Results of Qualification of ADSS Cable with Reduced Weight and Diameter

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Abstract

For ADSS cable weight and diameter are very important characteristics because they directly impact on the mechanical tension induced on the supporting structure (pole or tower).

The cable diameter itself has to be as small as possible because it has a quadratic influence on the tension when ice and/or wind are considered.

Current design technique uses aramid as the cable strength element but it has limitations when very high spans or very adverse environmental conditions are an issue.

This paper presents the results of qualification of new a All Dielectric Self-Supported (ADSS) loose tube cable design technique that provides a reduction in cable weight and cable diameter and, consequently, a reduction of the load induced on the supporting structure, like poles and towers

Keywords

Optical Cable; ADSS; self-supported; aerial cable; PBO; aramid.

1. Introduction

One key point for a new long distance network is where the cable will be installed. The main possibilities are along highways, railways, gas and oil ducts, undersea or on overhead lines. Recently, some companies outside of the telecom sector have found they can increase their revenues charging telecom companies for the use of the right of way (ROW) of their infrastructure. Some of these companies decided to be players in this profitable market, deploying their own cables and becoming carriers carriers.

A solution for the utilities companies in this market is to install ADSS cables on their overhead lines. Initially, it has been a challenge for the fiber optic cable industry to design cables strong enough to support the installation on long spans usually found in the field. The stronger cables had higher weight and diameter placing a higher weight load on the supporting cables and towers.

It has been a constant goal of the optical fiber cable industry to develop ADSS cable designs with reduced weight and diameter in order to increase the maximum installation span and make possible the usage of this type of cable on Extra High Voltage (EHV) overhead lines.

The ADSS structure would also be effective in extreme environmental situations like hurricanes and/or temperatures variations coming from negative values up to positive values including the area saliencies.

The concept of cables with this new techniques begin present here, concluding that PBO (poly-para-pheylene-oxazole) is an effective alternative to the current design technique using aramid yarn. For a span of 1000 meters, the MWT (maximum working tension) of the cable with PBO is 9% smaller than when aramid is used. The thinner yarn layer obtained using PBO also gives more stability to the production process.

2. Mechanical cable strain

Aerial cables are routinely subjected to harsh environments: high winds, ice storms and lightning. OFS loose tube cable products are free of fiber tensile strain while the cable is within its operating constraints. Operating constraints differ for different products and applications. For standard loose tube cables, these constraints typically are a maximum rated cable load of 600 pounds and a temperature range of -40°C to +70°C. For all-dielectric self-supporting aerial cable, there will be no fiber tensile strain up to the maximum rated cable load as dictated by the worst case loading condition and under the conditions as listed on sag and tension charts. Cables can be custom designed to meet special customer applications.

There are situations where aerial cables are the only solution; as over river crossings, mountain slopes, or across a highway. There are two techniques to design the cable in accordance with field conditions; (1) the current technique, which uses aramid yarn, a dielectric material with very high modulus and low specific weight that has proven to be an excellent structure and (2) a novel technique that substitutes the aramid yarns with another synthetic fiber with higher modulus.

3. Prototypes

3.1 Features

We are presenting the characteristics of cables with PBO and aramid with 6 % of sag at EDS (every day stress) condition; Four prototypes were produced to confirm the theoretical calculations: 2 cables for 500 max span and 2 cables for 600 m max span. Two of the prototypes used the current technique and two used the novel technique.

Table 1. Characteristics of cables using the current technique

Characteristics	P1	P2
Span (m)	500	600
Diameter (mm)	15.1	16.2
Weight (kg/km)	202.0	236.5
Maximum working tension (kgf)*	1030	1450
Modulus (kgf)	250,634	265,366
LEC (10^{-6} 1/°C)	0.22	0.34

*Without fiber strain

Table 2. Characteristics of cables using the novel technique

Characteristics	P3	P4
Span (m)	500	600
Diameter (mm)	13.6	13.9
Weight (kg/km)	170.0	176.5
Maximum working tension (kgf)*	860	1070
Modulus (kgf)	215,810	274,374
LEC (10^{-6} 1/°C)	-0.82	-0.18

*Without fiber strain

4. Tests Results

We are showing here the results of qualification tests of prototypes:

4.1 Tensile Strength Test

The intent of this test is to verify the ability of cable to satisfactorily perform while undergoing tensile loading encountered during operation. The cable is designed to withstand rigorous tensile loading levels.

The cable is subjected to a first tensile loading of 15 % of MWT Load and the increase to a loading up to 150% of its maximum allowable tensile load. The load is applied in 45 %, 75 %, 105 % and 112% of MWT Load cable.

Cable Test Length:

220 meters

Table 3. Tensile Loading Test for 500 m span - aramid

% MWT	Load (kgf)	Elongation (mm/mm)
15	150.0	0.00
45	485.5	0.25
75	810.9	2.45
105	1081.2	3.47
112	1135.3	3.70
150	1621.8	5.38

Table 4. Tensile Loading Test for 600 m span-aramid

% MWT	Load (kgf)	Elongation (mm/mm)
15	150.0	0.00
45	227.0	0.26
75	681.0	1.74
105	1135.0	3.18
112	1589.0	4.58
150	1695.0	4.93

Table 5. Tensile Loading Test for 500 m span – PBO

% MWT	Load (kgf)	Elongation (mm/mm)
15	139.0	0.00
45	418.0	1.29
75	697.0	2.46
105	976.0	3.62
112	1041.0	3.86
150	1395.0	5.29

Table 4. Tensile Loading Test for 600 m span - PBO

% MWT	Load (kgf)	Elongation (mm/mm)
15	160.5	0
45	481.5	1.4
75	802.5	2.55
105	1123.5	3.78
112	1198.4	4.04
150	1605.0	5.49

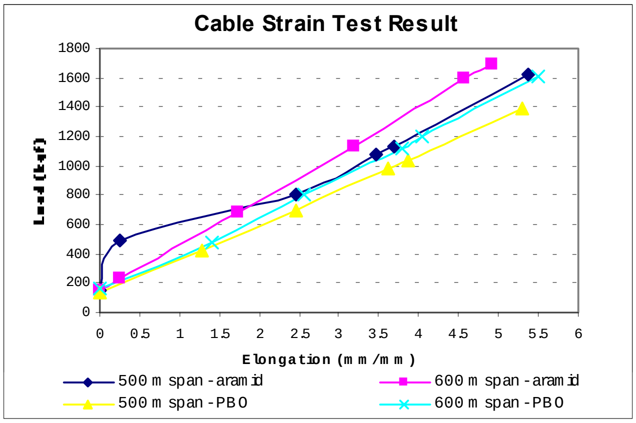

Figure 1. Prototypes cable strain

Comment:

None of the cables exhibited any fiber strain or change in attenuation up to the maximum rated tension.

4.2 Creep Test

Creep is the slow, continued lengthening under a constant load and the intent of this test is to measure the cable creep under the MWT load.

During 240 hours under the MWT load the cable elongation needs to measure in each 5 minutes during the first hour and in each 15 minutes during the next seven hours. In the rest of time three measure during 24 hours. The creep projection curve must have at least a correlation factor of 90 % (R^2) to a trust interval of 95 %.

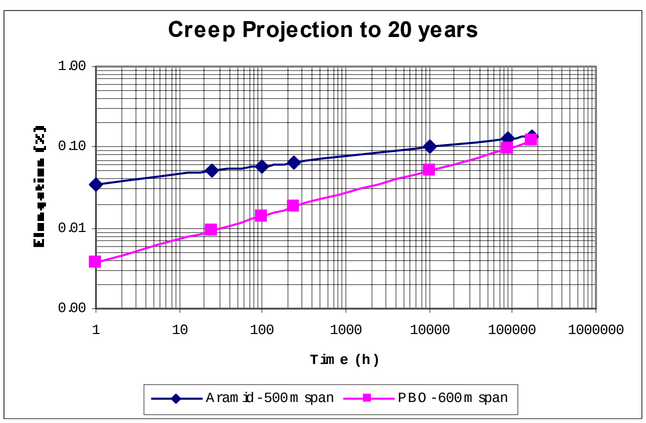

Figure 2. Creep Projection

Comment:

In the time the PBO comportment is different than aramid, but the projection of creep during 20 years are very similar.

We obtained the following correlation factors:

- ✓ 500 m span prototype – aramid: R^2=0.9669;
- ✓ 600 m span prototype – PBO: R^2=0.9764.

4.3 Cable Aeolian Vibration Test

The intent of this test is to assess the fatigue performance of cable and the optical characteristics of the fibers under typical aeolian vibrations. Aeolian vibrations are caused by gentile, steady wind blowing across a cable and are generally of low amplitude and high frequency. Amplitudes are typically considerably less that the cable diameter and frequencies are in the order of 10 to 100 Hz, depending on wind speed and cable diameter. The cable is be subjected to a minimum of 100 million vibration cycles, under the MWT and amplitude equal to one-half the diameter of the cable.

Cable Test Length:

25 meters

Comment:

No broken fibers as a result of test, no changes on attenuation level and no damage to sheath, core components or hardware was observed.

Table 5. Cable Aeolian Vibration Test

Cable	Status
500 m span with aramid	Passed
600 m span with aramid	Passed
500 m span with PBO	Passed
600 m span with PBO	Passed

4.4 Temperature Cycling Test

The intent of the Temperature Cycling Test is to ensure that our cables maintain mechanical and optical integrity when exposed to temperature extremes during storage, installation, and operation.

The reel of cable is placed in an environmental chamber and preconditioned at 23°C. During the Temperature Cycling Test the cable is subjected to 4 cycles of exposure to 48 hours at -20°C and 24 hours at 65°C. Attenuation measurements are made on the fibers at both temperature extremes during the second cycle.

Comment:

No changes on attenuation level.

Table 6. Temperature Cycling Test

Cable	Status
500 m span with aramid	Passed
600 m span with aramid	Passed
500 m span with PBO	Passed
600 m span with PBO	Passed

4.5 Breaking Strength Test

The intent of this test is checking the breaking cable strength without the creep influence.

Table 7. Breaking Strength Test

Cable	Load (kgf)
500 m span with aramid	3653
600 m span with PBO	2800

Comment:

No damages in cable sheath were observed and the practical cable breaking elongation is 1 %.

5. Conclusion

Worldwide usage and applications of ADSS cables continues to increase. Improvements into cable design and response to customer requirements is essential to compete in the fiber optic cable market. Improved strength material with PBO is available to address issues regarding flexibility and handling for the user. PBO proved that it is a good alternative for long spans applications and extreme environmental conditions.

After final qualification tests proved the PBO technical reliability.

6. References

[1] Giacaglia, Vallente, Marcello, "Novel ADSS Cable Design Technique for a Reduction Weight and Reduced Cable Diameter" *Proceedings of the 50th IWCS, (November 2001).*

Author

Alessandro Nunes received a Bachelor's degree in Electrical Engineering from Sorocaba University in 1998 and a MBA degree in Based Value Management from Getulio Vargas University in 2001. He is now the Product Manager of OFS cable Brazil plant.