DVP Refurbishes Guyed Transmission Towers

In the mid 1960s, Dominion Virginia Power (DVP; Richmond, Virginia, U.S.) constructed the first operational 500-kV transmission lines in the United States. These lines traversed a 350-mile circuitous route from the company's Mount Storm Power Station in the Allegheny Mountains of West Virginia to the Piedmont of central Virginia near Richmond. NESC heavy loading criteria formed the basis of the new line design, but with terrain specific additions that included a vertical loading based on a radial ice thickness on the conductors of two inches for the sections in the mountainous regions, and a 70-mph hurricane wind loading. A new family of weathering steel, lattice structures was fabricated to meet the design requirements.

DVP used five types of suspension guyed-structures to support the conductors in the rugged mountainous sections of these 500-kV lines.

The PIAB RTM 20 D allows crews to determine the tension of a guy before they move it.

Tower Aging and Failure

Line inspections during the past few years have revealed an increasing incidence of guy deadend grip strand failures, probably the result of fatigue and cyclic loading, but there is no history of failures or damage to the actual guy wires. However, following the complete failure of an upper guy grip on an FLT-GV tower in December 2000, DVP's engineers began an in-house study of the problem.

Suspension Guyed Structures Used

Tower Type	Number of Towers	Number of Guys/Tower	Number of Guys	Existing Guy Wire
FLT-GV (light angent-guyed vee)	215	4	860	7/5 Alwd
FMT-GV (medium tangent-guyed vee)	112	4	448	19/.1481 Alwd
FHT-GV (heavy tangent-guyed vee)	54	8	432	19/.136 Alwd
FST-GM (08 in-line guyed mast)	37	8	296	19/.166 Alwd
FMA-GM (28 – 308 guyed mast)	22	16	352	19/.148 Alwd

On Jan. 10, 2001, a FLT-GV tower collapsed on the side of a mountain valley during a major wind storm. During the restoration efforts, DVP shipped the failed guy grips back to the manufacturer, Preformed Line Products (PLP; Cleveland, Ohio), for analysis. PLP's report concluded that, while there was evidence of long-term aeolian vibration damage, this was not a contributing factor to the failure of the BG-4171s on this structure. The primary cause of failure of the BIG-GRIP deadends was "fatigue caused by longitudinal cyclical loading on guying members." The report went on to discuss the importance of maintaining a minimum everyday tension of 10% of the strands rated breaking strength (RBS).

Using PLS-CADD software, DVP's structural engineers modeled these transmission lines and structures. Their analysis of the actual structural guy loading, a field-climbing inspection and in-depth file research led to the following conclusions:

- The original guy wires were pretensioned between 3500 lbs and 22,500 lbs each, depending on the tower type and guy wire size.
- The existing guy wire tensions are unknown. Guy grips had been replaced in the past, and no records could be found on the reinstalled tensions or the methods used for installation.
- The existing anchors, anchor rods and bottom adjustable hairpin anchor connections are in good condition and can remain.
- Most of the existing guy wire is in good condition and can be reused (guy wire samples were tested in an independent laboratory). Some guy wire had to be replaced due to the loads developed in the PLS-CADD analysis exceeding their design limits.
- All hardware should be replaced.
- The seat diameters for all guy grip connections, except those on the FLT-GV, shall be increased.

Planned Refurbishment

The three 500-kV transmission lines with these structure types are vital to DVP's service reliability and power-transfer capability. Therefore, DVP decided to replace all guy deadend grip assemblies and associated hardware provided by PLP. PLP provided suggestions on how to accurately measure the tensions in the existing guys and the reinstated tensions. DVP selected the PIAB Rope Tension Meter RTM 20 D from Sweden because it was the only device that met DVP's requirements. The device's specifications and features include: calibration for 10 different wire sizes; direct-digital readout for

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the wire tension; easy to install; and available for 2-, 5-, 10- or 20-ton applications.

To comply with DVP's tight construction schedule, PIAB agreed to supply one of the three units to be purchased as soon as possible, the remaining two units being delivered within six weeks.

Once the rope tension meters arrived, they were field tested on several different tower guy systems. Guy tension values were determined by the PIAB RTM's and then compared with a digital dynamometer's reading. A tension range of 300 lbs or less was common between the devices, but DVP accepted that this difference was reasonable in view of the magnitude of the tensions measured.

DVP's transmission maintenance crew was responsible for replacing the guying assemblies on those towers in "hurricane alley" in the fall of 2001. The PIAB RTM 20 D was introduced to them by using it in conjunction with a dynamometer. After just a few guy grip installations with both devices recording similar tension readings, the dynamometer was packed away as the ease-of-use and the direct load readouts available on the RTM 20 D converted all skeptics.

The most impressive demonstration of the RTM's capability came when the crew moved to a new site and installed the RTM on the existing guy to check the tension before beginning the changeout. The wind suddenly gusted and the meter's digital readout started changing to reflect the loading effect the wind was having on the tower and associated conductors.

A second crew was added to this guy grip replacement project. Their response to the use of the PIAB RTM 20 D was much like the first crew, cautious and then complete acceptance. They now have the capability of knowing the tension on a guy before trying to remove it. It provides the information to determine the correct rigging for the change-out. It also was used to re-tension the guy by installing it on the guy as the tension adjustment nuts were tightened.

This project was completed in December 2003. ■