

VOLTAGE UPGRADING and RECONDUCTORING with HTLS

Dale Douglass, Douglass Power Consulting, LLC

Jim Stewart, Consultant

26-28 October, 2016

COURSE SCHEDULE

Daily Class Times

9:00AM to 4:30PM (Day 1) -- 8:00AM to 4:30PM (Day 2)

8:00AM to 4:00PM (Day 3)

DAY 1 – Line Design Overview

9AM Introductions & Discussion

Instructor background

Student background

9:15AM Introduction to Line Design, Upgrading & Upgrading

- Main Components of Lines & Recent Trends
- Upgrading vs New Line Design
- Class Example of Voltage Upgrading
- Class Example of Current Upgrading

10:15AM Break

10:30AM Power System Constraints

- Thermal Limit
- Voltage Drop
- Phase Shift Stability

11:00AM Conductor Design & Selection

- Aluminum, Copper and steel wires
- Basic Stranded Conductor Designs
 - Conventional
 - HTLS
- Stranding Rules & Choices
- Conventional Wire Materials
- High Temperature Wire Materials
- IEC and ASTM Product Specifications

12:00PM Lunch

DAY 1 (cont.) – Conductor Issues

1PM Conductor Elongation – Mechanical/Thermal

- Manufactured Conductor Length
Reversible elongation – Elastic & Thermal
- Plastic elongation – Creep & High Stress
- Thermal Elongation at High Temp
- Annealed vs Hard drawn Aluminum
- Steel vs Composite Cores

1:45PM Sag-tension Calculations

The catenary - sag vs tension

Tension Limits

- Conductor Length, Slack & Ruling span
- Wind & Ice Loads
- Aluminum Plastic Elongation – Initial vs Final
- Stringing Tension (Initial %RBS & H/w)
- Maximum tension for ice & wind loading
- Sag at high temperature (knee-point temp)

3:15PM *Break*

3:30PM Wind-Induced conductor Motions

- Blowout & Insulator Swing
Aeolian Vibration & Dampers
Ice galloping & Control methods
Bundled conductor oscillation & Fixes
- Wind-motion Resistant Conductors

4:30 PM End of Class

DAY 2 – Line Thermal Rating & Uprating

8:00 AM Thermal Rating Calculations

- Conductor Heat Balance
- Steady State Normal Ratings
- Transient Emergency Ratings
- Weather Conditions
- Impact of Design Tmax on Risk

9:00 AM High Temperature Effects

- Annealing of Copper and Aluminum
- Sag clearance at high temperature
- High temperature creep elongation
- Zirconium Aluminum vs Annealed Aluminum

10:00AM Break

10:15 AM Line Uprating - No Physical Modifications

- Reviewing Rating Constraints
- Reviewing Weather Assumptions
- Statistical Analysis of Annealing
- Dynamic Ratings

11:15 AM Line Uprating – Running the Line Hotter

- Using Up the “Fat”
- Raising Supports
- Re-tensioning the Conductors

12 PM Lunch

DAY 2 (cont.)– Reconductoring & Insulating Lines

1:00 PM Line Uprating by Reconductoring

- Present Worth of Electrical Losses
- Conductor Material & Labor
- Cost of Structure Modifications
- Generation savings

2:00 PM Insulator Types

- Post and Tension Insulators
- Porcelain and Non-ceramic Insulators
- In-Span Insulating Spacers

Power Frequency Insulation

- Clearances to Structures
- Contamination
- Leakage Distance
- Insulator Surfaces/Design of Insulator Skirts

3:00 PM Break

3:15 PM Switching surges

- Switching Surge distributions
- Insulation strength
- Mitigation methods

4:15 PM Lightning

- Lightning phenomena
- Fast Transients

4:30 PM End of Class

DAY 3 – Voltage Upgrading Concerns

8:00 AM Lightning (continued)

- Backflashovers
- Shielding Failures
- Insulation Strength – Fast Transients
- Mitigation methods

8:30 AM Corona & Field Effects

Environmental Effects

- Criteria, Prediction and Evaluation
- Exceedance Levels

Electric Field

- Field at Conductor Surface and Corona
- Field at Ground Level and Coupling
- Unperturbed and Perturbed Fields
- Safety, Annoyance and Perception

Magnetic Field

- Maximum and Resultant Field
 - Inductive Coordination
 - Field Profiles
- Problems Comparing Calculation to Measurement

10:00 AM Break

10:15 AM Corona & Field Effects (continued)

Corona: Noise and Losses

Audible Noise

Radio and Television Noise

- Spark Discharges
- Corona
 - Weather Dependence
 - Criteria
 - Signal strength
 - Signal to Noise Ratio

12:00 Lunch

DAY 3 (cont.)– Line Thermal & Voltage Upgrading - Examples

1:00PM Detailed Review of 115kV Line – Current Upgrading Options

- Power System Requirements
- Normal vs emergency power flow
- Electrical Losses & HTLS
- Avoiding Structure Reinforcement
- Dynamic & Ambient-Adjusted Rating Methods
- Use of HTLS conductor
- Hardware/Connectors
- Conductor Replacement with HTLS

2:30 PM Break

2:45 PM Detailed Review of 115kV Line – Voltage Upgrading to 230kV

- Line Characteristics
- Evaluation of insulation level
- Switching surge performance
- Lightning performance
- 60 Hz insulation
- Radio noise

3:45PM Summary

4:00PM End of Seminar