Transmission Operations and Maintenance Conference

June 23, 2016
Denver Marriott South at Park Meadows
Lone Tree, CO

Instructed by:
Todd Myers, Technical Advisor, EPRI Transmission Research, EPRI
Tim McJunkin, Power Systems Engineer - Project Manager, Idaho National Laboratory - Energy Systems Lab
Tim Vice, Transmission Maintenance Analyst, Westar Energy
Eileen Lockhart, UAS Program Lead, Xcel Energy
Kelly Daly, Partner, Stinson Leonard Street LLP
Kip Schuettler, Corporate Safety Manager, Nebraska Public Power District
Lane Cope, Electrical Engineer, Western Area Power Administration
John Quintana, Transmission Asset Maintenance Manager, Western Area Power Administration
Will Schnyer, Rocky Mountain Region Safety & Occupational Health Manager, Western Area Power Administration
David A. Mullon, Jr., Counsel, Venable LLP

WiFi Information
Network: Marriott_Conference
Password: 07798642
This presentation presents rate conductors in real-time and load flow conditions to observing environmental Rating (DLR) is the process IEEE Std. 738. Dynamic Line limit, typically as defined in static thermal and ampacity are traditionally given a

Overhead transmission lines concentrates on developing tools and technologies to support asset management decision-making based on minimizing equipment life-cycle cost and maximizing performance benefits with acceptable risks. Many electric utilities are considering or already have moved toward implementing asset management concepts and decision-making procedures based on minimizing equipment life-cycle costs and risks. However, the data, analytical tools and models required for power delivery equipment risk assessment and management are not well established. EPRI’s T&S asset management R&D concentrates on developing tools and technologies to support asset management decision-making based on minimizing equipment life-cycle cost and maximizing performance benefits with acceptable risks.

9:15 a.m. - 10:00 a.m. Modernizing an Aging Infrastructure Through Real-Time Transmission Monitoring

Tim McJunkin, Sr. Research Engineer, Idaho National Laboratory – Energy Systems Lab

Overhead transmission lines are traditionally given a static thermal and ampacity limit, typically as defined in IEEE Std. 738. Dynamic Line Rating (DLR) is the process of observing environmental and load flow conditions to rate conductors in real-time. This presentation presents practical applications and potential improvements to by using DLR through the collection of climatology data and computational fluid dynamic simulations. In doing so, we demonstrate that dynamic line rating leads to improved capacity at safe operating conditions. A time domain modeling and simulation approach is investigated for capturing the inherent dynamics in a transmission line. The overarching DLR methodology is described, which includes the cognitive psychologist supported human factors R&D required to successfully integrate advanced data analytics and control center displays for human consumption and efficient processing, as well as the ability to incorporate forecast weather data as it applies to transmission line capacity predictions.

10:00 a.m. - 10:15 a.m. Networking Break

10:15 a.m. - 11:15 a.m. Drone Technology Panel

Unmanned Aerial Systems (UASs) and Utility Operations
Tim Vice, Transmission Maintenance Analyst, Westar Energy
Drone Technology at Xcel Energy
Elleen Lockhart, UAS Program Lead, Xcel Energy

Legal Aspects of Drone Technology
Kelly Daly, Stinson Leonard Street LLP

11:15 a.m. - Noon Personal Protective Grounding Practices at Nebraska Public Power District
Kip Schuettler, Corporate Safety Manager, Nebraska Public Power District

The presentation will discuss Personal Protective Grounding practices utilize at NPPD. Reasons for grounding, grounding techniques utilized on overhead, underground, substations and equipment grounding. The utilization of isolating, isolating and equipotential grounding.

Noon - 1:00 p.m. Networking Lunch

1:00 p.m. - 1:45 p.m. History and Use of Long Line HEC Methods at WAPA
John Quintana, Transmission Asset Maintenance Manager, Western Area Power Administration

Many utilities have used helicopters successfully to perform electrical line maintenance for decades. The helicopter maintenance program at Western Area Power Administration has successfully been in place for approximately 6 years. This presentation addresses how WAPA developed an HEC program at the grass roots, receiving senior management buy-in, and enabling line workers to perform their jobs safely and efficiently while addressing all safety and environmental concerns through an enterprise risk analysis.

1:45 p.m. - 2:30 p.m. Implementation of OSHA Ruling on MADs and TOV Studies
Lane Cope, Electrical Engineer, Western Area Power Administration

John Quintana, Transmission Asset Maintenance Manager, Western Area Power Administration

The revised OSHA 29 CFR 1910.269 and 29 CFR Part 1926, Subpart V requires employers to comply with revised minimum approach distances (MADs) for voltages of 5.1 kilovolts and more. The MADs for energized equipment are based on the worst case transient overvoltage (TOV) for a given transmission line or power system equipment. The revised MADs are based on a new default worst case transient overvoltage (TOV) to be 3.5 per unit whereas the old MADs were based on a worst case TOV of 3.0 per unit. An alternative to using the default MADs is for the employer to calculate the actual TOV for the transmission line as a basis for the MAD. This presentation walks you through the steps Western has taken to comply with the OSHA ruling as well as address the problems associated with implementing the new safety requirement with respect to Western’s live working program and high voltage arc flash boundaries.

2:30 p.m. - 2:45 p.m. Networking Break
2:45 p.m. - 3:00 p.m.
Attendee Announcements
Any registered attendee is invited to make a short announcement on their company, new products, technologies or informational updates. Announcements may include showing a product sample but not videos and power point slides. Please limit announcement to 5 minutes.

3:00 p.m. - 3:45 p.m.
Transmission Safety Panel

Steel and Wood Pole Fall Protection Implementation
Kip Schuettler, Corporate Safety Manager, Nebraska Public Power District
The presentation will discuss how NPPD implemented fall protection on wood poles and steel structures. We will discuss how equipment was selected; rules were put in place and the importance of change management and getting buy in from the field workers.

Fall Protection
Will Schnyer, Rocky Mountain Region Safety & Occupational Health Manager, Western Area Power Administration

3:45 p.m. - 4:30 p.m.
Key Provisions of New Regulations Governing Rights-of-Way on Indian Lands
David A. Mullon Jr., Counsel, Venable LLP
The presentation will highlight the more important aspects of the Department of the Interior’s recently promulgated regulations on rights-of-way on Indian lands. The new regulations are lengthy and complex, so the goal of the presentation will be to provide the audience with an introduction to the regulations the “big picture,” with an emphasis on how the new regulations differ from prior regulations that have been in place for several decades and how they address new matters that have never been covered by past regulations. The presentation will also discuss the status and substance of recently filed litigation over the regulations.

Thank You RMEL Transmission Committee

CHAIR
John Humphrey
Corporate Projects Manager
Nebraska Public Power District

VICE CHAIR
Angela Piner
VP
HDR, Inc.

Scott Bayer
Managing Engineer, Substation Relay Engineer
Austin Energy

Ana Bustamante
Superintendent, T&D
UNS Energy Corporation

Randy Harlas
Manager, Substation & Relay
El Paso Electric Company

Chris Koch
Manager, Substation Engineering
Kansas City Power & Light

Keith Nix
VP, Technical Services and System Reliability
Texas New Mexico Power

Mike Pfeister
Manager of Scheduling & Reliability Services
SRP

John Quintana
Transmission Asset Maintenance Manager
Western Area Power Administration

The RMEL Transmission Committee plans all RMEL Transmission events. If you’d like to send information to the committee, email James Sakamoto at jamessakamoto@rmel.org.
EPRI Transmission and Substations
Asset Management Research

Todd Myers
Technical Advisor, EPRI Transmission Research
EPRI
Focus of Today’s Presentation

- EPRI’s role in asset management research for the electric power industry
- Degradation and failure modes
- Asset health algorithms
- Industry-wide equipment failure and performance data bases
- Inspection and sensing technologies
- Asset management analytics
Born in a Blackout

Founded in 1972 as an independent, non-profit center for public interest energy and environmental research

New York City, The Great Northeast Blackout, 1965
Mission

Advancing safe, reliable, affordable and environmentally responsible electricity for society through global collaboration, thought leadership and science & technology innovation
Three Key Aspects of EPRI

- Objective, scientifically based results
- Chartered to serve the public benefit
- Bring together scientists, engineers, academic researchers, industry experts
Our Members…

- 450+ participants in more than 30 countries
- EPRI members generate approximately 90% of the electricity in the United States
- International funding of nearly 25% of EPRI’s research, development and demonstrations
EPRI’s Portfolio Spans the Entire Electricity Sector

### Generation
- Advanced Coal Plants, Carbon Capture and Storage
- Combustion Turbines/Combined Cycles
- Environmental Controls & Combustion Performance
- Materials & Chemistry
- Major Component Reliability
- Operations and Maintenance
- Power Plant Water Management
- Renewables

### Nuclear Power
- Advanced Nuclear Technology
- Chemistry, Low-Level Waste and Radiation Management
- Equipment Reliability
- Fuel Reliability
- Long-Term Operations
- Material Degradation/Aging
- Nondestructive Evaluation and Material Characterization
- Risk and Safety Management
- Used Fuel and High-Level Waste Management

### Power Delivery & Utilization
- Transmission Lines and Substations
- Grid Operations and Planning
- Distribution
- Energy Utilization
- Information & Communication Technology

### Environment
- Air Quality
- Energy and Environmental Analysis
- Land and Groundwater
- Occupational Health and Safety
- T&D Environmental Issues
- Water and Ecosystems
T&S Asset Based Research
Asset Management Institute’s Asset Management Model

Main Focus of EPRI T&S Area Portfolio

Enabled by EPRI Resources
Transmission and Substations at a Glance

P35 Overhead Transmission
- Asset Management - Decision Bases
- Reference Books
- Design
- Lightning and Grounding
- Increased Power Flow
- Live Working

P36 Underground
- Asset Management Decision Bases
- Reference Books
- Design and Construction
- Pipe Type Cables
- Extruded Cable

P37 Substations
- Asset Management Decision Bases
- Reference Books
- Fleet Management
- Physical Security

P162 HVDC
- New Applications of HVDC
- Component Performance DC Versus AC
- Electrical Effects
- Planning

Degradation and Failure Modes
Equipment Performance Databases
Inspection and Sensing Technologies
Asset Health Algorithms
Remediation Technologies

Common approach to all programs
Overhead Transmission Research

- Inspection & Assessment
- Lightning & Grounding
- Design & Construction
- Live Working
- Insulators
- Increased Transmission Capacity
- Asset Management Analytics
# Program Summary Overview

## Design & Construct
- Reference Books
- Software
- Component Testing
- Spec Test Development
- New Materials

## Operate (Live Working)
- Training Tools
- Reference Books
- Practices
- Robotics

## Inspect & Assess
- Field Guides / Training
- Technology Evaluation
- Population Assessment
- Technology Development
- Failure Modes Degradation

## Refurbish
- Practices
- Evaluation
- Approaches

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**Short Term**  
**Long Term**
Substations Research

Transformers

Circuit Breakers, SF6 and GIS

Protection & Control

Grounding, Disconnect Switches & Ratings

Substation Asset Management Analytics

Substation Insulation Contamination Flashover Performance
Sample of T&S Asset Focused Initiatives

- **Unmanned Airborne Vehicles**

- **Lowering Underground Cost**

- **EMP**

- **Physical Security**
## T&S Resources

### Staffing

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**Charlotte Laboratory**

- Conductor / Connector Aging, Cable Testing, Overhead & Substation Sensor Development, SF6 Testing, Corrosion Lab

**Lenox Laboratory**

- Full Scale Outdoor Test Laboratory, Indoor Accelerated Aging Chamber & Contamination Test Chamber, Mechanical Lab

**Utility Sites**

**Suspension Leakage**

- Sensor Demos, Remediation Demos, etc.
Asset Management Institute’s Asset Management Model

Enabled by EPRI Resources

Main Focus of EPRI T&S Area Portfolio
Mapping EPRI Research into Asset Management

**Acquire**
- New Materials & Designs
- Component Evaluation
- Engineering Tools
- Best Practices / Reference Guides
- Construction Guides & Tools

**Operate**
- New Materials & Designs
- Operating Tools & Practices
- Best Practices / Reference Guides
- Remediation

**Maintain/Diagnose**
- Maintenance Practices & Intervals
- Inspection Tools & Techniques
- Online Monitoring
- Fleet Management
- Industry Wide Databases
- Reference and Field Guides

Understand Failure Modes & Degradation
EPRI’s Transmission Asset Research Roadmap
Future States

- INCREASED Utilization of Right of Way
- EFFECTIVE Field Practices
- CONDITION Monitoring and Automation
- EFFECTIVE Inspection Assessment and Maintenance
- NEW Components and Materials
- Asset MANAGEMENT Analytics
- IMPROVED Design and Construction
NEW Components and Materials

Examples of EPRI Approach

Evaluate Potential of New Technologies

Accelerated Aging of Components

APPLY NEW MATERIALS & COMPONENTS WITH CONFIDENCE
Develop New Technologies

Evaluate Emerging Technologies

Examples of EPRI Approach

ENSURE EFFECTIVE TECHNOLOGIES ARE AVAILABLE
CONFIDENTLY APPLY ADVANCED MONITORING SOLUTIONS
INFORMED DECISION MAKING

Examples of EPRI Approach

Industry Based Hazard Rates

No Action

Watch

Consider Action

Fleet Management Tools

PTX Software

Abnormal Condition Index

Paper Degradation Index

Asset MANAGEMENT

24
Advanced Transmission Asset Health Sensors
Drive for Sensors

Applications

- Identify Risks
- Determine Life Expectancy
- Understand Performance
- Rate Dynamically

Impact

- Safety
- Reliability
- Investment
- Design
- Operation
- Asset Utilization
RF Sensor Suite

Overhead – Substations – Underground

“Measure what has never been measured before”
EPRI Roles in Advanced Sensor Development & Deployment

- Identify

- Develop

- Evaluate

- Controlled Laboratory Testing

- Monitored Field Demonstrations

- Guidance on Specifications

Advanced Analytics
38 Active EPRI Member RF Sensor Demonstration Sites
T&S Asset Management Analytics
## Asset Management Analytics

### Asset Characterization & Performance Information

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### Industry wide Failure & Performance Database

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### Technical Decision Support – Vintage Guides, Triggers/Alarms (Specific Maintenance Actions)

### Program Decision Support – Effectiveness Metrics and Spares Strategy

### Asset Health Algorithms

### Technology Transfer– Asset Management Practices, and Enterprise-wide Asset Health Systems Interest Group
T&S Industry Wide Asset Failure and Performance Databases

Failure Forms, Data & Analysis Reports – 5 Assets

Conductor
Connectors
Polymer Insulators
Bushings
Transformers

Circuit Breaker
Structures
Extruded Joint
Extruded Termination
Extruded Cable

Failure Forms – 5 Assets
Asset Health And Aggregation
Towards Uniform Approach

Transformer and circuit breaker fleet management
Disconnect switches
Ground Grid
Structures
New modules
Insulators
Connectors
Substation Bay
Substation Risk Index
Underground Transmission Assets
Batteries
Transmission and Substation Fleet Management Tools
Transformer Example of Industry-wide Failure and Performance Database

- Individual Utility Failure & Experience
- Industry Wide Failure & Experience

Enhanced Asset Base Knowledge

- Industry Based Hazard Rates
- Emerging Industry Issues

- Identify Emerging High Risk Issues
- Modify Maintenance & Monitoring
- Prioritize Replacement
- Develop Spares Strategy
Transformer Example of Asset Health Analytics

Power Transformer Expert System (PTX) Overview

Measurements
- DGA
- Oil Quality
- Furans
- Routine Electrical
- Bushings PF and Cap
- LTC DGA & Oil Quality
- LTC Operation Count

- Manufacturer
- Vintage
- Nameplate Data

EPRI PTX Algorithms (Rule-based)

Basis for Asset Management Decisions

Belief & Likelihood of Fault Conditions Present

Transformer Fleet Risks – Short Term/Long Term

Readily Available Data

Integrates decades of expert knowledge in a rule-based framework.
Asset Health Algorithms: 2016 Plan

Overhead Transmission

Substations

Underground Transmission
EPRI Asset Health System Interest Group

Approach

- Awareness of Vendor Technologies
- Sharing of Utility Experiences
- Briefing on Related EPRI Research Results
- Identifying Gaps & Research Needs

No Funding Required – Participation only by EPRI T&S Members
Together…Shaping the Future of Electricity
Modernizing An Aging Infrastructure Through Real-Time Transmission Monitoring

Tim McJunkin
Power Systems Engineer – Project Manager
Idaho National Laboratory – Energy Systems Lab
Overhead Transmission Line Ratings

Weather-based Dynamic Line Rating with CFD and Forecasting

Jake P. Gentle
Tim McJunkin
Porter Hill
Kurt Myers
Alex Abboud
Idaho National Laboratory

Transmission Operations and Maintenance Conference
Rocky Mountain Electrical League
Denver, Colorado
June 23, 2016
Dynamic Line Rating (DLR) Introduction

Static Rating Results in Underutilized Assets

• A transmission line’s maximum capacity is traditionally limited by the conductor thermal capacity. The thermal capacity is normally defined by a static rating using predetermined environmental conditions assuming there’s little or no wind blowing. Without accurately measuring environmental conditions and their effects, existing transmission lines can be critically underutilized.

Closing The Gap

• A dynamic line rating system accurately monitors the wind and temperature, and transfers those conditions to every point along the electricity line, which leads to improved line ampacity ratings. Using WindSim and GLASS, INL is able to follow the IEEE 738.2012 Standard for static ratings, and apply them to the dynamic environmental conditions in an innovative way to create a state-of-the-science DLR system that closes the gap between the static line rating and the maximum operating temperature for each specific span’s conductor type and ground clearance requirements.
INL Weather-Based Dynamic Line Rating Overview

Solution for competing goals of asset owners
  • Electric power line owners MUST prevent excessive sag due to line temperature.
  • Also wants to transmit as much power as possible

INL developed a cost-effective method for optimized use of thermally limited transmission
  • Weather stations combined with computational fluid dynamic compute wind speed and direction at all line locations
  • Determines power flow limits to avoid sag using IEEE 738 standard
  • Communicates real-time limits to control room to enable accurate decisions

A cost-effective way to accurately determine DLR
  • Small number of weather stations
  • Limited additional data communications
  • Modular software/algorithm integration for utilities
Data Flow for INL DLR

Diagram showing the flow of data through Electric Utility Data, GIS Terrain Data, WindSim, Weather Station Data, and other components related to Weather Forecast Source, Line Segment Conductor Types, GLASS, Conductor Specifications, and more.
INL DLR to date:

Set-up Period
- Historical Weather Station Data
- CFD Look-up Tables

Real Time DLR
- Real Time Weather Station Data
- CFD Downscaling
- Weather Data at all line segments
- General Line Ampacity Solver
- Output: Ampacity and Conductor Temperature
Proposed complete DLR system with mesoscale forecasting

Set-up Period

- Mesoscale Hindcast
- Historical Weather Station Data

Forecasting

- Global Forecast
- Mesoscale Forecast
- ANN Forecast Correction
- CFD Downscaling
- Weather Data at all line segments
- General Line Ampacity Solver
- Output Ampacity and Conductor Temperature
CFD/WindSim Overview

- Power Line Locations
- Build Terrain
- Weather Stations
- Midpoint Locations
- Calculate Windfields
- Historical Weather Data
- Line Load Data
- Scaled lookup tables for all midpoints
- Realtime Weather data
- GLASS
- Line Ampacity Ratings
Windfield Example

Mapped windfield onto terrain
Points shown are weather stations and proposed windfarm
**Postprocessed Windfields**

Mean windspeed based on climatologies

Corresponding power density
The system being developed and tested by INL improves overall dynamic line rating quality and leads to average capacity improvements of 10-40%, or more in some areas.

<table>
<thead>
<tr>
<th>Monitor</th>
<th>Purchase Cost</th>
<th>Install Cost</th>
<th>Maintain Cost</th>
<th>Line Outage</th>
<th>Measurement Reach</th>
<th>Normal Wind</th>
<th>Normal Wind</th>
<th>High Load</th>
<th>High Load</th>
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<td>low</td>
<td>low</td>
<td>no</td>
<td>variable</td>
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<td>good</td>
<td>low</td>
<td>good</td>
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<tr>
<td>Weather + CFD</td>
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<td>low</td>
<td>low</td>
<td>no</td>
<td>wide area</td>
<td>high</td>
<td>good</td>
<td>good</td>
<td>high</td>
</tr>
<tr>
<td>Weather + CFD + Forecasting*</td>
<td>medium</td>
<td>low</td>
<td>low</td>
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<tr>
<td>Conductor Replica</td>
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<td>no</td>
<td>variable</td>
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</tr>
<tr>
<td>Temperature</td>
<td>high</td>
<td>medium</td>
<td>high</td>
<td>no</td>
<td>point</td>
<td>good</td>
<td>low</td>
<td>good</td>
<td>good</td>
</tr>
<tr>
<td>Tension</td>
<td>high</td>
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<td>multi span</td>
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<td>multi span</td>
<td>good</td>
<td>good</td>
<td>high</td>
<td>good</td>
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</tbody>
</table>

*Forecasting has not been analyzed through demonstration.
*These values are based on best judgment practices, and adapted from literature.
Time Scale Concept

- IEEE Std. 738 does not address the slow and fast inherent dynamics
- Perturbations in a transmission line are not taken into account
- Computationally challenging system!

Time Domain Modeling

- Instantaneous calculations of Line Current and Line Temperature
- Real-time calculations – Decision Making → SCADA/EMS
- Import MATLAB® model library into GLASS
- Controller Design - Mitigating system perturbations

Controller Design

- 

Electrical Dynamics

Thermal Dynamics

Transmission Line

Fast time scale

Slow time scale

IEEE Std. 738 does not address the slow and fast inherent dynamics
Perturbations in a transmission line are not taken into account
Computationally challenging system!
**Suggested Timeline**

1. Instantaneous
2. Short-term: Thermal Inertia
3. Short-term look ahead
4. Daily Peak Loading, Generation Dispatch
5. Maintenance, Power Marketing
6. Maintenance, Marketing, Construction
7. Construction, Refurbishment, Voltage Upgrades

**Visualization Suggestions**

- What to look for in forecasts
- Key Information to glean from data

**U.S. Trial Site Average Temperatures**

- spring
- summer
- fall
- winter

**Time**

- $t$  $15 \text{ min} \leq t \leq 60 \text{ min}$
- $4 \text{ hr} \leq t \leq 24 \text{ hr}$
- $60 \text{ min} \leq t \leq 4 \text{ hr}$
- $24 \text{ hr} \leq t \leq 48 \text{ hr}$
- $3 \text{ days} \leq t \leq 7 \text{ days}$
- $t \geq \text{ months}$
Control Room DLR Integration

• Transmission operators must already monitor a large amount of complex data

• Operators do not want more data in the control room

• Using a science-based human factors approach, INL will design and evaluate effective integration of DLR data into existing control room operations to facilitate decision making
### Partners and Collaborators

<table>
<thead>
<tr>
<th><strong>Boise State University</strong> – Boise, ID</th>
<th><strong>University of Idaho</strong> – Moscow, ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Graphical processing units CFD research (GIN3D)</td>
<td>• PhD student intern supporting multiple publications</td>
</tr>
<tr>
<td>• Masters student, DLR standard development</td>
<td>• Undergraduate student intern (3 years)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Durham University</strong> – Durham, UK</th>
<th><strong>WindSim AS</strong> – Tonsberg, Norway</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Collaborator &amp; methodology validation/comparison</td>
<td>• Computational fluid dynamics (CFD) software collaborator and development partner</td>
</tr>
<tr>
<td>• Joint publications</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Idaho Power Company</strong> – Boise, ID</th>
<th><strong>AESO</strong> – Alberta, Canada</th>
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<tbody>
<tr>
<td>• Test area (~500 line miles)</td>
<td></td>
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<tr>
<td>• Equipment funding and installation</td>
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<tr>
<td>• Engineering support</td>
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<table>
<thead>
<tr>
<th><strong>Idaho State University</strong> – Pocatello, ID</th>
<th><strong>AltaLink</strong> – Alberta, Canada</th>
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<tbody>
<tr>
<td>• Graduate intern (1.5 years) – full-time position hire</td>
<td></td>
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<tr>
<td>• 2010 to 2012 Senior Design Projects (8 students)</td>
<td></td>
</tr>
<tr>
<td>• 2013 to 2015 PhD Candidate - Dissertation</td>
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<tr>
<th><strong>Montana Tech</strong> – Butte, MT</th>
<th><strong>Nexans, The Valley Group</strong> – USA</th>
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<tbody>
<tr>
<td>• Undergraduate student intern (4 years)</td>
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<tr>
<td>• Graduate student intern (2 years)</td>
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</table>

<table>
<thead>
<tr>
<th><strong>Genscape (Promethean Devices)</strong> – Boston, MA</th>
<th><strong>Southwire Company</strong> – Carrollton, GA</th>
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<tbody>
<tr>
<td>• Field validation subcontract (3 months)</td>
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<table>
<thead>
<tr>
<th><strong>WindSim AS</strong></th>
<th><strong>Lindsey Manufacturing</strong> – Azuza, CA</th>
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<tr>
<th><strong>StormGeo</strong> – Houston, TX</th>
<th><strong>TechFlow</strong> – San Diego, CA</th>
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<tr>
<th><strong>TechFlow</strong></th>
<th><strong>OSIsoft</strong> – San Leandro, CA</th>
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<tr>
<th><strong>Bonneville Power Administration</strong> – Portland, OR</th>
<th><strong>Bonneville Power Administration</strong> – Portland, OR</th>
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<tr>
<th><strong>Southwest Power Pool</strong> – Little Rock, AR</th>
<th><strong>OSIsoft</strong> – San Leandro, CA</th>
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<tr>
<th><strong>Stantec</strong> – Portland, OR</th>
<th><strong>Southwest Power Pool</strong> – Little Rock, AR</th>
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**Interactions w/ Industry & Academia** – **10+** Non-Disclosure Agreements, **1** SPP Agreement Executed, **1** CRADA Project Executed, **1** CRADA Project Initiated, Over **$1M** invested by industry/academia partners over a 3-year period.
INL Contacts

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Unmanned Aerial Systems (UASs) and Utility Operations

Tim Vice
Transmission Maintenance Analyst
Westar Energy
Unmanned Aerial Systems (UASs) and Utility Operations
Taking reliability to heart

- Serving nearly 700,000 residential and business customers in eastern 1/3 of Kansas
- Approximately 4500 miles of line and 67,000 assets
Taking reliability to heart

• Serving nearly 700,000 residential and business customers in east-central Kansas
Why UASs? Why now?

- Increased Safety
- Reduced Impact
- Rapid Deployment
- Lower Operational Costs
Kansas State University Collaboration

- Hobby vs. Commercial Use
- Regulatory/Legislative Landscape
- Discussions started in 2013
- Numerous Opportunities in Westar Territory
Visual Inspections

- Transmission Infrastructure
- COA’s for areas near Salina and Manhattan
- Hi-Def Still Imagery and Video
Visual Inspections (cont.)
Orthomosaic Imagery
Additional Activities/Flights

• Wind Turbine Blade Inspections
• Boiler Inspection (JEC)
Future Plans

- Corona (UV) Scans
- Infrared (IR) Scans
- LiDAR
- Planemetrics/Geospatial Mapping
Continued Training and Research

- Continued support to develop commercial usage and new technology's
- Joint efforts to improve efficiency and uses

Flight Pavilion
- Currently the largest in the United States, 200’ x 300’ x 50’
- Dedicated on October 21, 2015
Public Outreach

- Legislative Presentations
- Student Education
Current Aircraft: DJI Inspire

- Pro Model
- 15 Minute flight time
- Fixed, proprietary payload
- 4K Video and Still
- Used for Training/Demos
Current Aircraft: TurboAce Matrix

- Matrix E Series
- 50 Minute flight time
- Open/Modular payload
- Used for Operations and Advanced Research
Questions?

Tim Vice
Transmission Maintenance Analyst
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Tim.Vice@westarenergy.com
Drone Technology at Xcel Energy

Eileen Lockhart
UAS Program Lead
Xcel Energy
DIVERSE OPERATING AREAS

NSP-Minnesota (NSPM)
- 9,843 miles Distribution Main
- 100 miles Gas Transmission
- 4,942 miles Electric T-Line
- 26,700 miles Electric D-Line

NSP-Wisconsin (NSPW)
- 2,300 miles Distribution Main
- 3 miles Transmission
- 2,403 miles Electric T-Line
- 9,747 miles Electric D-Line

Public Service Co. of Colorado (PSCo)
- 22,000 miles Distribution Main
- 2,000 miles Transmission
- 4,602 miles Electric T-Line
- 22,000 miles Electric D-Line

Southwestern Public Service (SPS)
*No residential gas customers
- 19 miles Transmission
- 6,839 miles Electric T-Line
- 15,689 miles Electric D-Line

Operate in 8 States
Customers
- 3.5 million electric
- 2.0 million natural gas

NSPM = 1.5 million
NSPW = 272,330
PSCo = 1.7 million
SPS = 363,559 (Electric only)
Xcel Energy recognizes UAS technology as transformational and it promises to change how work is executed.

- Developed a small internal Unmanned Aircraft Systems team in 2014.
  - Evaluated sUAS technology capability
  - Developed internal operational use cases
  - Shared our sUAS vision with federal legislators
  - Selected initial craft
  - Filed an FAA Section 333 waiver application to commercially operate sUAVs
  - Established several “proof of concept missions” within operations
  - Partnered with several agencies including:
    - EEI, EPRI, INL & more.
UAS MISSION APPROACH

Proof of Concept Missions
Execute POC missions and establish lessons learned for implementation

Visual Line of Sight
Internal visual line of sight operations

Beyond Line of Sight
Partner with outside organizations for beyond the line of sight operations

UAS Program & Operations Office
Dedicated resources to manage VLOS and BLOS operations
MORE THAN 8 MISSIONS COMPLETED  AUGUST 2015 – FEBRUARY 2016

• Completed 7+ missions in 2015
  – **Indoors:** (performed several to date)
    • Boiler inspections (burner fronts)
    • Duct inspections (structural)
  – **Outdoors:**
    • Inspections of five energized substations
    • Transmission line inspection
    • Volumetric survey of ash storage facility
    • Wind turbine blade inspection
    • T&D Gas pipeline inspections

**February 3, 2016:** Xcel Energy became the first electric utility in the United States to complete an FAA-approved beyond-line-of-site (BLOS) mission (OHTL inspection)

• Each mission has been benchmarked against a predefined set of performance metrics
  – Define success
  – Ensure data are gathered for business case evaluation
  – Identify opportunities for improvement
WHAT DOES THE FUTURE BRING?

THIS?

THIS?

OR THIS?
• We want to move our missions from proof of concept to missions that obtain enterprise wide efficiencies.
  – Transmission corridor assessments
    • Including Vegetation Management
  – Transmission line inspections
  – High Pressure gas leak detection
  – Electric T&D post storm assessment
  – Asset Inventory and defect detection
    • GIS Data Collection
    • Potential of automated defect detection
    • Consistent ranking of defects
  – Overall health of assets- One flight many uses
THANK YOU!
MISSION 1

- Boiler Inspections (Indoor)
  - Completed condition inspections of boiler burners and overfire airports.
  - Structural Duct Inspections (Indoor): Inspections of structural integrity of the internal duct work

- Heat Recovery Steam Generator inspections focused on physical damage & insulation placement
  - Note: Indoor use is not subject to FAA regulations.
August 2015 – Substation Data Collection:

- Successfully completed its first outdoor mission.

- The mission focus was to use a small UAV (under 55 pounds) to conduct an inspection of five Amarillo-area energized substations to validate equipment ratings.

- The aerial vehicle, equipped with a high resolution camera, took still photographs of energized electrical equipment nameplate data located high off the ground.
  - The data was needed to comply with NERC reliability standards.
• **October 2015 – Overhead Transmission Line (OHTL) Inspection:**
  - Conducted an inspection of a seven-mile section of rebuilt 230kV transmission line near the Canadian border in North Dakota to verify compliance with Xcel standards and assess ROW conditions.
  - Simulated BLOS operations by using preprogrammed autonomous flight capabilities.
  - Pilot intervention was only required for takeoff and landing.
  - Planted “defects” to assess image quality and detection capabilities in a blind test.
• **October 2015 – Volumetric Survey of Ash Storage Facility:**
  
  - Completed a volumetric survey of an ash storage facility southeast of the Twin Cities by using imagery collected while flying preprogrammed transects over the 42 acre site together with Pix4D software.
  
    - In just 11 minutes the UAS generated enough images to develop a three-dimensional rendering of the ash landfill and certify the volume of ash.
    - Compared to ½-day minimum (with full-size helicopter and LiDAR).
    - Compared to full-day with survey crew.
    - Post-mission analysis revealed the accuracy to be within 0.01% of historic methods.
MISSION 5

- **October 2015 - Wind Turbine Inspection:**
  - Completed an inspection of the condition of wind turbine blades, lightning protection systems and protective gel coat at the Grand Meadow wind farm in Minnesota.
  - Proved the safety benefits and efficiency of using UAS in lieu of climbing methods.
    - The inspection was completed in a fraction of the time required to perform a climbing inspection.
    - Identified blade damage that required repair.
  - Proved the effectiveness versus ground-based inspections using binoculars/spotting scopes.
• November 2015 – Gas Pipeline Inspection (T&D):
  – Completed condition inspections of exposed sections of T&D pipelines. Also, deployed a gas leak detection sensor for the transmission pipeline inspection.

• Transmission Pipeline:
  – Simulated BLOS operations by using preprogrammed autonomous flight capabilities. Pilot intervention was only required for takeoff and landing.
  – Planted “defects” to assess image quality and detection capabilities in a blind test.
  – Successfully detected simulated gas leaks

• Transmission and Distribution Pipelines:
  – Proved capability to assess pipeline and ROW conditions.
MISSION 8

• February 2016 – BLOS OHTL Inspection:
  – Completed condition inspection of a 69kV OHTL using two UAS (helicopter and fixed wing).
  – First FAA-approved BLOS mission by an electric utility in the U.S.
    – Aircraft remained aloft for 60 minutes during the longest duration flight.
    – Employed a higher resolution camera than used in previous missions thereby further improving imagery (analysis still in the works).
    – Overlapping images were captured to enable 3D modelling of both the line and a substation with Pix4D (analysis still in the works).
Legal Aspects of Drone Technology

Kelly Daly
Partner
Stinson Leonard Street LLP
UAS/Drone Regulation: The Changing Landscape

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Stinson Leonard Street, LLP
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(202) 728-3011
UAS/Drone Regulations: Square Peg, Round Hole

**Until This Week:** FAA treated UAS like any other aircraft, UAS had to comply with general aircraft requirements, including:

- Registration of aircraft
- Airworthiness Certificate
- Operators must have a recreational pilot certificate, or higher, and a valid driver’s license

**Problem:** UAS are inherently different from “manned” aircraft, so new rules were needed to keep pace with technology to allow US to maintain role as world leader in this area
Until This Week - Two “Exemption” Paths to the Sky “The Streamlined Process”

**SECTION 333: CIVIL OPERATIONS**
- Any UAS used for a Commercial Purpose (i.e., compensation)
- **Two step process:** 1) Request exemption from certain regulations; and 2) to extent use exceeds “blanket” Certificate of Waiver or Authority (COA), request civil COA

**SECTION 334: PUBLIC OPERATIONS**
- Any UAS used for a Governmental Purpose (i.e., no compensation)
- **Single step process:** Requires a public Certificate of Waiver or Authority (COA)
- Applicable to public power entities /Municipalities?

Except in limited instances, replaced by Part 107
New – Commercial UAS Rules – Part 107

REQUIREMENTS

- 16 years of age
- Remote Pilot Airman Certificate
  - Pass Aeronautical Knowledge Test (every 2 years); or
  - Part 61 Pilot w/UAS course
- Unmanned Operator Certificate
- Physical/mental health cannot adversely interfere with safety

OPERATIONAL LIMITATIONS

- Less than 55 lbs (with payload)
- Within Visual Line of Sight (of remote pilot in command or visual observer)
- Daylight hours (or 30 min before or after sunrise/sunset w/anti-collision lighting)
- 400 feet above ground (or structure)
- < 100 MPH (87knots) & Yield to Aircraft
- No flights over uninvolved persons
More Operational Limitations

- Minimum visibility 3-miles
- Permitted in Class B, C, D & E airspace (with ATC permission)
- Permitted in Class G airspace (without ATC permission)
- No operations from moving aircraft
- No operations from moving vehicles (unless sparsely populated)
- One pilot/visual observer per UAS at one time

- No carriage of hazardous material
- Carrying load permissible if secured and doesn’t impact controllability
- Transporting property for hire permitted if:
  - Total weight <55 lbs
  - Flight is within VLOS
  - Flight is within 1 state (not DC an Hawaii)
New – Commercial UAS Rules – Part 107

OTHER RESPONSIBILITIES & PROVISIONS

- Must register UAS prior to flight & ensure aircraft markings
- Must conduct preflight inspection of UAS (aircraft and station)
- Must make UAS and documents/records available to FAA upon request and report accidents involving serious injury, loss of consciousness or damage to property (> $500) to FAA within 10 days
- Check local (privacy) laws before gathering information
What’s Next? ➡️ One Step to Broader Process

- FAA to issue more NOPRs; committed to keep pace with technological advances
- UAS Pathfinder Program is continuing to provide tests and research in key areas (CNN, PrecisionHawk and BNSF are key players in beyond line-of-site, flights over people, airport integration, counter-UAS support technology and low altitude safety infrastructure)
- FAA will entertain waivers on a case-specific basis and have an Online Portal for such requests
Hot Legal Issues

- Enforcement parameters already include civil and criminal penalties and revocation of certificate. Presumably:
  - Penalties of up to $25,000 - 49 U.S.C. § 46301
  - Prison sentence of up to 20 years - 18 U.S.C. § 32(a)(8)

- Privacy Issues
- Preemption Issues
- Safety and Insurance Coverage Issues
- Industry pressure for new uses/technology - Geofencing
Legal Aspects of Drone Technology

Kelly Daly
Partner
Stinson Leonard Street LLP
UAS/Drone Regulation: The Changing Landscape

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UAS/Drone Regulations: Square Peg, Round Hole

直到本周之前：FAA将UAS视为任何其他航空器，UAS必须遵守一般航空器要求，包括：

- 航空器注册
- 空气适航性证书
- 操作员必须持有休闲飞行员证书，或更高，并持有有效的驾驶执照

问题：UAS与“有人驾驶”航空器本质不同，因此需要新的规则以跟上技术步伐，允许美国保持在该领域的世界领导者角色
**Until This Week - Two “Exemption” Paths to the Sky**  
“The Streamlined Process”

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<th>SECTION 333: CIVIL OPERATIONS</th>
<th>SECTION 334: PUBLIC OPERATIONS</th>
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<td>Any UAS used for a Commercial Purpose (i.e., compensation)</td>
<td>Any UAS used for a Governmental Purpose (i.e., no compensation)</td>
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<td><strong>Two step process:</strong> 1) Request exemption from certain regulations; and 2) to extent use exceeds “blanket” Certificate of Waiver or Authority (COA), request civil COA</td>
<td><strong>Single step process:</strong> Requires a public Certificate of Waiver or Authority (COA)</td>
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<td>• Applicable to public power entities /Municipalities?</td>
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*Except in limited instances, replaced by Part 107*
# New – Commercial UAS Rules – Part 107

## Requirements
- 16 years of age
- Remote Pilot Airman Certificate
  - Pass Aeronautical Knowledge Test (every 2 years); or
  - Part 61 Pilot w/UAS course
- Unmanned Operator Certificate
- Physical/mental health cannot adversely interfere with safety

## Operational Limitations
- Less than 55 lbs (with payload)
- Within Visual Line of Sight (of remote pilot in command or visual observer)
- Daylight hours (or 30 min before or after sunrise/sunset w/anti-collision lighting)
- 400 feet above ground (or structure)
- < 100 MPH (87 knots) & Yield to Aircraft
- No flights over uninvolved persons
New – Commercial UAS Rules – Part 107

MORE OPERATIONAL LIMITATIONS

- Minimum visibility 3-miles
- Permitted in Class B, C, D & E airspace (with ATC permission)
- Permitted in Class G airspace (without ATC permission)
- No operations from moving aircraft
- No operations from moving vehicles (unless sparsely populated)
- One pilot/visual observer per UAS at one time
- No carriage of hazardous material
- Carrying load permissible if secured and doesn’t impact controllability
- Transporting property for hire permitted if:
  - Total weight <55 lbs
  - Flight is within VLOS
  - Flight is within 1 state (not DC an Hawaii)
New – Commercial UAS Rules – Part 107

OTHER RESPONSIBILITIES & PROVISIONS

- Must register UAS prior to flight & ensure aircraft markings
- Must conduct preflight inspection of UAS (aircraft and station)
- Must make UAS and documents/records available to FAA upon request and report accidents involving serious injury, loss of consciousness or damage to property (> $500) to FAA within 10 days
- Check local (privacy) laws before gathering information
What’s Next?  ➡️  One Step to Broader Process

- FAA to issue more NOPRs; committed to keep pace with technological advances
- **UAS Pathfinder Program is continuing to provide tests and research in key areas** (CNN, PrecisionHawk and BNSF are key players in beyond line-of-site, flights over people, airport integration, counter-UAS support technology and low altitude safety infrastructure)
- FAA will entertain waivers on a case-specific basis and have an **Online Portal** for such requests
Hot Legal Issues

- Enforcement parameters already include civil and criminal penalties and revocation of certificate. Presumably:
  - Penalties of up to $25,000 - 49 U.S.C. § 46301
  - Prison sentence of up to 20 years - 18 U.S.C. § 32(a)(8)
- Privacy Issues
- Preemption Issues
- Safety and Insurance Coverage Issues
- Industry pressure for new uses/technology - Geofencing
Personal Protective Grounding Practices at Nebraska Public Power District

Kip Schuettler
Corporate Safety Manager
Nebraska Public Power District
Personal Protective Grounding
Kip Schuettler, Corporate Safety Manager
This presentation is designed to provide accurate and authoritative information about NPPD’s approach to the subject matter covered. It is provided with the understanding that the presenter nor NPPD is engaged in rendering legal or other professional service, and this presentation should not be relied upon as legal or profession advice. If legal or other expert assistance is required about this subject matter, the services of a competent professional should be sought.
About Nebraska Public Power District

• Established January 1, 1970

• Nebraska’s largest electric generating utility

• 11-member popularly-elected Board of Directors

• Integrated Utility System:
  – Generation Facilities
  – Transmission Facilities
  – Distribution Facilities

• More than 40 percent of our energy mix is carbon free
Nebraska Public Power District

- 5,200 miles of Transmission Lines
- 273 total Substations
- 89,000 Retail Customers
- 50 Wholesale Communities
Hazardous touch and step voltages can be developed at a work site from several sources such as the following:

1. Accidental energization
2. Induction
3. Lightning
The purposes for the ground jumper are:

1. Trip the protective device if the circuit is inadvertently energized
2. Provide equipotential at the work location, in particular the worker on the structure.
NPPD
Personal Protective Grounding

• Early to Mid 1990’S Original Creation of the NPPD Personal Protective Grounding Manual
  – Equipotential Grounding was the preferred grounding method for all grounding applications.
  – The equipotential grounding method provides the best protection available for the worker.
  – Master Grounding was still an approved grounding method
Master grounding

- Used to short circuit and ground all conductors
- Can be used to assure clearing of an unexpected source
- Does not assure a zone of equipotential
- Master grounding requires the use of a Personal Ground to provide an EPZ.
NPPD
Personal Protective Grounding

• A team was formed consisting of NPPD Teammates along with a External Consultant
  
  – To review and document work methods to Insulate, Isolate or Ground with an EPZ methods
  – Develop effective personal protective grounding practices/procedures.
  – Provide illustrations of different methods in the field in the manual to address not all but a few most common grounding applications.
  – Develop a plan for implementing the new practices/procedures
  – Developing a plan for training District personal on the new method (s) and their proper application
The three approved methods for working de-energized lines and/or equipment include:

1. **Insulation** (use of rubber PPE).
2. **Isolation** (disconnecting and isolating both the conductor and system neutral). Master Grounds can be installed and line worked.
3. **Creating an equipotential zone** (proper grounding at the work location).
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Personal Protective Grounding

ZONE OF EQUIPOTENTIAL (EPZ)

• Is a safe work zone where all conductive objects are bonded or grounded together to create an environment of same potential of all conductive parts before, during, and after a fault.
Personal Ground

- Used in conjunction with the Master Ground
- Provides an equipotential zone for the worker
NPPD
Personal Protective Grounding

MASTER GROUND WITH PERSONAL GROUND

• A Master Ground may be placed at the immediate work site or adjacent to the work site.
• The Master Ground method includes the use of a Personal Ground.
• The distance between the Master Ground and the work site Personal Ground shall be less than 1.0 mile from either side of the Master Ground.
• A Personal Ground shall be used on the phase being worked.

NOTE: The use of a cluster bracket is required with the Personal Ground if the structure is a wood pole.
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Personal Protective Grounding

Grounding Cluster

- Used to include the pole in the zone of equipotential
- Attached to the pole below the work position (or aerial device).
- May be installed at the base of the wood structure provided approved grounds and ground sets are utilized.
NPPD
Personal Protective Grounding

- Before any work is performed on de-energized lines or equipment, an authorized employee must obtain a clearance.
- The approved methods for detecting voltage will be used.
- Grounds may be applied only after a test indicates that a line or piece of electrical equipment is de-energized.
- The grounding jumper shall first be connected to the approved ground.

Note: Ground connections shall be cleaned or brushed before installing the grounding jumpers.
• The order of the approved grounds changed (1 and 2 exchange places).
• Three was added to the list as shown below.

1. Power plant or substation ground grid.
2. Multi-grounded neutral (MGN) of the circuit being worked.
3. Pole Ground with Shield Wire
4. System ground rods, steel towers, and non-insulated anchor rods in place (never guy wires).
5. Temporary driven ground rods that are installed to a minimum depth of 4 feet
Selection of Grounds

- Depends on the available fault current on the line or substation being worked.
- A chart is provided to determine the proper size of a ground set for the line or substation being worked.

The ground set shall:

- Be capable of conducting the maximum anticipated fault current and breaker clearing duration.
- At minimum, No. 2 AWG copper.
- As short as practical and properly secured.
- If paralleled shall be like sizes of equal length.
Inspection of Grounds

- Before each use, ground jumpers shall be visually inspected for the following:
  - Broken cable strands.
  - Poor connections.
  - Checked for proper operations.

- If grounds are subjected to fault currents, they should be removed from service and tested.
Installation of Ground Jumpers

- An appropriate insulated tool or device shall be used
- Minimum approach distances shall be maintained
- Grounding jumpers shall be kept clear of the worker during installation.
- Employees shall wear HRC 2 fire-resistant (FR) clothing
- When installing on a steel structure, the ground jumper shall be connected to a secure permanent member of the structure
NPPD
Personal Protective Grounding

Cluster Bar
Below Work Position

Cluster Bar Below Working Position
Personnel Grounding Jumper
NPPD
Personal Protective Grounding
Insulated Bucket
NPPD
Personal Protective Grounding

Sub-T with
Distribution Underbuild
NPPD
Personal Protective Grounding

H Frame Structure
NPPD
Personal Protective Grounding

Single Pole Structure
NPPD
Personal Protective Grounding

Lattice Metal Tower
While maintaining continuity during splicing conductors at ground level requires bonding and conductive mats or isolation blankets are utilized.
Substation Equipotential Zone

- Substations are designed around the concept of “Equipotential.”

- When a fault occurs, all grounded and bonded metals rise to approximately the same potential.
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SUBSTATIONS & SWITCHYARDS

• Grounds shall be in place close as reasonably possible to the work
• Grounds shall be installed on major substation equipment in the following manner:
  1. On both sides of a de-energized circuit breaker, circuit switcher, or recloser.
  2. On all leads/bushings (primary, secondary, and tertiary windings) of the power transformer or reactor.
To avoid getting in series when separating or removing bus or conductors in a substation, a jumper shall be used to maintain continuity.

Leads may be disconnected from the bushing terminals, for equipment testing as long as the grounds remain connected to the de-energized conductors.
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- Acceptable to utilize three long grounds
- Acceptable to utilize two short ground jumpers along with one long ground jumper
NPPD
Personal Protective Grounding
Transformer
NPPD
Personal Protective Grounding Bus
NPPD
Personal Protective Grounding

Circuit Breaker
NPPD
Personal Protective Grounding

• To Avoid any possibility of induction on ungrounded buss, which could lead to personal injury all equipment being work will be grounded.

Colleagues working on the circuit switcher, oil circuit breaker and Transformer at the same time it would require a minimum of six sets of grounds.
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Personal Protective Grounding
Underground

• Underground similar to overhead, and includes the same approved techniques:
  – Insulation (use of rubber PPE)
  – Isolation (disconnecting and isolating both the conductor and concentric neutral)
  – Creating an equipotential zone (proper grounding at the work location)
个人防护接地（Personal Protective Grounding）

**UNDERGROUND**

- 类似于架空线路，地下系统需要特别小心，以避免危险的接触-踏步电位。
- 接地跳线在经过电气电位测试并获得批准后才能安装。

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Similar to installing cluster on pole
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Personal Protective Grounding
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Personal Protective Grounding

Insulate the cable being worked from all other cables and concentric neutral wires using insulated cover-ups, gloves, sleeves, and other insulated tools.
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Isolate

Isolate the cable being worked from all other cables, concentric wires, and grounds.
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Place worker in an Equipotential Zone to prevent differences of potential across the worker. *(Radial feed, one worker)*

*Illustration VI-3*

Place worker into an Equipotential Zone to prevent differences of electrical potential across the worker. *(Loop feed, two workers)*
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Personal Protective Grounding

Man-lift Grounding
• When working inside a substation, equipotential grounding can be accomplished by attaching the vehicle ground to the ground grid, provided the phase being worked is also grounded to the substation ground grid.
Grounding While Stringing Conductors

Stringing or Removing Conductors

- All pulling and tensioning equipment shall be bonded to the best-approved ground.
- The tensioner/puller shall incorporate the use of a traveling ground, bonded to the best-approved ground.
- Sheave grounds or additional traveling grounds shall be installed at the first structure from each the tensioner and puller equipment.
- Sheave grounds shall also be installed at energized crossings unless other provisions (guard structures, insulated hose, etc.) have been installed.
Grounding While Stringing Conductors

Stringing or Removing Conductors

• Clearly marked barriers shall be used at the puller and tension sites when a hazard to the public exists.
• Workers standing on the ground when attending stringing equipment shall use rubber gloves, EPZ mat or Type 2 switch board matting.
• All other persons shall be kept out of the work area.
• Where available, the automatic reclosing feature of the circuit interrupting device shall be made inoperative.
Conclusion

- Nebraska Public Power District (NPPD) is committed to providing its employees with a safe working environment.
- These rules will reduce the risk of accidental injury or death to workers from electrical shock.
- Properly applying the grounding principles with discretion and judgment will result in safe working conditions.
Questions?