10kV XLPE cable ampacity improvement research in Guangzhou area

Zhixin SUO
China Southern Power Grid– China
soney@126.com

Guopei WU
China Southern Power Grid– China
wuguopei@hotmail.com

Jian CHEN
China Southern Power Grid– China
87567534@qq.com

ABSTRACT

This paper will take the Guangzhou City（China）10kV XLPE cable ampacity approved as a starting point, to solve the long-standing cable ampacity standard inconsistency problem. In this paper, refer to the IEC and other international standards, combined with the manufacturers to provide product standard basis. Through the actual verification, by measuring the control of wire core temperature, actual load flow control in different cable laying different conditions and provide the basis for analysis, improve asset utilization efficiency and the safety of cable.

0.PREFACE

10kV XLPE cable ampacity is the comprehensive assessment of the reliability and economy of the cable running basis. Load flow standard is too low, limiting the transmission capacity of the cable, the peak and grid transformation pressure increase; load flow standard is too high, it may cause the cable insulation material accelerated aging, reduce the service life, it caused heavy cable overheat burning. Therefore, carrying capacity is an important parameter for ensuring the safe and stable operation of cable. The 10kV feeder load flow check, is not only the need of distribution network safety dispatching, also is to make full use of cable transmission capacity, improve asset utilization rate is needed, the distribution management an important work of.

The use of ratio above 95% in the Guangzhou of 10kV XLPE cable, and with the city development is still at a speed of 500 kilometers per year increase. But according to the operation data of the current statistics, cable average load rate reached only 30%, but heavy overload lines has reached 120, accounting for 10%, heavy overload lines bring challenges to the power supply reliability and safety. But considering the power grid construction investment is large and the central areas of the city is quite difficult to implement, so it is very necessary to improve the utilization rate of cable.

Query based on IEC standard and the main supply manufacturers products standard, obtains the ampacity of the reference value, that is a long time in the environment standard laying allowable ampacity values, also as the traffic load in Guangzhou area of different types of cable maximum allowed value. Insulation aging condition is simulated by using the measurement method, the key factors affecting the service life of the cable current value analysis, to find out the cable body aging damaged critical load current and load duration of interval. Tested in Baiyun District site device through optical fiber temperature measurement, indirect temperature measurement way, clear influence laying conditions on the temperature rise of the load flow. Combining the theoretical analysis and experimental means, to Guangzhou area 10kV XLPE cable ampacity recheck, and puts forward some technical measures for improving the cable ampacity.

1.CHECK THE LOAD FLOW METHODS AND PRESENT MANAGEMENT SITUATION

1.1Check method of load flow

Check the cable ampacity is the maximum allowable temperature of the material continued operation of insulated cables based on. 10kV cable is generally used by the cross-linked polyethylene as insulating materials, the continuous operation of the maximum allowable temperature is 90^{o}C. At the temperature above 90 ^{o}C, aggravate the pyrolysis reaction of crosslinked polyethylene, cross-linked structure was destroyed, significantly reduce the insulation of electrical, physical and chemical properties of materials, the damage could not be restored. Current of the 10kV cable ampacity of cable core verification method for temperature reached 90^{o}C value.There are two commonly used methods for checking the cable ampacity, analytical method and numerical method.

1.2Check standards currently in use in Guangzhou area

Guangzhou area 10kV feeder load flow calibration method is based on the relevant provisions of GB 50217 in the cable laying, according to different conditions (such as temperature, soil temperature, soil resistance coefficient, arrangement), using the "coefficient correction method" on the single back to the cable ampacity checked. Because GB-50217 is not considered correction coefficient of multi loop pipe laying way,

Guangzhou area according to the actual situation of adding. At present, the relevant domestic power supply enterprises (Shenzhen, Shanghai, Foshan), cable manufacturing enterprises (Guangdong Cable Factory) and checking all adopt "coefficient correction method" for 10kV cable ampacity, correction coefficient selection dimensions roughly the same, just slightly in the coefficient difference.

1.3Comparison of several domestic important check of power supply enterprise.

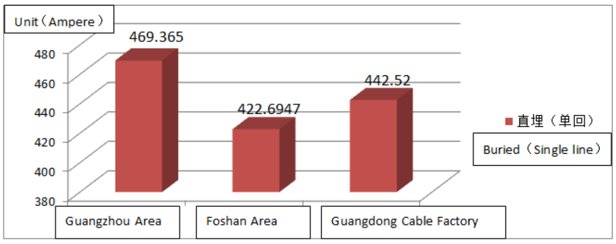

Figure 1 Buried conditions (300mm^2) 10kV cable ampacity comparison chart

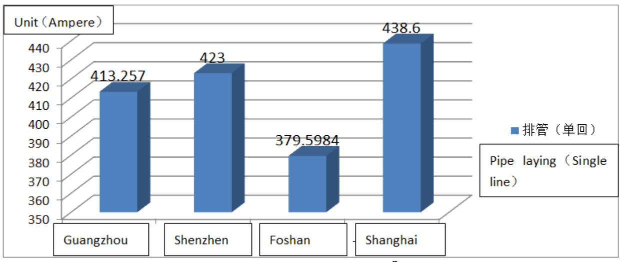

Figure 2 Pipe laying conditions (300mm^2) 10kV cable ampacity comparison chart

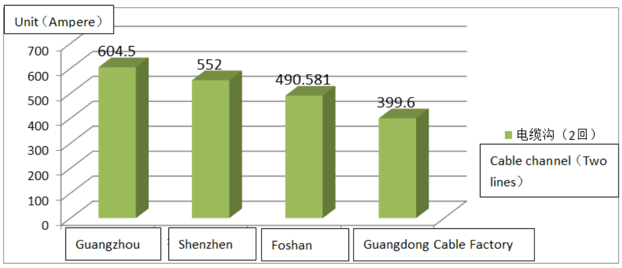

Figure 3 Cable channel conditions (300mm^2) 10kV cable ampacity comparison chart

As shown in Figure 1,2,3, under the same environmental condition, the Guangzhou area of 10kV 300mm2 the cable ampacity in buried (Single line), cable trench (Two lines) means lower, in pipe laying (single line, without considering the multi loop correction coefficient of row third)mode. Load flow whole accounting standards high, but compared with the actual operation experience, there is still great room for improvement.

In Guangzhou each distric,the experience standard and the current standard has some difference, the maximum error reached a staggering 50%, difficult to unified and standardized management.

2. ACTUAL VERIFICATION COEFFICIENT CALIBRATION METHOD

It is self-evident importance of load flow check work, "coefficient calibration method" is the more common method, proved to be effective. But at present, Guangzhou Bureau of load flow calibration standard and related coefficient to determine, in reflecting the cable operation in different conditions still have space to improve the. The theory calculation of ampacity values more in line with the current Guangzhou area of the actual operation environment, and then revise the related coefficient, the need for inspection and aided experimental means.

2.1 Test the overall situation

Distributed optical fiber temperature measurement system (DTS) in fiber is the transmission media and sensing media, mainly composed of optical fiber temperature measurement and temperature sensing cable is composed of host. According to the monitoring environment with different temperature sensing cable of different types. Combined with the distributed optical fiber temperature measurement system and the 10kV cable core temperature conversion algorithm, and improve the 10kV cable ampacity forming method of research, formulate specific implementation plan.

The test site location: actual operation condition of 10kV station in Baiyun District meet outgoing cables, specific for Ling Bo substation.

Ling Bo Substation on-site temperature measuring optical fiber laying situation as follows:

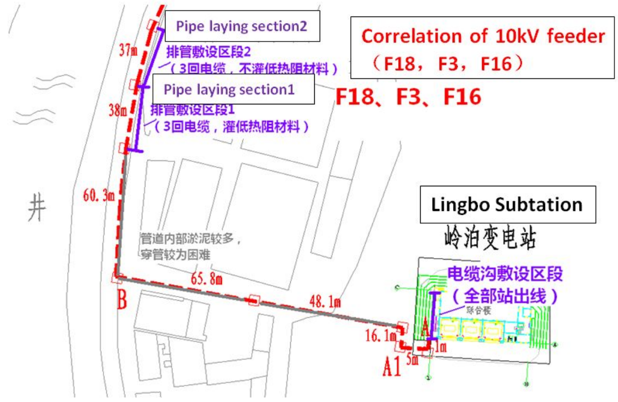

Figure 5 LingBo Substation north of temperature measurement optical fiber, cable trench laying situation

Figure 6 Pipe laying and Cable trench site map (red for fiber)

2.2 The experimental results and brief analysis

Testing by 10kV cable surface temperature distributed optical fiber temperature measurement system to test in the actual operation, through the algorithm to convert outlet core temperature theory value, at the same time, the actual temperature synchronous measurement wire core, to compare the difference of both, to verify the effectiveness of the algorithm.

2.2.1 Indicating that the cable, the load condition

Provide 2014.7 - 2014.8 data according to the Baiyun District, a few lines of F18 load monitoring the weight, and the maximum load appears in July 24, 2014. Analysis for F18, F18-0 for the cable trench laying, pipe laying (F18-1 tube filling water is relatively small), F18-2 for the pipe laying (more water filled tube).

2.2.2 The maximum load analysis

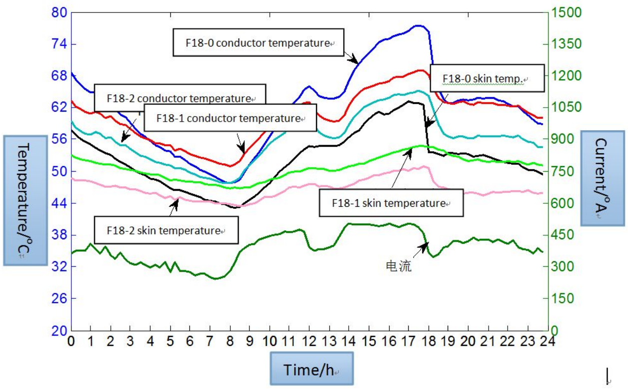

Figure 7 maximum temperature load on F18 changes of various cable conductor

It is seen from Figure 7 can be, in July 24, 2014 the highest F18 cable load, peak current up to 504.77A, has more than cable of rated load (453A, in accordance with the table data) 11%. The calculation of cable trench section of F18-0 maximum conductor temperature is 77.51 ^{o}C, and the cable's maximum allowable working temperature of 90 ^{o}C is 12.49 ^{o}C. We can see that F18-1 and F18-2 conductor temperature lower.

2.2.3 Before the comparison of before and after pumping

Due to long-term water discharge pipe, heat dissipation and temperature effects will affect the cable of each layer of cable. In August 18th,arrangement will exhaust pipe laying F18-1 segment of water drained and non F18-2 segment changes after pumping water pumping, cable temperature contrast.

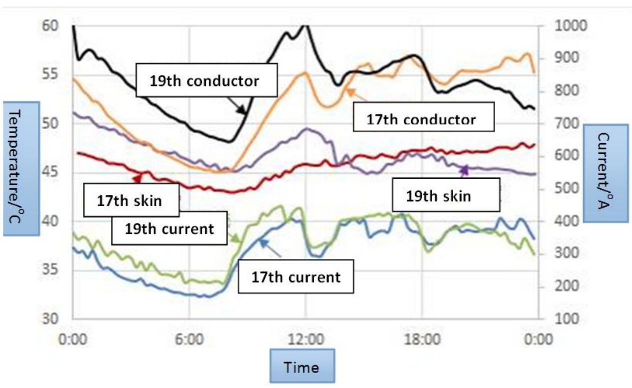

Figure 8 F18-1 after pumping water cable temperature contrast

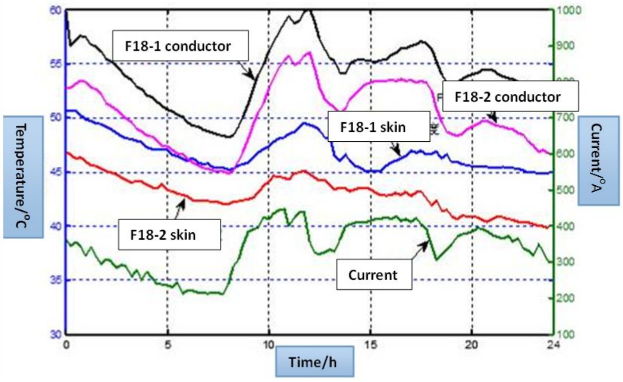

Figure 9 F18-1 and F18-2 cable temperature contrast

It can be seen from figure 8 pumping two days before and after the load is similar, and the pumping before the conductor temperature changes smoothly, after pumping temperature changes more obvious. It may be because the water is conducive to cable heat so that the temperature is changed slowly.

Figure 9 for the August 19th F18-1 and F18-2 cable temperature contrast, can be seen not pumped F18-2 section of cable conductor and the skin temperature was significantly lower than that of F18-1 segment after pumping.

2.2.4 The spatial analysis

The same section of cable with different laying mode, from the spatial variation analysis of conductor temperature can find the highest temperature point, explore the cable transmission bottleneck.

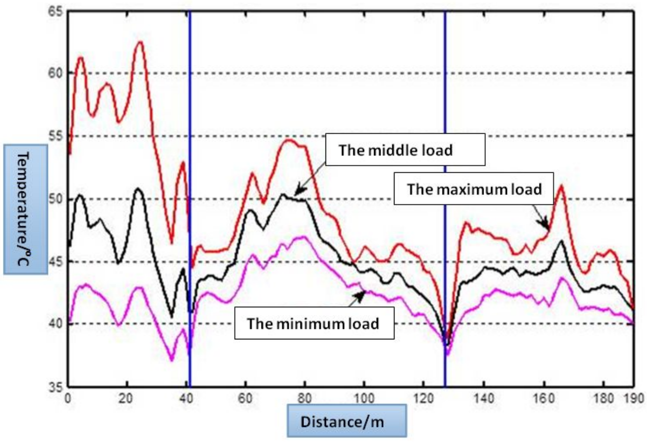

Figure 10 Temperature variation with distance

In Figure 4, the first section is a F18-0 cable laying, second sections of F18-1 pipe laying, third sections of F18-2 pipe laying.

Through the analysis of relevant data, draw the following conclusions:

1.Field measured data and the calculated value differences, need further experimental verification of load flow, there may be considerable improvement space.

2.Cable temperature load curve with the same change trend, have a certain lag;

3.In a row tube filled with groundwater scenario, in cable trench cable temperature than in the row tube high, influence of groundwater discharge pipe number larger cable temperature;
4.The same period of exhaust pipe, exhaust pipe at both ends of the middle than high temperature.

3 LOW THERMAL RESISTANCE OF THE BACKFILL MATERIAL EFFECT

The low thermal resistance of the backfill material is a kind of SH gel, water, sand and other components of low thermal resistance materials according to a certain proportion and through special processing of the (thermal resistance coefficient is 0.17 ~ 0.49K.m/W). Through the experimental verification authority test structure, which can effectively enhance the carrying capacity of about 17.3%.
The test content is 10 kV 3 x 3 cable pipe laying, cable sequentially numbered 1-9. Applied 330A current 48h, to exert 275A current 72h, stay cable temperature stability after recording. And then poured into the tube in all wear low thermal resistance of backfill material, ruled out the air tube, applying the 275A current, 24h after adjustment for the 325A current, cable conductor temperature after 72h records after stabilization, cable surface temperature.

Table 1 10kV cable 3 x 3 through pipe laying cable temperature measurement results

Unit: ℃

The test current	Before Grouting（℃） 275 A		After Grouting（℃） 325 A	
Measure position / Cable label	Conduct	Skin	Conduct	Skin
Cable #1	74.8	70.5	75.9	69.5
Cable #2	81.3	76.5	83.8	76.2
Cable #3	76.0	71.3	78.6	70.8
Cable #4	81.6	74.3	82.3	71.4
Cable #5	91.1	83.9	92.5	83.9
Cable #6	81.9	77.7	84.3	72.4
Cable #7	74.9	68.8	74.4	64.6
Cable #8	81.4	71.1	81.02	83.5
Cable #9	72.2	68.7	74.7	68.8
Cable #10	15.0		15.0	

See from the table 1, the surrounding environment has not changed circumstances, although before and after grouting current is 50A, but because of the low thermal resistance of the backfill material existence, 9 cables before and after grouting temperature difference, which fully shows that the low thermal resistance of backfill material significantly to wear tube cable cooling effect.
Because the load flow is a current conductor temperature of 90 DEG C, according to IEC 60287 standards on wear tube group cable ampacity calculation method, with the most heat cables for reference, through calculation, obtained in the conditions of the experiment, when the soil temperature is 15 degrees centigrade, ampacity values before and after grouting. The use of low thermal resistance materials before grouting ampacity ampacity of I2=320A I=273A, after grouting. Ascension is about 17.3%.

4 CONCLUSION

According to the optical fiber temperature measurement results and the calculation and analysis, the following conclusions are obtained:
(1) the calculation of three core cable real-time conductor temperature value and the test result error range in the project acceptance, and its correctness is verified calculation.
(2) cable Ling Bo distributed optical fiber temperature measurement system based on station cable operation monitoring shows that: the summer heavy load period, Ling Bo station distribution cable transmission bottleneck segments are cable trench laying section, to improve the transmission capacity of the cable is to strengthen the key heat station outlet cable channel.
(3) Cable Ling Bo distributed optical fiber temperature measurement system based on station cable operation monitoring shows that: in more than the existing load flow case, the heaviest load of F18 cable sheath temperature to a maximum of 68.13°C, the calculation of a maximum of 77.51 °C
the conductor temperature, much lower than 90 °C
, the transmission capacity of the cable can be further improve, in order to improve the utilization rate of cable.
(4) Cable Ling Bo distributed optical fiber temperature measurement system based on station cable operation monitoring shows that: the transmission bottleneck in cable trench other cable jacket temperature generally is 35 to 45°C.
(5) Have an influence on the pipe laying cable temperature in the inlet pipe. With the increase of inlet pipe, cable sheath and conductor temperature reduced; high specific heat capacity of water makes the cable temperature peak valley difference becomes small. So based on the cable waterproof good treatment, can consider to use water cooling on the cable, which can increase its current carrying capacity.
(6)The low thermal resistance of backfill material on pipe laying cable heat has the promotion function. Compared to the air, the backfill material can effectively reduce the cable temperature, improving the transmission capacity.
(7) Duct laying cable temperature varies with the medium in the pipe. Generally speaking, under the same load current, the medium is air cable highest temperature, low thermal resistance of the backfill material times, the minimum water.

5. PROSPECT

By the experience, knowledge and the fit of the model restrictions on cable structure, the existing "coefficient correction method of all parameters in the" still has a large optimization promotion space, including pipe laying conditions of multi loop correction coefficient of load characteristics, etc..
(1)The next step will focus on the analysis of the data obtained from the field, and puts forward a set of traffic

load is more in line with the Guangzhou area of the operating condition of the calculation method, not only to ensure the safe operation of power distribution network; but also can make full use of the transmission capacity of the feeder, maximization of economic benefit.
(2) The carding load flow bottleneck point, take measures targeted.In checking the load flow, there are many load flow "card neck" position, such as multi loop discharge pipe section and the size of the wire diameter cable connection, through the adjustment of cable pipe position, to avoid multi loop laying side by side, in the row tube perfusion of low thermal resistance materials, the exhaust pipe is changed in cable trench,, can improve the carrying capacity of the cable.
(3) Consider the impact of load characteristics on load flow."The coefficient correction method" to calculate the cable ampacity is steady, that the cable can be current through the long-term stable operation of value. In the actual operation, because of the influence of power grid peak valley difference, especially the Guangzhou residents, industrial and commercial load larger proportion, load flow in transient state still has certain promotion space.

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