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Strength Ratings of Conductor Support Hardware – Part 1

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From where did these originate? Why were these particular rating levels chosen? Why do they differ from other industries? What is RBS? What is UTS? Why are they used? These are all very good questions, the answers to which are sometimes obscure, and often misunderstood.

Let us begin with conductors, and RBS. The acronym RBS, commonly used in our industry is "Rated Breaking Strength." RBS is a calculated load based on a series of values determined and assigned by ASTM B230 and ASTM B232, for ACSR, basically calculating the cross-sectional area of each individual aluminum strand, including a factor of 91% to compensate for the yield rating of the 1350H19 Aluminum alloy, and combining that total with the total steel, based on the calculation of the cross-sectional area of each individual steel strand, including a factor of 96% at 1% elongation per ASTM B498. The result of the above calculations will roughly coincide with test results where the conductor is actually pulled, at typical ambient temperatures of about 23°C (73°F), with a continually increasing load until it breaks! That is wonderful, but what has it to do with actual working conditions or practical tensile conditions of overhead conductors? Unless, perhaps your only concern is a really heavy ice load during power off conditions, at which time conductor strength is typically not at the top of the list! There is plenty of technical information available concerning the method of rating the conductors, so this article will be confined to a simple explanation of the more practical aspects of the conductor in field conditions under load.

(Source: Human Resources and Social Development Canada: *Ice Storm '98 Emergency: A Study in Response*)

So what happened to safety factors? Don't most components for overhead suspended load applications use safety factors? Yes, most do. However, somebody, several years B.C. (that stands for "Before Carl" ☺), determined that appropriate safety factors would be incorporated during the design phase, and these would be based on the known maximum strength ratings for the components, such as conductor, suspension components such as clamps and shackles, etc. Thus we have stringing tensions, or sag tensions that typically represent about 15 to 20% of the conductors RBS! Depending on terrain, typical weather conditions for the area, and other factors, the design tensions may be more or less, but rarely exceed 25%, which represents a safety factor of 4. As with tensile rating methods, much more comprehensive information on design factors is available from a variety of publications, including the NESC, which stands for National Electrical Safety Code.

The NESC has been adopted by most utilities in the U.S. as a guide used for line design. To address conductor tension limits in simplistic terms, concerning the maximum tension applied to conductors is found in Section 261, Paragraph H., sub-section 1, item (a):

> The supply conductor and overhead shield wire tensions shall be not more than 60% of their rated breaking strength for the load of Rule 250B in Rule 251 multiplied by a load factor of 1.0.

Again, in simplistic terms (that is Carl's interpretation – not intended to represent that of the "official panel"), this means that the design of the line is to be such that under maximum wind and ice conditions for the area, the line tension, under these conditions, is not to exceed 60% RBS. There is an additional safety factor for lines in extreme areas (identified on associated maps) further reducing that to 52% of the conductor RBS. Most utilities design for maximum of 50% conductor RBS under worst case conditions, but there are exceptions of course. Thus, a normal safety factor of 4 or 5 is reduced to 2 under these worst case conditions.

What about the hardware that holds those conductors in the air? What is this UTS rating?
The acronym UTS represents "Ultimate Tensile Strength" and is, for all practical purposes, the same as RBS, however it is typically not a "calculated" rating, but rather one that is defined and proven empirically. It is most commonly determined by actual testing of sample parts which are destroyed during the test, as the load is increased until severe deformation or destruction of the component occurs. Depending on the component, the conductor to which it is normally attached may, or may not, be part of the test.

To explain that, we need to discuss standard ratings, and what they mean. Historically, the UTS ratings of support hardware were coordinated with the M&E ratings of porcelain and glass suspension insulators, as defined by ANSI C29 standards. Changes in insulator strength classes were reflected by corresponding changes in support hardware UTS ratings. Because hardware UTS ratings represent the minimum ultimate strength, hardware has typically been applied at 40% UTS, resulting in a safety factor of 2.5. ANSI C29 also standardized the dimensions of connection hardware such as balls, sockets, and clevis fittings. Several national and international standards cover the test requirements and procedures for overhead transmission and distribution hardware; including IEEE C135.61. ANSI C119.4 covers connectors for use between aluminum to aluminum and aluminum to copper on bare overhead conductors and serves both to convey the electrical current as well as the mechanical integrity requirements for the connector and conductor. Being the only recognized standard that includes current stability, it has been adopted by many manufacturers and utilities as a guide for mechanical strength and performance of strain clamps and bolted dead ends as well, although they are technically not current carrying devices.

The ANSI C119.4 standard had three mechanical classes for connectors, and this past year, added a fourth class. There has now been an additional standard added to the industry, being IEEE PC135.64 which is specifically intended for strain clamps and similar line hardware apart from current carrying connectors. Both documents are essentially identical regarding the mechanical performance classes of the respective components. These ratings are not UTS ratings (where the device breaks), but technically are "conductor slip" ratings, and are the values that the user really needs to know! They are as follows:

Class 1, represents "Full Tension" and requires tensile performance of a minimum of 95% of the strongest conductor RBS.

Class 1A, represents "Normal Tension" and requires tensile performance of a minimum of 60% of the strongest conductor RBS.

Class 2, represents "Partial Tension" and requires tensile performance of a minimum of 40% of the strongest conductor RBS.

Class 3, represents "Minimum Tension" and requires tensile performance of a minimum of 5% of the strongest conductor RBS.

This ends Part 1 of a 2 part paper. Part 2 will be published in the November newsletter.