage	75kVAC	Good
	Applied current cycle condition	Conductor temperature 90°C×25 cycles 105°C×5 cycles	
	Loading cycle	30 cycles	
2nd	Applied voltage	65kVAC	Good
	Applied current cycle condition	Conductor temperature 90°C×150 cycles 105°C×30 cycles	
	Loading cycle	180 cycles	

At the third stage, a long-term test for the 110kV class termination was planned. Table 3 shows the test conditions.

Table 3 Conditions for long-term test for 110kV class

Stage	Items	Condition
3rd	Applied voltage	128kVAC
	Applied current cycle condition	Conductor temperature 95–100°C×20 cycles
	Loading cycle	20 cycles

Figure.5 Condition of long-term loading cycle test

Figure.6 View of dry-type out-door terminations in long-term tests

7. DEVELOPMENT FOR 154-230KV CLASS

Based on the design of the 66–110kV XLPE cables, an outdoor termination for 154-230kV class was designed using a similar structure. The length of the termination is about 2.4m. The initial characteristics of the outdoor termination for 154-230kV class cables have already been confirmed.

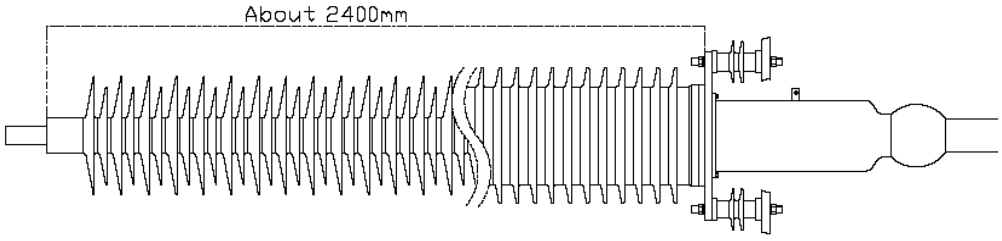

Figure.7 Structure of dry type out-door termination for 154-230kV class

8. ENTIRELY SYNTHETIC TERMINATION

We are developing an entirely synthetic termination for 110kV XLPE cable. This termination is made of silicone rubber and consists of an insulated part with a high resistance to tracking, vulcanized to a semi-conducting part which forms the field controlling stress cone. Assembling can be completed just to insert an XLPE cable. Figure 8 shows the outline diagram of entirely synthetic termination for 110kV class XLPE cable. The initial characteristics of the entirely synthetic termination for 110kV class cables have already been confirmed.

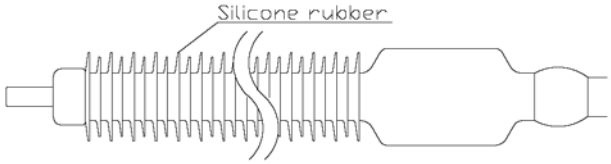

Figure.8 Outline diagram of entirely synthetic termination for 110kV class

9.CONCLUSION

The authors developed a dry-type outdoor termination for 66–110kV XLPE cables, in which no porcelain bushing or insulating oil is used. This outdoor termination is connected with XLPE cables by CSJ, and can be assembled easily without using special tools or skills. Initial and long-term electrical performance tests verified that the electrical performance is excellent. The authors are planning to conduct an IEC 110kV class long-term loading cycle test and develop a dry-type outdoor termination for 154-230kV class cables.

10.REFERENCES

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