

XWGB2-02_HighTempLimits – Chair, LenCuster**xWG – Thermal Aging of Conventional Conductor Systems****Task: Comparison between ACSR and TACSR Penguin Conductor****by:****Do Nascimento, C.A.M. and UEDA, S. - Brazil****1. Introduction**

Recently in a power utility, the areas of planning, design, operation and maintenance are well used to the urgent necessity of better exploring the ampacity of existing and also future transmission lines, joining technology, reliability and safety. In this way, the new types of conductors and high temperature limit of conventional ACSR are appearing for transmission line ampacity improves its capacity. An increase of ampacity rating can be achieved on conventional ACSR conductor without acceleration aging knowledge about it. For this propose designers teams have to take into account the impact of operation in high temperature limit about 100 °C on conventional conductor ACSR.

2. CEMIG's Experiment with Task Force Aging of ACSR and TACSR Conductors

In a partnership with NEXANS BRAZIL (old Furukawa Brazil), CEMIG has performed a research on TACSR and ACSR conductors aging in an experimental line, in order to check the aging conductor performance compared to a new and old ACSR. In normal operation the temperature of a TACSR and ACSR conductors can reach up to 150° C at this experimental line. Figure 1 shows the configuration of the Experimental Line where a conductor ACSR and a TACSR with the same diameter (4/0-Penguin) have been subjected to high temperatures.

3. Practical Comparison**3.1 Details of Experimental Line**

An Experimental Line - "Nova Lima-Bonsucesso" was adapted to receive the new ACSR and TACSR conductors with the same diameter and geometry (4/0 Penguin). For this reason this Experimental Line was reconstructed for the implementation of the proposed experimental procedure as showed at Figure 1 and operated along of one year.

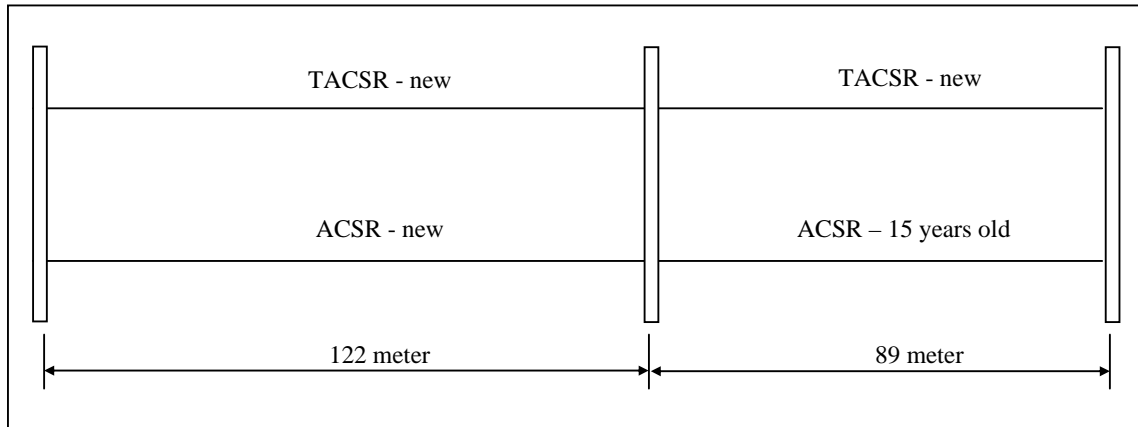


Figure 1 - Configuration of ACSR and TACSR Conductors in the Experimental Line.

3.2 Energy System

The current in Experimental Line was regulated through the voltage regulator that maintains a level of line voltage almost constant, so the maximum line current ($I_{max} = 680 \text{ A}$) is controlled. Figure 2 shows the transformer (300 kVA) and two voltage regulators used.

3.3 On-Line Monitoring System

The surface temperature and current sensors were installed in Experimental Line by using the Power Donut Technology, where each sensor works in contact with the conductor and transmit this information direct by radio to a ground station and store them in data acquisition system.



Figure 2 – Power Transformer System (300 kVA), two Reguladores de Tensão, Power Donut Sensor of Monitoring Temperature System and Weather Station in Experimental Line

3.4 Assessment Rating

Table 1 shows the static rating calculation of the Experimental Line depends on the design temperature and EDS% of conductors.

Table 1 – Static Rating Calculation.

Design Temperature (°C)	EDS(%)	Ampacity Rating (A)	I (pu)
75	18.5	328	1.0
140	22	524	1.6

3.5 Experimental Data

All conductors of Experimental Line were kept at high temperature for one year to compare the performance of the traditional ACSR 1350 alloy conductor (new one). Figures 3 to 5 show the profile of the variations of hourly average of conductor temperature and current and on site hourly average of wind speed, respectively.

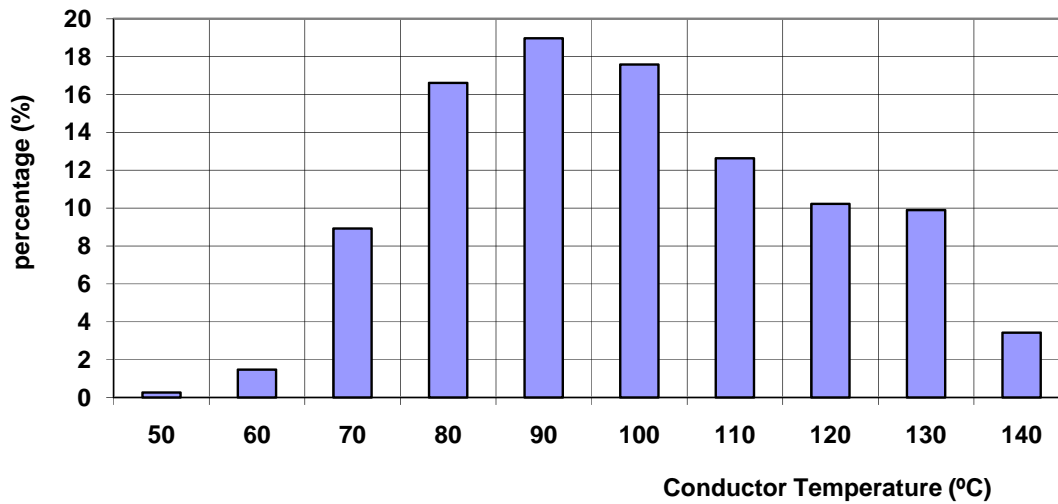


Figure 3 - Hourly average of conductor temperature in the Experimental Line.

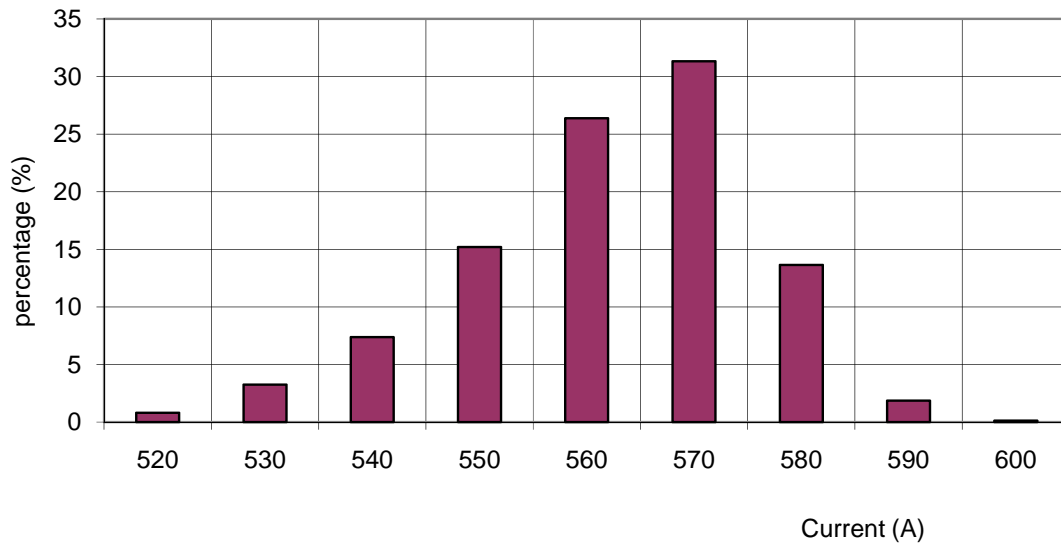


Figure 4 - Hourly average of current in the Experimental Line.

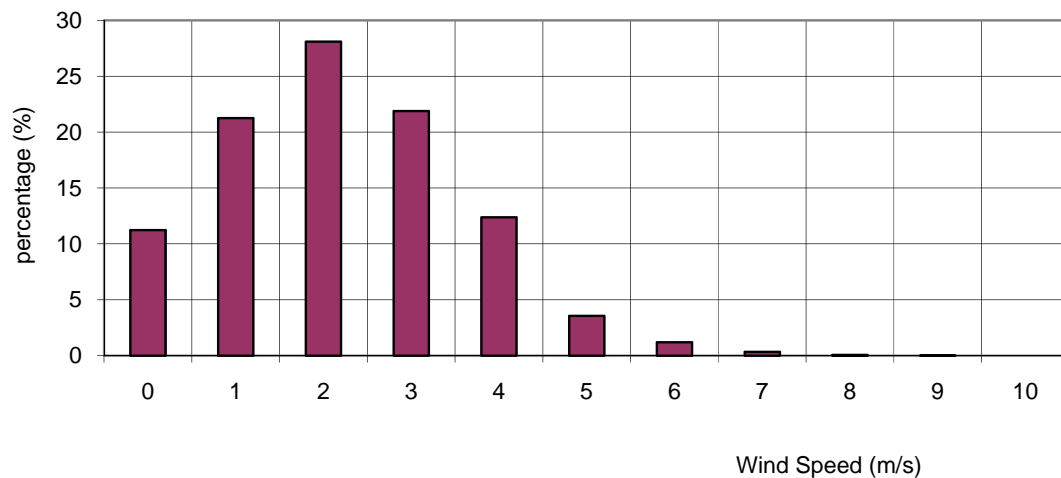


Figure 5 - Hourly average of wind speed in the Experimental Line.

3.6 Conductor Break-Test

The break test was performed to measure the tensile strength of the conductor. In these tests were observed values of elongation and tensile strength. The life time of a conductor can be measured by this test, since the loss of mechanical strength is correlated with material age, being more critical than the loss of other characteristics of the conductor. Samples were taken

from the conductors for all stages of experience. Conductor break tests were made in horizontal traction machine of 40 tons (where 8 meter of conductor of sample was pulled until to break as shown in Figure 6).

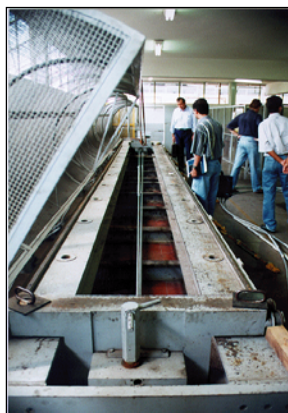


Figure 6 - Conductor break tests in horizontal traction machine of 40 tons view.

3.6.1 Results of Conductors Break-Test

Table 2 shows the evolution of loss of strength observed during the energization of one (1) year of Experimental LT. It was observed that the losses in the conventional ACSR 1350 alloy are significant (between 0 to 8.9%) when compared to them (Reference New).

TABLE 2 – Percentage of Conductor Strength Lost

Conductor		Reference New before experiment	After 4 months of experiment	After 12 months of experiment
ACSR	Kgf	3990	3778	3636
	Strength Lost %	-	5.3	8.9
TACSR	Kgf	3810	3825	3913
	Strength Lost %	-	~0	~0

3.7 Wire Break-Test

The aluminum and steel wires were also tested separated on a vertical traction machine of 10 tons as shown in Figure 7.



Figure 7 - Aluminum and steel wires vertical traction machine of 10 tons view.

3.7.1 Results of Wire Break-Test

Table 3 shows the evolution of loss of strength observed during the energization of one (1) year of Experimental LT. It was observed that the losses in the convectional Al 1350 alloy wire (between 0 to 60%) and TAL alloy wire (between 0 to 37%) when compared to them (Reference New).

TABLE 3 – Percentage of Wires Strength Lost

Alloy		Reference New before experiment	After 4 months of experiment	After 12 months of experiment
Al 1350	σ_{break} (kgf)	322.5	127.5	151
	Strength Lost (%)	-	60	53
TAL	σ_{break} (kgf)	323.6	275.4	203.4
	Strength Lost (%)	-	15	37

3.7.2 Graphics Results of Wire Break-Test

The Figures 8 and 9 show the tension-deformation diagrams for the alloys Al 1350 and TAL wires. It was observed that after 4 months in operation the conductor is subjected to heat treatment, due to high temperature in the Experimental Line.

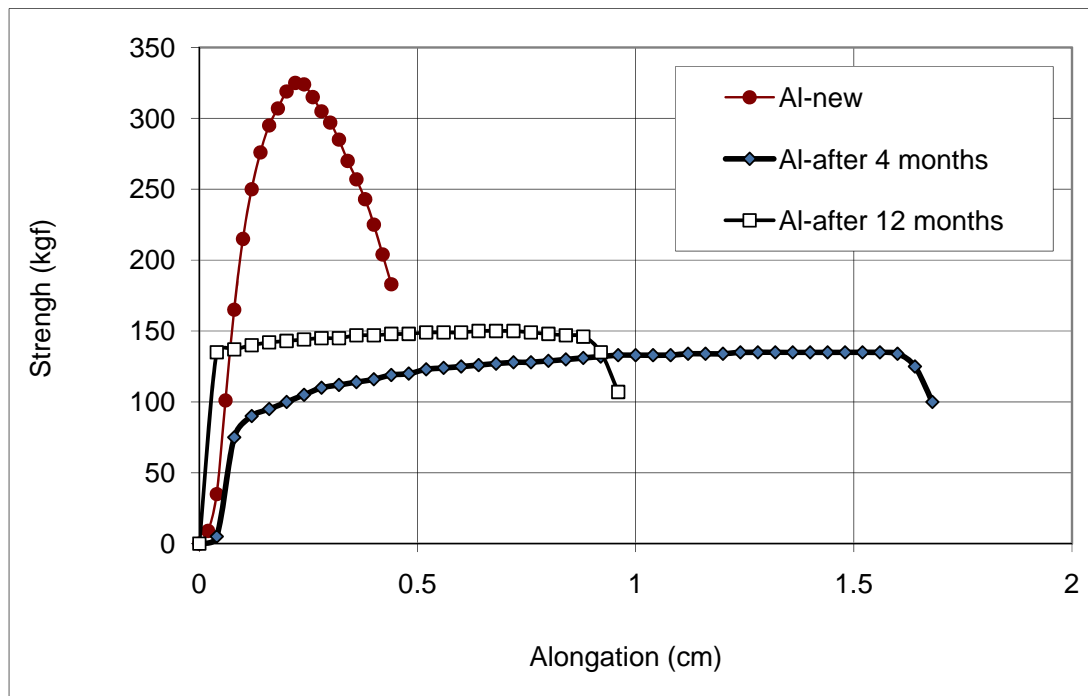


Figure 8 - Tension-deformation diagrams for the alloys Al 1350 wires view.

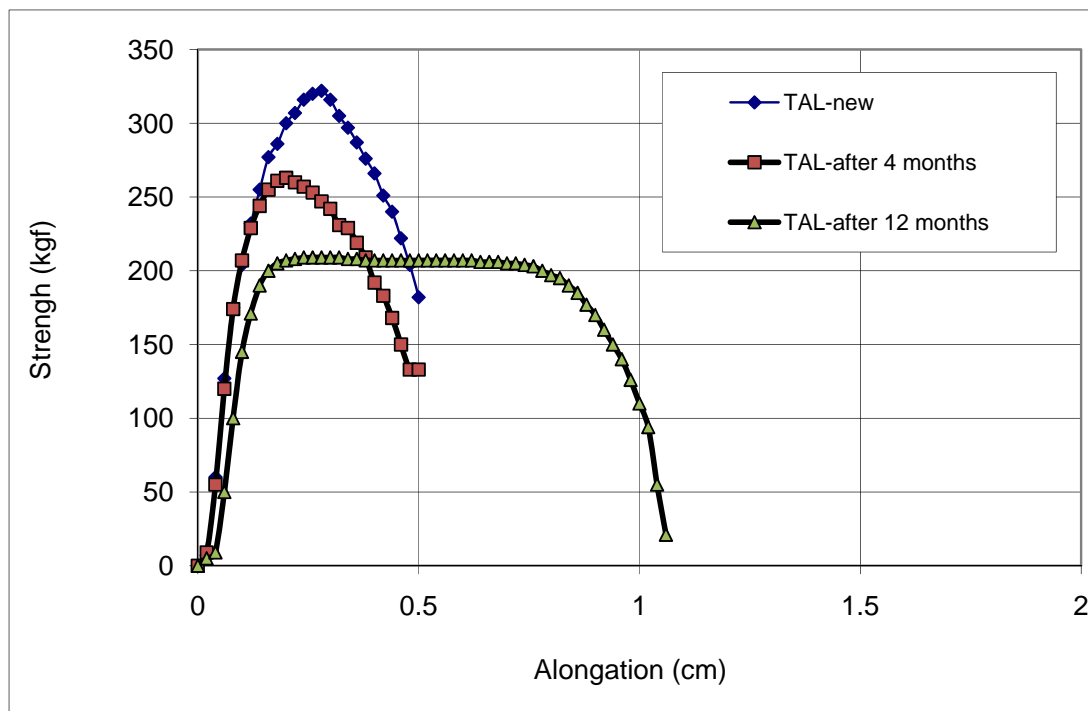


Figure 9 - Tension-deformation diagrams for the alloys TAL wires view.

3.8 Metallographic Analysis

In metallography of TAL alloy was observed the highest percentage of inclusion of zirconium (Zr), shown by dark spots at left side column at Table 4. This chemical works to the grain boundaries of the alloy helping to increase the temperature of annealing of aluminum alloy. Table 4 shows even the behavior metallographic and tensile strength of conventional aluminum alloys Al 1350 and TAL. Note that, with the loss of mechanical strength of the material, there are inclusions, observed in the metallographic images of conventional alloy by formation of crystals that indicate aging of the material. In TAL alloy, this phenomenon is reduced according to the metallurgical properties of the chemical element zirconium in the formation of this alloy. In metallography of steel core no significant difference could be observed as shown in Table 5.

TABLE 4 – Samples of Metallography of Wires









	Al – 1350 Cross section	Al – TAL Cross section
New Sample		
After 4 months		
After 12 months		

TABLE 5 – Samples of Metallography of Steel Core

	Steel Core Al – 1350 Cross section	Steel Core Al – TAL Cross section
New Sample		

3.9 CONCLUSION

The Experimental Line thermal and mechanical tests show the main results of accelerated aging of conductors. Aluminum alloys and whole conductor loss of mechanical strength were showed. The ACSR-TAL conductor shows that aging was reduced and how important is the inclusion of zirconium in aluminum alloys for really provided the reduction of loss of mechanical strength.

The metallographic analysis confirmed visually mechanical loss observed in the conductors tested and indicating a direct correlation between the graphs of loss of mechanical strength and its metallographic images.

The 50% of loss mechanical strength of ACSR Al 1350 wires found in Experimental Line is so relevant that this issue of accelerated aging of ACSR Al 1350 should be researched much better than until now.