Technical Background Supporting Removal of the Lightning Ground Wire on NRG TallTowers

Introduction

Extensive testing and analysis conducted by NRG Systems, Inc and Lightning Technologies, Inc. concluded the NRG 60m XHD TallTower structural members and guy wires alone provide sufficient protection for the electronics and wiring against direct attachment lightning strikes to permit removal of the down-tower copper conductor. This write-up substantiates the removal of the down-tower copper conductor on all NRG XHD TallTowers.

The removal of the down-tower copper conductor does not impact the electrostatic discharge (ESD) protection of the electronics (sensors and Symphonie logger). No change has been made to the grounding system electronics, so their ESD protection is unaffected by removal of the down-tower conductor.

Considerations for Analysis and Test

The work behind this report directly considered the NRG 60m XHD TallTower. However, the conclusions apply equally well to the NRG 80m XHD TallTower due to the increase in metallic area relative to the 60m tower, which will in turn result in lower voltage gradients and current densities during a direct attachment lightning strike. This is the basis for not including a down-tower conductor on the 80m XHD TallTower at initial production release.

To quantify the effects of direct attachment lightning strikes to the tower and electronics, with and without the down conductor, numerical simulations were performed using a software program called SPICE (Simulation Program with Integrated Circuit Emphasis). In addition, lightning-level current tests were performed at Lightning Technologies, Inc. on a tower test section equipped with powered electronics.

Analysis and Test Conclusions

The following conclusions were derived from the testing and analyses:

- The current propagates down the tower when a direct lightning attachment occurs with or without the down conductor.
- The large number of guy wires reduces the current going down the main tower with or without the down conductor.
- Voltage gradients generated during a direct lightning attachment without the down conductor are 13% higher (197 kilovolts (kV)) than voltage gradients generated with a down conductor (174 kV). However, the difference does not increase the risk of damage to the tower, sensor cabling, or electronics. The highest calculated voltage gradient during a direct lightning attachment, occurring without the down conductor, is 67 volts/cm (V/cm), which is well below the 18 kV/cm dielectric strength of air. As such, flashover, the unintended arcing of current from the tower to the electronics, which could potentially damage the electronics, is not predicted to occur with or without the down conductor.

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- Lightning-level electrical current tests were conducted at Lightning Technologies, Inc. All tests were performed on a between-guy-level tower section equipped with powered electronics and a 2.5-m (95-inch) boom supporting an anemometer. The tower was not equipped with a down conductor. Test currents ranging from 10 kiloamps (kA) up to 100 kA were injected into the boom or top of the tower section. No damage occurred to the tower, sensor cabling, or electronics when actual lightning level currents were injected into the instrumented tower section.

- Fast-rising currents associated with a lightning strike create large oscillating magnetic fields, potentially inducing elevated, damaging voltage in the sensor wires. The “common mode” induced voltage means the sensor wires and electronics are raised to the same electric potential when magnetic field coupling occurs during a lightning strike. The electronics are equipped with devices to suppress transients and therefore are protected against induced voltages. As such, only the sensor wires are at risk of damage from the induced voltages during a lighting strike. We were initially concerned about the potential for higher induced voltages occurring without the down conductor, which prompted this aspect of the investigation. The magnitude of the induced voltage is easily calculated from the peak currents obtained from the SPICE simulations. Based on peak currents at the top of the tower (without the down-tower conductor), induced voltage, generated by the changing magnetic field, is less than 2 kV. Test sensor wires were exposed to voltage transients greater than 8 kV with no evidence of dielectric breakdown or insulation damage, indicating induced voltage damage from fast-rising currents will not occur.

As indicated above, all testing and analyses confirmed that no additional risk of damage to the electronics, sensors and wiring will exist with the removal of the down-tower conductor.

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