PILOT INSTALLATION OF GTACSR CONDUCTORS IN THE SPANISH POWER SYSTEM

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INTRODUCTION

The significant increase in power demand, with the resulting saturation of electrical transmission and distribution lines, has made Iberdrola to review its strategy to increase the ampacity of existing lines. Traditionally, line upgrading techniques have been applied (change from single conductor to twin bundle, increase in conductor cross section, increase in voltage level or the use of double circuits).

However, currently Iberdrola is trying to deal with the problem of increasing transmission current capacity by uprating the saturated lines using GTACSR (Gap-Type TAL Aluminium Alloy Conductor) conductors. The characteristics of these conductors make possible the replacement of traditional conductors without modifying the existent towers, so the line uprating can be considered as a maintenance work.

Prior to the installation of these conductors in its distribution lines, Iberdrola developed technical studies, simulations and laboratory tests over a test span. This work has made possible to verify the behaviour of GTACSR conductors under different electrical (current), mechanical (sag/tension characteristics), and thermal conditions (temperature). Specifically, these tests were developed by a Japanese manufacturer of GTACSR conductors under the supervision of Iberdrola.

In May 2004, Iberdrola has developed a pilot installation of the GTACSR conductor in a distribution line of the Spanish distribution system, being the first experience in the installation of these conductors in Spain. In this line, the LA-280 ACSR conductor of one phase has been replaced by the GTACSR-260 conductor.

In this paper, the most relevant aspects considered in the installation process of the GTACSR pilot installation are described.

GTACSR CONDUCTORS

GTACSR conductors are characterised by having a special structure, which is shown in Fig. 1. The aluminium wires in the internal layer, closest to the core, have a trapezoidal cross section in such a way that a gap is formed between the steel core and the aluminium layers. This gap is usually filled with grease resistant to high temperatures.

This construction method makes it possible to reduce the friction between the core and the aluminium wires in such a way that the GTACSR conductors can be strung by tightening only the steel core and leaving the aluminium layers untightened. This fact means that the elongation of the conductor depends almost exclusively on the linear expansion coefficient and on the elongation characteristics of the steel core. Thus, at temperatures higher than those at stringing, only the steel core supports the stress, with the sag in the conductor depending only on the expansion of the steel. The direct consequence is that the conductors accept a higher temperature, for the same sag, which in turn brings about an increase in the ampacity of the line.

Nevertheless, in order to achieve this performance from the conductor, it is necessary to apply a special stringing procedure that proves to be more complex than those normally used in conventional ACSR conductors.

Furthermore, the high temperature of the new conductors could have a negative effect on traditional clamp systems. The characteristics of the clamp system has to be analysed before the installation is carried out.

OBJECTIVES OF THE PILOT INSTALLATION

The objectives of the pilot installation are related to the clamp systems, the stringing procedure and the low sag performance verification.

The first objective is the validation of the capability of the clamp systems. A compression clamp system suitable for the GTACSR requirements has been designed and manufactured. This clamp has been used in the pilot installation.

The second objective is to gain experience with the stringing procedure. Furthermore, the cost increase will be estimated.

The last but not least objective is to verify the correct low sag performance after the conductor is installed.
CHOICE OF PILOT INSTALLATION LOCATION

In order to change from the current ACSR to the GTACSR conductor, the first step was to choose a suitable overhead line for the installation. The characteristics required for the overhead line where the GTACSR has been installed were the following:

1. Easily accessible so that it can be closely monitored. In this way, those overhead lines situated in urban areas and close to substations are preferred.
2. It does not have to be a critical line to the electric power system. In case of an incident in the pilot line, the effect on the electric power system is reduced. For this purpose, medium voltage (20-30 kV) lines are more appropriate than high voltage lines (132 kV).
3. Easy installation. Taking into account the inexperience of the installers in the GTACSR stringing and sagging, the location of the towers and their characteristics should make it easier. For this purpose, medium voltage lines that are close to substations are appropriate.
4. Versatility. By means of a transference of loads, it is possible to increase the current capacity in the pilot line. In this way, the low sag characteristic of the GTACSR can be evaluated in the worst conditions.

Taking into account these requirements, the lines of the broad distribution network of IBERDROLA DISTRIBUCIÓN were analysed until one line that satisfies all the requirements was found.

The chosen line is the 30 kV Ortuella-Santurtzi line located in Santurtzi (Bizkaia). The longitudinal and topographical profile of the line has been carried out and the suitability for the installation of low sag conductors has been verified.

In this line, the LA-280 ACSR conductor of one phase has been replaced by the GTACSR-260 conductor, along three spans A, B and C of 143 m, 128 m and 169 m respectively, which makes a total length of 440 m. In the other two phases the existing ACSR conductors have been maintained.

The main difficulty of the installation of the GTACSR conductors is related to the installation of compression clamps. In the three spans of the pilot line, all the clamps are of compression type. Hence, it is possible to gain experience of the installation process.

COMPRESSION CLAMP DESIGN

In this pilot installation, the compression systems specially manufactured by Industrias Arruti, for this type of conductors, were used. The requirements for the clamp systems are determined by the high temperature – low sag characteristics of the GTACSR conductor.

Due to the high temperature characteristic of the GTACSR conductor, the current capacity is higher than in an ACSR of similar cross section. This higher current goes through the clamp system as well. Therefore, the higher current density will imply a higher temperature in the clamp system [1,2].

This effect can be reduced increasing the cross section of the clamp system and consequently reducing the current density. Furthermore, due to the increase in the cross-section, the area of the aluminium surface is larger and the capacity of dissipation of the heat produced increases. Besides increasing the cross-section of the aluminium clamp, the cross-section of the terminal lug has to be increased as well.

Another characteristic of the GTACSR conductor is the low sag characteristic. This characteristic is achieved in the GTACSR because all the mechanical load is supported by the steel core. In a conventional conductor both the steel and aluminium support the conductor load. The proportion of load supported by each material is variable depending on the conductor type. The contribution of the aluminium to the conductor rated strength is between the 30 % and the 50 %.

The steel used in the GTACSR conductor has a strength 40 % greater than the standard steel. The strength of the steel clamp also has to be higher than that of a conventional clamp system in order to fulfil the requirements.

The manufacture of the compression clamp for the pilot installation is similar to the manufacture of a conventional compression clamp. The only differences are related to the dimension changes.

In Fig. 2, the components of the compression clamp installed in the pilot installation are shown.

The aluminium clamp is obtained from an extruded aluminium tube where a cone is machined on one edge of the tube. As the dimensions of the aluminium tube are special new tools have been manufactured for the extrusion process. The terminal lug is made in cast aluminium. Afterwards, it is machined until the required dimensions are obtained.

The steel clamp is manufactured from a forged component. This component is machined in order to obtain the required dimensions.
**GTACSR INSTALLATION**

Different Spanish installers (ELECNOR, SEMI, INABENSA, TESSAG), under the supervision of the Japanese manufacturer, carried out the stringing and sagging of the conductor.

The main difference with respect to the installation of an ACSR is the installation of the compression clamps. In the case of the GTACSR conductor, the aluminium alloy layers must be destranded and restranded [3-5].

When there are several suspension towers between two dead-end towers, the destranding and restranding is carried out in both compression clamps of the two dead-end towers. This is carried out in order to make easier the sliding between steel and aluminium layers. In the pilot line, as there is no suspension tower, it is enough if the destranding is carried out only in one of the dead-end tower. In the other dead-end tower the compression clamp is joined to the conductor in a conventional way. Hence, as the pilot installation has three spans the destranding and restranding has been carried out three times.

The installation was carried out in one day and a half. The first day the stringing of the three spans and the sagging of span C was carried out. The next day the sagging of spans A and B was carried out. The second day, the destranding and restranding was carried out much easily due to the skill acquired in the first day.

For the stringing process, the existing ACSR conductor was used as the pilot conductor. The new GTACSR conductor was connected to the existing ACSR using a conductor stringing clamp.

When the GTACSR reached the final dead-end tower, in each of the spans one compression clamp was installed in the conventional way. On the other side of the span, the destranding and restranding of the aluminium layers was carried out before the compression clamp was installed.

**Installation of the GTACSR compression clamp**

The first step is the connection of the conductor to the tower by means of an aluminium gripping clamp. Then, the presagging of the conductor is carried out. The conductor is pulled by means of the aluminium gripping clamp until the 70 % of the tension indicated by the sagging table is achieved.

The conductor is trimmed leaving enough length for the following connection to the compression clamp. Then, the conductor is inserted in the aluminium clamp. The aluminium clamp slides along the conductor until it is situated beside the aluminium gripping clamp.

In order to proceed with the sagging, the aluminium alloy layers are destranded. This operation has to be carried out with great care so that the conductor is not damaged.

Then, the grease existing on the steel core surface is removed. The steel core is connected to the tower by means of a steel gripping clamp. Then, the conductor is pulled by means of the steel gripping clamp until the 100 % of the tension indicated by the sagging table is achieved.

The next step is to leave the conductor at rest so that the aluminium alloy layers slide along the steel core. If there are several suspension towers between two dead-end towers, the conductor has to be at rest for at least 24 hours. Then, the tension is adjusted again by means of the steel gripping clamp. In the case of the pilot installation, as there is no suspension tower, the time at rest can be much lower. The conductor has been at rest for half an hour.

Taking into account the length of the insulator string, the steel core is trimmed to the exact length and it is inserted in the steel clamp. The steel core and the steel clamp are compressed and connected to the insulator string. Then, the steel gripping clamp is removed.

The next step is the restranding of the aluminium layers (Fig. 3a). This operation has to be carried out with great care so that the conductor is not damaged. Finally, the aluminium clamp slides along the conductor (Fig. 3b), and it is compressed together with the steel clamp giving the final compression clamp. Then, the aluminium gripping clamp is removed.

**MONITORING THE PILOT INSTALLATION**

So far, the correct behaviour of the installation has been verified. For this purpose, in each span, the sag of the GTACSR conductor has been compared with the sags of the two ACSR conductors.
Table 1 shows the sag values after the stringing and sagging of the line. This process was carried out in May 2004.

<table>
<thead>
<tr>
<th>Span</th>
<th>Phase a (GTACSR)</th>
<th>Phase b (ACSR)</th>
<th>Phase c (ACSR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3.16</td>
<td>2.96</td>
<td>2.97</td>
</tr>
<tr>
<td>B</td>
<td>1.97</td>
<td>2.02</td>
<td>1.86</td>
</tr>
<tr>
<td>C</td>
<td>3.71</td>
<td>3.96</td>
<td>3.86</td>
</tr>
</tbody>
</table>

During electrical load conditions, it has been observed a lower sag increase in the GTACSR conductor. As an example, Table 2 shows the sag increase measured in July, with an electrical load of 10 MVA (184 A) and an ambient temperature 4 °C higher than that of the stringing and sagging day.

<table>
<thead>
<tr>
<th>Span</th>
<th>Phase a (GTACSR)</th>
<th>Phase b (ACSR)</th>
<th>Phase c (ACSR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.18</td>
<td>0.33</td>
<td>0.35</td>
</tr>
<tr>
<td>B</td>
<td>0.13</td>
<td>0.21</td>
<td>0.23</td>
</tr>
<tr>
<td>C</td>
<td>0.22</td>
<td>0.34</td>
<td>0.33</td>
</tr>
</tbody>
</table>

Although there are small differences between the three spans, the increase in the GTACSR sag is a 40 % lower than the increase in the ACSR sag. Therefore, the low sag characteristic of the GTACSR conductor is verified.

It also has been verified that there is no sliding in the installed compression clamps. So far, the behaviour of the clamp systems are as expected (Fig. 4).

CONCLUSIONS

Currently, the behaviour of the installed conductor under real operation conditions of the mentioned electrical line is being verified. The conclusions extracted from this supervision, in addition to the results obtained from previous simulations and tests, will allow the utility Iberdrola to define:

- The guidelines to follow in the analysis of the technical and economical feasibility of the uprating of a certain line.
- The guidelines in the installation process of GTACSR conductors
- The possible maintenance work that may be required in electric lines with the GTACSR conductors installed

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REFERENCES


