Contribution ID: **185** Type: **Oral Presentation**

An AC Arc Discharge Model for Ice-Covered FRP Live-Line Tools

Wednesday, 6 July 2016 11:15 (15 minutes)

Four separate FRP hot-stick flashover incidents have occurred in Canada during live-line working under steady-state system conditions at the peak of the voltage negative half-cycle during cold and freezing conditions. The incidents were reported at 500-kV AC line voltage working stress (95-96 kV/m) in 1997 and 2002 in Manitoba, and at 230-kV AC line voltage working stress (71 kV/m) twice in the neighbouring province, Saskatchewan, in 2012.To the best of our knowledge, the most reliable reproduction of these incidents has been achieved at UQAC Laboratories at a voltage stress of 105 kV/m at -1.04 ℃, RH of 109 % with visible fog and 2.8 µg/cm2 ESDD during a series of "true" cold fog tests. Findings fromprevious studies could well justify the cold-fog flashover mechanism for the flashovers that occurred on FRP live-line tools especially for the two flashovers that occurred at temperatures down to -13 and -19 ℃ in Manitoba and Saskatchewan. In the present study, suitable mathematical models for predicting the AC flashover voltage of ice-covered insulators are studied by considering a 1-mm ice layer covering an FRP hot stick. To the best of our knowledge, such modeling has never been attempted so far. By adapting the Obenaus approach, the arc constant parameters in air gaps as well the arc reignition conditions for an ice-covered FRP hot stick should be determined experimentally to develop its AC arc model. However, these issues need to be determined in further research and won't be addressed in this paper. Instead, issues about the present AC arc models developed for ice- or snow-covered insulators as well as various AC arc models developed for pollution flashover are discussed. It should be noted that the arc models developed for polluted or ice-covered insulators may not be adapted adequately for FRP hot-stick flashovers due to the following reasons. The ESDD values measured on the accident sticks in Manitoba and Saskatchewan were 2-3 µg/cm2.These values are considered to be at typical background level and are ignored in polluted insulator cases. On the other hand, the thickness of ice on a FRP hot stick, e.g. 1 mm, may be much less than that for even light ice-covered insulators. Therefore, arc models developed mainly for heavy ice-covered insulators may not be adapted for FRP hot stick cases. Moreover, the most reliable reproduction of the occurred flashovers was achieved during a series of "true" cold fog tests while none of the present arc models for polluted or ice-covered insulators have been developed for cold fog conditions. Considering the mentioned points, various existing models are considered in order to examine the ones having good concordance with the experimental results obtained at UQAC laboratories.

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Session Classification: Oral 1

Track Classification: Dielectrics, Insulation, and Breakdown