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Predicting & Operating with Variable Line Ratings

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October 22-23, 2016

Course Outline & Summary

This new 2-day course explores the differences and similarities in IEEE and CIGRE heat balance calculations, explains how to select suitably conservative weather conditions for static rating calculations, and describes the process by which such line ratings may be adjusted for season.

Unlike electrical limitations, which primarily depend only on line geometry (phase spacing, bundle dimensions, and conductor diameter), line thermal ratings depend on: conductor resistance and diameter; conductor thermal elongation, acceleration of plastic elongation, and loss-of-tensile strength at high temperature; weather conditions within the line corridor; and on whether the power system is operating normally or experiencing a system emergency. Given the dependence of line thermal ratings on weather, ratings may be constant, vary with the season, vary each day or hour with peak air temperature (ambient-adjusted ratings), or may vary rapidly with wind, air temperature, and solar heating (dynamic line ratings).

In most operations centers, static line ratings are adjusted for air temperature on a daily, hourly or instantaneous basis. These line ratings are typically described as ambient-adjusted and the course provides insight into the risks involved in such variable line ratings.

Over the last 30 years, many types of line and weather monitoring instruments have been developed to allow the dynamic thermal rating of overhead lines. These instruments are typically placed at multiple locations within critical line corridors and linked back to the system operations center with real-time communication links. The advantages and disadvantages of different types of weather and line conductor monitors are explained and demonstrated. In particular, the determination of rating risk through the new IEEE 738 temperature tracking method is explained.

The use of dynamic rating methods typically yields the greatest increase in line rating relative to static but is used far less often than ambient-adjusted methods. The course explains the difficulties of predicting dynamic ratings and suggests methods by which such difficulties can be overcome considering both weather forecasting models and statistical analysis of line corridor field data.

IEEE and CIGRE documents as well as the Second Edition of the Southwire Conductor Manual serve as course texts. NERC Audits inevitably involve questions about the basis for line rating calculations expecting to see reference to industry standard documents such as IEEE 738, IEEE 1283 and CIGRE TB 299. The course reviews these documents explaining how they are best applied to calculate thermal line ratings. Detailed examples are studied to demonstrate the full range of choices that confront the design engineer, the system planner, and the system operator.

Day 1 – Transmission Line Rating Methods (Morning)

9:00AM Introductions, Outline & Quiz

Instructor background & experience

Student interest and experiences in Line Monitoring

Quiz questions & answers

9:45AM Power Systems & Cool Conductors

History of Transmission Line Ratings

Impact of Regulated vs Open Access Power Systems

System Normal vs System Emergency Operation

Why most TLine currents are low?

What causes emergency loading of lines

Why this makes line monitoring difficult

Weather vs Line Monitoring

10:30AM Rating Power Circuits

Overview of Power Equipment Categories

Rating Power Transformers

Rating Underground Cable Sections

Substation Terminal Equipment

Rating Overhead Lines

11:15AM Coffee Break

11:30AM Conventional (Static) Line Ratings

Steady-State Heat Balance

Convection – Forced and Natural

Radiation

Solar Heat Gain – Direct & Indirect

Internal Conductor Heat Flow – Axial and Radial

IEEE 738 Calculation Example

Transient Heat Balance

Conductor Heat Capacity

Thermal Time Constant

Step-Change Current

Day 1 – Transmission Line Rating Calculations (Afternoon)

12:30PM Lunch

1:30PM Conventional "Conservative" Weather Conditions

Recommendations of CIGRE TB 299

Airport Weather Data

Schurig & Frick

House & Tuttle

PJM Rating Method

NY ISO Rating Method

2:30PM Conventional Conductor Temperature Limits

IEEE 1283 & Range of Weather Assumptions for Static Ratings

Recommendations of CIGRE TB 299

Clearance Temperature Limits

Loss of Strength Limits

3:00PM Coffee Break

3:15PM Conductor Selection for New T-Lines

Conductor Choices

Optimization of Conductor Type & Size

Minimizing Structure Cost for Thermal Rating

4:00PM End of First Day

Day 2 – Variable Line Rating Calculations

9:00AM Line Specific Natural Rating Variation

Diurnal Weather Variation

Atmospheric Models

Seasonal Variation

10:00AM Ambient-Adjusted Line Ratings

Typically System-wide

Determining Maximum Air Temperature

Hourly Air Temperature

11:00AM Coffee Break

11:15PM Weather-Based Dynamic Line Ratings

Weather instruments

Solar Pyranometer

Air Temp Sensor

Anemometers

Temperature Monitors

Power donuts

EPRI Monitor

12:15PM Lunch

1:15PM Line Monitor-Based Dynamic Line Ratings

Sag-tension Monitors

CAT-1 Tension Monitors

Sagometer

Promethean B Field Sensors

2:15PM Break

2:30PM Predicting Line Ratings

Weather Forecasting Accuracy

Integration of VLR into Operations

Development of Line Corridor Wind Statistics

3:30PM Conductor Temp For LiDAR & Ground Survey

Based on Weather Monitors

Based on Conductor Temp Measurement

4:00PM End of Seminar