

## Research on Sheave Test and Optimization of Expanded Diameter Conductors JL/G1A-530(630)/45

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**Abstract.** Expanded diameter conductors are widely used for high voltage electricity power transmission. But the stability problem of its section often occurs during the construction processes, especially for the not-well-designed conductor structures. This phenomenon is typically characterized by the appearance of outer wire/wires jumping out of the layer; therefore it is also referred as wire jump-out problem. The solution is sheave test research for the study of section stability. In this paper, a kind of sheave test is introduced and a kind of ovality analysis of the expanded conductor has been designed for the study.

### Introduction

The former Soviet Union developed and applied the expanded diameter conductor which used the glass fiber reinforced plastic wire as the central support of expanded diameter. Japan studied and tried to manufacture a large number of expanded diameter conductors with various structures, but expanded diameter conductors were not widely applied in Japan due to its specific national conditions. The ultra-high voltage lines in Japan were originally designed to use the 8×610 mm<sup>2</sup> expanded diameter conductors, in order to satisfy the electrical requirements and the requirement for current carrying capacity. However, some problems occurred in the stringing of expanded diameter conductors during construction, so they were all replaced by 8×810 mm<sup>2</sup> conductors in the end. In the vast countries, such as, the United States, Brazil and India, the 750kV transmission lines were constructed, and expanded diameter conductors were used in many sections of the lines in the plateaus <sup>[1]</sup>.

Along with the construction of ultra-high voltage transmission lines in the highland areas of China, the research and promotion of expanded diameter conductors will be of great significant to enhancing the design level of transmission lines, optimizing the design scheme of projects, improving the electromagnetic environment of lines, facilitating the technical upgrading of grids and driving the sustainable development of national grid construction <sup>[2]</sup>.

Expanded diameter conductors were utilized for the first time in the Guanting-East Lanzhou Transmission Line Project, which was a 750kV transmission and transformation demonstration project of Northwest China Power Grid. After they were uncoiled and laid, it was discovered that there was the phenomenon of wire jump-out in the outer aluminum wire strand of conductor at some areas. Wire jump-out distributed unevenly, and most of jump-out aluminum wires were single <sup>[3]</sup>. Moreover, the jump-out was 1/3 to 2/3 of the diameter of single wire. At the places with large height difference between towers, the wire jump-out phenomenon became very serious, while the wire jump-out was slight in the flat terrains. Due to the unstable structure of conductors and some unsettled problems of construction technique, expanded diameter conductors were not widely applied in the project. Later on, design, manufacturing and other units focused on the research and changed the model, and especially made some improvements with regard to the structure of conductor and the tolerance of single strand aluminum wire. In the end, the conductors were successfully uncoiled and laid in the test <sup>[4]</sup>.

## Sheave Test of Expanded Diameter Conductors

Through the test research, this paper gains the critical tension causing the wire jump-out of JL/G1A-530(630)/45 expanded diameter conductors. Moreover, we observe the times of conductor passing through sheave under the effect of different test tensions, as well as wire jump-out location, cross-sectional condition<sup>[5]</sup>.

Test devices include sheaves, tracks, winches, wire strands and tensile machines. The parameters of devices are shown in Fig. 1.

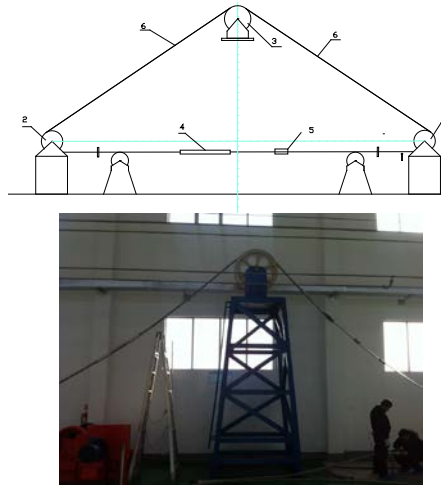


Fig.1 Test Devices

Test conditions:

- (1) Test sample length: 21m;
- (2) Model and specification of conductor: JL/G1A-530(630)/45;
- (3) Outer diameter of conductor: 33.75mm;
- (4) Maximum loading force: 500kN;
- (5) Angle: 30°;
- (6) Elevation of test devices: 1.5m.;
- (7) Type of motion: reciprocating motion;
- (8) Travelling speed of mechanism: 1m/s.

## Test Results

**Critical Tension of Wire Jump-out.** When the tension is 35%RTS, there is slight wire jump-out on the surface of the conductor after the conductor passes through sheave for 20 times. When the tension is 40%RTS, there is serious wire jump-out on the surface after the conductor passes through sheave for 20 times. Therefore, it can be judged that the critical wire jump-out tension of JL/G1A-530(630)/45 expanded diameter conductors is 40%RTS.

The wire jump-out process is as shown in Fig. 2.





35%RTS



40%RTS

Fig.2 Wire Jump-out Process of Conductor

**Cross-sectional Ovality Analysis of Conductor.** When the conductor passes through sheave, it is always twisted and bent, so its diameter is always changing as well. The ovality of test sample of the conductor is studied as follows, in Fig. 3-5.

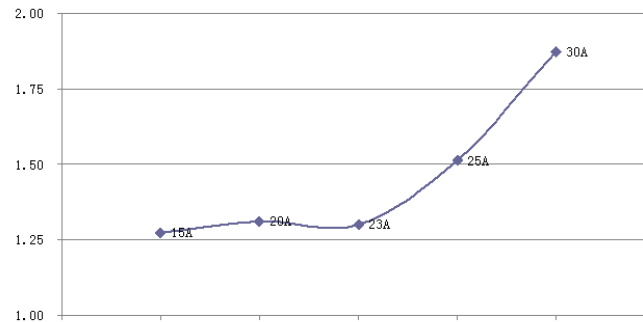


Fig. 3 Curve of the Maximum Difference between Maximum and Minimum Intermediate Cross Sections under Each Tension for the Test Sample of Conductor

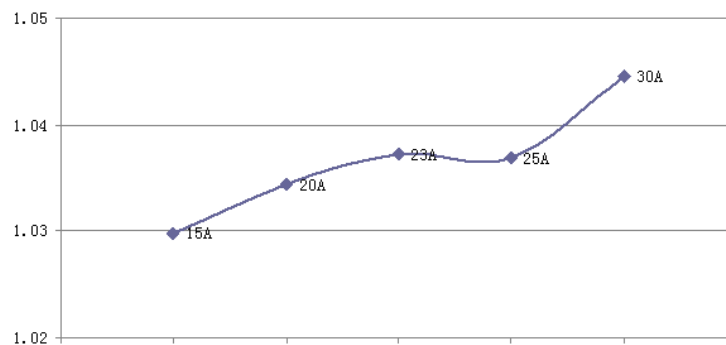


Fig. 4 Average Curve of Conductor Compression Coefficients

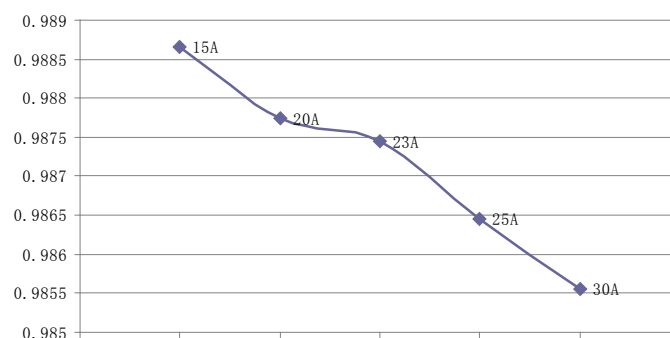


Fig. 5 Average Curve of Conductor Circumferences

As shown in Fig. 3, Fig. 4 and Fig. 5, if the tension is 40%RTS and the diameter of sheave is 650mm, the maximum difference between the maximum and minimum intermediate cross sections and the average of eccentricity, when the conductor passes through sheave, are higher than other tensions. With regard to the geometric relationships, cross section tends more to ovality. Based on the change trend of the average conductor circumference and the tested cross-sectional diagram, it is

judged that, if the tension is lower than 40%RTS, the gap between outer wires decreases gradually, the mutual compression of wires gets worse and the indentation increases when the conductor passes through sheave<sup>[6]</sup>.

## Conclusions

By analyzing the test results, it is concluded that wire jump-out is mainly caused by the obvious plastic indentations between aluminum wires when the conductor is constantly bent under the effect of tension load since it passes through sheave<sup>[7]</sup>. The maximum difference between the maximum and minimum intermediate cross sections and the average of eccentricity, when the conductor passes through sheave, are higher than other tensions. With regard to the geometric relationships, cross section tends more to ovality. Based on the change trend of the average conductor circumference and the tested cross-sectional diagram, it is judged that, if the tension is lower than 40%RTS, the gap between outer wires decreases gradually, the mutual compression of wires gets worse and the indentation increases<sup>[8]</sup>. When the conductor passes through sheave, the indentations obviously reduce the diameter of expanded diameter conductor, and narrow the original gap between aluminum wires in the outermost layer.

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