Electric Corrosion due to the Discharge of Air Space between ADSS and Spiral Damper and the Solutions

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Abstract

This paper describes the electric corrosion due to the air space discharge between ADSS and the gripping section of spiral vibration damper. It has been found that the discharging electricity of air space between ADSS and the gripping section of spiral vibration damper is the main reason for causing failures of the installed ADSS cables. Firstly, this paper describes the electric corrosion mechanism due to the air discharge between ADSS and the gripping section of spiral vibration damper. The analytical methods are based on electromagnetic theory. Then secondly, in order to inhibit this type of electric corrosion, we have already developed the anti-corrosion paint, which can be used to fill up the space between ADSS and the gripping section of spiral vibration damper. In order to demonstrate the resistance of the anti-corrosion paint to erosion, the salt fog test has been carried out. The test results indicate that the ADSS cable with the anti-corrosion paint has a higher corrosion resistance and reliability. Finally, we have also introduced the new developed excellent track resistant cable sheath, the anti-corrosion spiral vibration damper and lighter stockbridge damper, which can also improve the corrosion resistance of the ADSS cable significantly.

Keywords: Cable; electric corrosion; discharge; air space; all dielectric self-supporting aerial optical cable (ADSS); spiral vibration damper; stockbridge damper; salt fog test

1. Introduction

All dielectric self-supporting aerial optical cables (ADSS) have been widely used in China. Up to now, over 100,000 km ADSS cables have been installed in China. However, utilities have also reported failures of the installed ADSS cables. In the polluted environment, the situations were more serious. A statistical study showed that more than 75% of failures were caused by the electric corrosion. Further investigation showed that the most failures occurred in the gripping section of spiral vibration damper. The eroded tracks on the cable's sheath look to be helically formed, and are consistent with the shape of the spiral damper, as shown in figure 1.

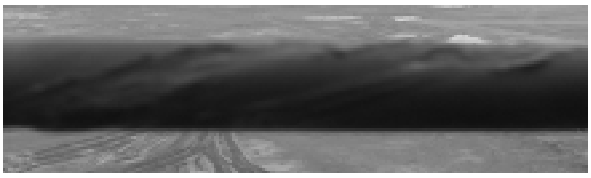

Figure 1. Helically formed corrosion tracks on the sheath of ADSS cable

The severe corrosion occurred in the place where the damper contacted the cable sheath. At the worst, the sheath was burnt, punctured and disintegrated. This type of electric corrosion cannot be explained using dry band arcing or corona discharge theory. We have investigated this type of corrosion intensively, and have found that the corrosions were caused by discharge of air space between ADSS and the gripping section of spiral vibration damper. In fact, the electric corrosion due to the discharge of air space between ADSS and the gripping section of spiral vibration damper is the main reason for causing failures of the installed ADSS cables.

2. Electric Corrosion Mechanism of the Air Discharge

The ADSS cables are installed in the vicinity of high-voltage lines. The capacitances between phase conductors to ADSS cable and spiral vibration damper store and transfer the energy from the high voltage conductors to the ADSS cable and damper. The cable, damper and air space between ADSS and the spiral vibration damper are located in the electrical field of high-voltage lines. The relationship between the electrical field strengths in the damper and air space is described as [1]:

$$\varepsilon_V * E_V = \varepsilon_A * E_A \qquad (1)$$

Where E_V and ε_V are the electrical field strength and dielectric coefficient in the vibration damper, respectively. E_A and ε_A are the electrical field strength and dielectric coefficient in the air space, respectively.

The electrical field strength in dielectric materials is in inverse proportion to the dielectric coefficient. The relative dielectric coefficient of air is equal to 1, so the electrical field strength in the air space is:

$$E_A = \varepsilon_V * E_V \qquad (2)$$

The polyvinyl chloride (PVC) is widely used for the spiral vibration damper. PVC has a relative dielectric coefficient of 3-4, so the electrical field strength in air space is three or four times higher than that in the damper.

Table 1 shows the relationship of breakdown tension (BDT) and voltage difference for causing discharge (VD) with the thickness of air space (TAS) [2].

Table 1. Relationship of BDT and VD with the thickness of air space (TAS)

TAS (mm)	0.01	0.05	0.1	0.2	0.5	1.0
BDT (KV/mm)	40	13.6	9.5	7.2	5.3	4.5
VD (KV)	0.4	0.68	0.95	1.44	2.65	4.5

From table 1 we can see that the voltage difference required for causing discharge decreases with decreased thickness of air space.

The thickness of air space between ADSS and the gripping section of spiral vibration damper is very small, so the discharge occurs more easily.

The equivalent circuit of the ADSS cable, damper and air space is shown in figure 2.

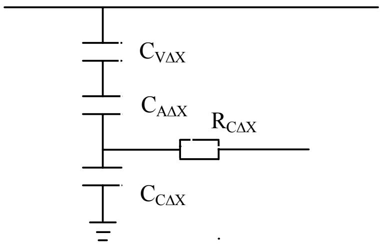

Figure 2. Equivalent circuit of the ADSS cable, damper and air space

In figure 2, $C_{V\Delta X}$, $C_{A\Delta X}$ and $C_{C\Delta X}$ are capacitances of the spiral vibration damper, air space and ADSS cable, respectively. $R_{C\Delta X}$ is resistance of the cable's sheath.

The charge and discharge times are dependent on resistance of cable sheath. In polluted environments, the cable surface is covered by dust, soot or salt, soaking rain and dew, and forms a closed layer with good electrical conductivity. In this case, the resistance of cable sheath is decreased, so the charge and discharge times become shorter and number of discharges of air space between cable and the gripping section of damper is increased. These discharges cause damages of cable's sheath. This is why the electric corrosion often occurs in the gripping section of spiral vibration damper. In order to inhibit this type of electric corrosion, we have already developed the anti-corrosion paint, which can be used to fill up the space between ADSS and the gripping section of spiral vibration damper. The anti-corrosion paint has a similar dielectric constant to that of the spiral damper and can significantly reduce the electric corrosion due to air space discharge between ADSS and damper. In order to confirm the corrosion resistance of the anti-corrosion paint, a salt fog test was carried out. The other purpose of test is to confirm our theory of air space discharge.

3. Salt Fog Test

3.1 Test Procedures

The objective of test is to confirm our theory of air space discharge and demonstrate the resistance of the anti-corrosion paint to erosion. The electrical test was conducted in accordance with the requirements of IEEE P1222 draft 1997 [3]or DL/T788-2001 [4]. Tracking on the outside of the sheath resulting in erosion at any point that exceeds more than 50% of the wall thickness shall constitute a failure.

The test conditions shall be as follows:

1. Duration: 1000 hours
2. NaCl content of water: 10 ± 0.5 kg/m^3
3. Salt water flow rate: 0.4 ± 0.1 l/h for each cubic meter of chamber volume
4. Test voltage: 40KV
5. Test tension: 25% RTS of ADSS cable

In the test three sections of ADSS cables with less corrosion resistant spiral vibration dampers were placed in a salt fog chamber. For two sections of ADSS, the air spaces between ADSS and the gripping section of spiral vibration damper were filled up with the anti-corrosion paint (sample A) or cable's filling compound (sample B), respectively. The third section of ADSS cable was not treated with the anti-corrosion paint or filling compound like the field-installed ADSS cables.

3.2 Test Results

The test results were showed in table 2:

Table 2. Test results

Test time (hour)	Without paint or filling compound	With anti-corrosion paint (Sample A)	With the filling compound (Sample B)
100	Tracks occurred on surface of damper	No corrosions	No corrosions
200	Deeper tracks on damper & slight tracks on cable sheath	No corrosions	No corrosions
400	Burnt damper's surface & deeper tracks on cable sheath	No corrosions	No corrosions
500	Damper with carbon deposit & much deeper tracks on cable sheath	No corrosions	No corrosions
600	Sheath punctured; Erosion on sheath exceeded more than 50% of the wall thickness	No corrosions	No corrosions
1000	Test stopped	No corrosions	No corrosions

From table 2 we can see that after only 100 hours of test run, the tracking occurred on the damper's surface for the ADSS cable without the anti-corrosion paint or filling compound. After 600 hours of test run, severe erosions occurred on both damper and cable, as shown in figure 3.

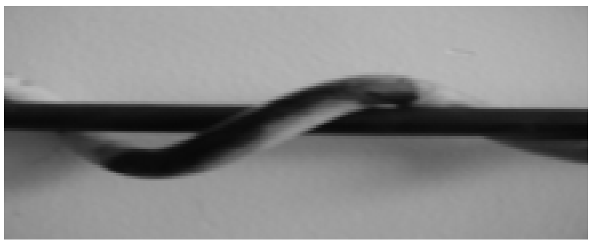

Figure 3. Severe corrosion for the ADSS cable without the anti-corrosion paint or filling compound

On the other hand, for the ADSS sections with the anti-corrosion paint (sample A) or filling compound (sample B), no erosion can be found even after 1000 hours of test run, as shown in figures 5 and 7, respectively. For sample A, there was still complete anti-corrosion paint in air space between cable and the gripping section of damper after test. For the sample B, after test a part of filling compound was lost. For the purpose of the comparisons, sample A and sample B before tests are also shown in figures 4 and 6, respectively. The test results indicate that the ADSS cable with the anti-corrosion paint has a higher corrosion resistance and reliability.

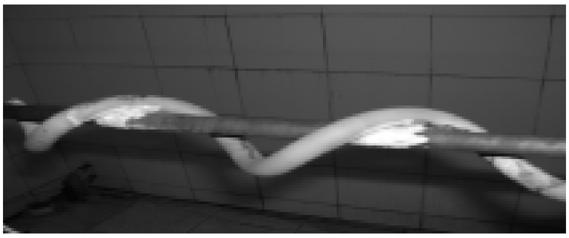

Figure 4. Sample A before of test run

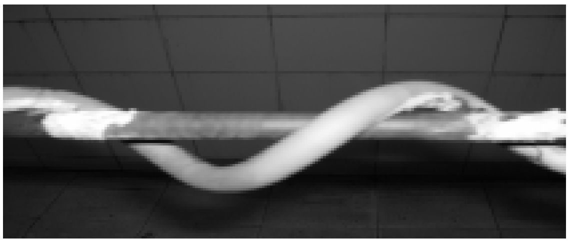

Figure 5. Sample A after 1000 hours of test run

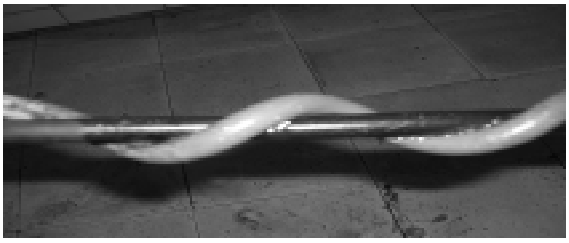

Figure 6. Sample B before test run

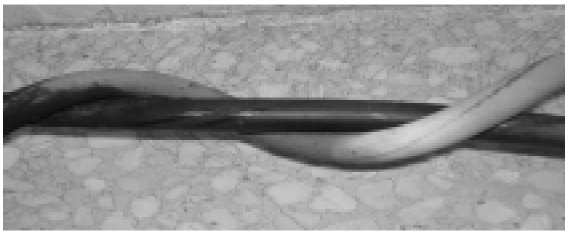

Figure 7. Sample B after 1000 hours of test run

4. Solutions of the Electric Corrosion

It is very important to improve the corrosion resistance of both ADSS cables and dampers. From above analysis and test results the following methods can be taken into account to improve the corrosion resistance:

1). The air space between ADSS and the gripping section of spiral vibration damper is filled up with the anti-corrosion paint. In this way, the electric corrosion resistance of both ADSS cables and dampers can be improved significantly. In the urgent case, the standard filling compound of cable can also be used instead of the anti-corrosion paint.

2). Excellent track resistant sheath material and anti-corrosion spiral vibration damper: We have also developed the new excellent track resistant cable sheath and anti-corrosion spiral vibration damper, which can be used to improve the corrosion resistance of ADSS cables and damper significantly.

3). Lighter stockbridge damper: Instead of spiral vibration damper, the lighter stockbridge damper can be used for eliminating the air space discharge. Figure 8 shows test result for ADSS cable with the stockbridge damper after 1000 hours in a salt fog chamber.

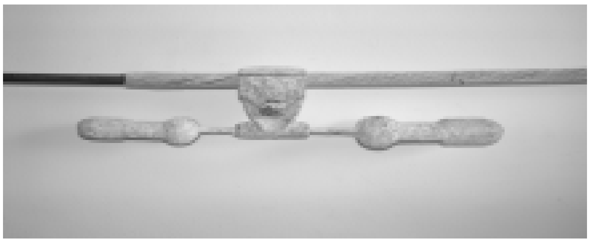

Figure 8. Test result after 1000 hours in the salt fog chamber

The lighter stockbridge dampers have been widely used in the East Coast of China. The tracking and corrosion resistance is excellent.

5. Conclusions

The installed ADSS cables are often damaged in the gripping section of spiral vibration damper. It has been found that the discharging electricity of air space between ADSS and the gripping section of spiral vibration damper is the main reason for causing failures of the installed ADSS cables. In order to inhibit this type of electric corrosion, we have already developed the anti-corrosion paint, which can be used to fill up the air space between ADSS and the gripping section of spiral vibration damper. In order to confirm the theory of air space discharge and demonstrate the resistance of the anti-corrosion paint to erosion, a salt fog test was carried out. In this test three sections of ADSS cables with less corrosion resistant spiral vibration dampers were placed in a salt fog chamber. After only 100 hours of test run, the erosions on the surface of damper in the gripping section of damper were found for the ADSS cable without the anti-corrosion paint or filling compound. On the other hand, for the ADSS sections with the anti-corrosion paint or filling compound, no erosion could be found even after 1000 hours of test run. The test results indicate that the ADSS cable with the anti-corrosion paint has a higher corrosion resistance and reliability. We have also developed the new excellent track resistant cable's sheath, anti-corrosion spiral vibration damper and lighter stockbridge damper, which can also improve the corrosion resistance of ADSS cables significantly.

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Biography not available.