

Distribution Systems - Program 128

Program Overview

Program Description

Utility distribution systems are challenged by an aging infrastructure, conventional designs, and increased demands for power. Electricity distribution companies are under pressure to improve reliability and system performance while dealing with the ongoing challenges of this aging infrastructure and increasing customer demands for higher reliability and power quality. Budget and investment constraints require electric utilities to manage their distribution systems more efficiently. EPRI's Distribution Systems program addresses these challenges by providing guidance to members on managing distribution assets, reducing O&M costs, and improving reliability and system performance. In close collaboration with its members, EPRI has developed a strategic plan to articulate its research objectives and ensure that its research focus is aligned with those objectives.

Research Value

With the knowledge acquired through this research program, members will have access to information that can help them:

- Improve management of aging distribution system components
- Improve assessment tools and techniques
- Optimize equipment application guidelines to improve investment decisions
- Enhance prediction of distribution fault locations
- Improve distribution system reliability
- Manage the risk of stray voltages and other issues facing distribution planners and operators.

Approach

EPRI research in distribution systems will yield a variety of data and knowledge beneficial to members of the program. This information will come in a number of forms and is expected to include:

- Component analysis and accelerated aging metrics
- Wood pole application alternatives
- Advanced fault location algorithms
- Neutral-to-earth voltage mitigation techniques
- Knowledge-Based Services Hotline

Accomplishments

In the past, EPRI's Distribution Systems program has delivered valuable information that has helped its members and the industry in numerous ways:

- A quick survey of distribution circuits in many locations can yield numerous instances of improperly applied wildlife guards. A primary factor in improper applications is lack of understanding of how the guard is designed to function and how it will interact with other components on the structure. The guidelines presented in the *Design and Equipment Issues for Overhead Distribution Systems* report are intended to provide a fundamental overview of proper guard application to mitigate wildlife interactions to the greatest extent possible. This information will benefit utility distribution engineers as well as line workers.
- The *Elevated Neutral-to-Earth and Contact Voltages in Distribution Systems* report is intended for the utility engineer who must address contact voltage concerns in the field as part of utility operations and maintenance. With the results from this multi-year research, members can improve both efficiency and

response time when addressing customer concerns surrounding the topic of contact voltages. This work is particularly important today, with the new emphasis placed on the subject matter by the news media.

- The goal of the research covered in the *Overhead Distribution Vegetation Challenges* report was to further assess the risk associated high-impedance tree-initiated faults on electric distribution systems, as a logical extension of work that began in 2007 with the *Optimal Design of Overhead Distribution Systems* report. Investigators completed high-voltage testing at 7.6 kV and 19.9 kV on three species of living trees. The project was successful in gathering data useful in assessing tree-conductor faults in conifers, touch potential exposures at ground level and aloft, and the effects of precipitation-wet bark on fault characteristics.

Current Year Activities

In the coming year, this research program expects to accomplish these objectives:

- Component analysis and accelerated aging metrics
- Advanced fault location algorithms
- Neutral-to-earth voltage mitigation techniques
- Knowledge-Based Services

Estimated 2010 Program Funding

\$2.0M

Program Manager

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Summary of Projects

PS128A Inspection and Assessment of Overhead Distribution Systems (062120)

Project Set Description

This Project Set builds on a component reliability dataset by addressing components on an individual basis each year. The dataset will build over time, with at least one new component being examined every year. Laboratory testing is combined with survey and field data from various utilities to build the dataset and provides a better understanding of individual component reliability, as well as operational parameters that affect reliability. The laboratory component of this work can include electrical, mechanical, accelerated aging, and flammability testing using a host of test and analysis equipment.

Information gained through this work will be published in annual test reports and also incorporated into a *Distribution Component Reliability and Specification* guidebook. In addition, this information will be part of a broader knowledge base that contributes to distribution inspection guides, procurement guides, field books, and other training materials.

In addition, this Project Set focuses on providing distribution utilities with the information necessary to accurately perform meaningful inspections that will enhance distribution system operations. This information can run the gamut from improved methods for performing basic inspections to the development and implementation of new inspection technologies.

Project Number	Project Title	Description
P128.001	Component Reliability	This project aims to build a component reliability dataset by addressing components on an individual basis each year. The dataset will build over time, with at least one new component being examined every year. Laboratory testing is combined with survey and field data from various utilities to build the dataset and provide a better understanding of individual component reliability as well as the operational parameters that affect reliability.
P128.003	Inspection and Assessment Technologies and Guidelines	This project may help to improve distribution inspection techniques and evaluate and assess the impact of new inspection techniques. The findings will be documented in a field guides and guidebooks.

P128.001 Component Reliability (065443)

Key Research Question

Quantifying distribution component reliability can be challenging for utilities, especially without a formal analysis program. The issue becomes even more muddled as manufacturers make seemingly small design and material changes that can have significant impacts on equipment reliability. Improved understanding of component reliability can be gained through a framework of testing and data collection. This information can then be used to assess unit risk and improve specification, purchasing, operation, and inspection criteria.

Approach

This project aims to build a component reliability dataset by addressing components on an individual basis each year. The dataset will build over time, with at least one new component being examined every year. Laboratory testing is combined with survey and field data from various utilities to build the dataset and provide a better understanding of individual component reliability as well as operational parameters that affect reliability. The laboratory component of this work can include electrical, mechanical, accelerated aging, and flammability testing using a host of test and analysis equipment.

Information gained through this work will be published in annual test reports and also incorporated into a *Distribution Component Reliability and Specification Guidebook*. In addition, this information will be part of a broader knowledge base that contributes to distribution inspection guides, procurement guides, field books, and other training materials.

Impact

Optimized distribution component selection, application, and inspection yields:

- Improved specification and purchasing decisions
- Enhanced distribution system reliability
- Reduced distribution system operating costs
- Improved safety for utility personnel and the general public.

How to Apply Results

Project results will be delivered in test reports, field and inspection guides, and other training materials. Results will also be compiled into the *Distribution Component Reliability and Specification Guidebook*. Members can directly apply this information to enhance their procurement, design, operation, and inspection practices. This work also helps counter the industry-wide trend of knowledge drain by creating a repository of component information that can serve as a training tool for new utility personnel.

2010 Products

Product Title & Description	Planned Completion Date	Product Type
Design of Overhead Distribution Systems – Component Reliability and Specification Guidelines: This project will provide ongoing updates and expansions to the <i>Distribution Component Reliability and Specification Guidebook</i> as a result of testing and evaluation projects prioritized by members.	12/31/10	Technical Update

P128.003 Inspection and Assessment Technologies and Guidelines (067465)

Key Research Question

Outages are costly for utilities and for end-use customers. Electrical outages interrupt industrial processes, disrupt commerce, and cause a variety of problems for residential customers. For utilities, outages are costly since they increase worker overtime, disrupt energy sales, and draw the attention of regulators. Routine inspection programs are one tool utilities can use to reduce failures on their circuits and minimize customer outages. By identifying problems that need repair before they develop into failures, inspection programs can be a cost-effective method for enhancing the quality and reliability of electric service.

Approach

This project aims to provide distribution utilities with the necessary information to accurately perform meaningful inspections that will enhance distribution system operations. This information can run the gamut from improved methods for performing basic inspections to the development and implementation of new inspection technologies.

Information learned through this work will be published in annual technical reports and also incorporated into a *Distribution Circuit Inspection and Assessment Guidebook*. In addition, this information will be part of a broader knowledge base that contributes to distribution inspection field guides, procurement guides, and other training materials.

Impact

Optimized distribution inspection technologies and procedures yield:

- Fewer service outages
- Improved power quality and reliability
- Reduced outage repair costs

How to Apply Results

Project results will be delivered in test reports, field and inspection guides, and other training materials. Results will also be compiled into the *Distribution Circuit Inspection and Assessment Guidebook*. Members can directly apply this information to enhance their procurement, design, operation, and inspection practices. This work also helps counter the industry-wide trend of knowledge drain by creating a repository of inspection procedures and best practices that can serve as a training tool for new utility personnel.

2010 Products

Product Title & Description	Planned Completion Date	Product Type
Inspection and Assessment Technologies and Guidelines	12/31/10	Technical Update

PS128B Improving Reliability and Fault Performance (067428)

Project Set Description

This project set is focusing on methods and practices for preventing reliability events and to quickly recover when such events happen.

Project Number	Project Title	Description
P128.004	Distribution Fault Location and Characterization	EPRI has developed and tested technologies to make fault location systems easier for utilities to install and use. Such systems allow operators to view the estimated location of a fault, which helps operators direct crews to do switching and locate faults faster. The main goal in 2010 is to test performance of this system to see if it is possible to extend its capabilities.
P128.008	Reliability Metrics	This project provides guidelines and cost/benefit analysis tools for improving reliability. The project will also track regulatory issues and standards development around the world to understand priorities for benchmarking and characterizing performance. New techniques for applying statistical characterization methods and normalizing results will be addressed.

P128.004 Distribution Fault Location and Characterization (062119)

Key Research Question

Automated fault location algorithms have not been widely used because of a lack of monitoring equipment and complexity. Previous EPRI research in this program and utility implementation by Con Edison and others has shown that fault location can be used successfully to reduce repair and restoration times. It may be possible to extend this functionality to provide location estimates to blips in current that are often precursors to faults. Another possibility is to use waveform signatures to try to estimate the type of fault, so crews know what to look for.

Approach

EPRI has developed and tested systems to make fault location systems easier for utilities to install and use. Such systems allow operators to view the estimated location of a fault, which helps operators direct crews to do switching and locate faults faster.

The main goal in 2010 is to test the performance of this system to see if it is possible to extend its capabilities to include:

- Communicating fault indicators, which offers another approach to locating faults. EPRI will research the state of this technology and how it can be most effectively applied for fault location.
- Integrating fault indicator data with substation-based fault location, which has the potential to improve location and accuracy.

- Advanced meters and triangulation. Hydro Quebec has developed a unique system for using downline primary metering to help locate faults. EPRI will research ways to extend this to include data from automated feeder devices like reclosers, switches, capacitors, and regulators as well as customer AMI. Integration with substation locating approaches will also be researched.

The project will also continue to investigate other ways to improve existing substation-based fault location.

Impact

- Improve restoration time for enhanced System Average Interruption Duration Index (SAIDI) and Customer Average Interruption Duration Index (CAIDI)
- Eliminate or reduce repeated momentary faults
- Improve repair times with reduced susceptibility to cascading failures
- Locate precursors of equipment failure, so failing equipment can be removed before it fails
- Provide information to operators on fault types based on waveform signatures

How to Apply Results

Distribution system operators can integrate this system with their own monitoring and information systems to dispatch crews to estimated fault locations in near real time. The fault-location system includes fault-location algorithms, interfaces to a variety of distribution modeling databases and monitoring equipment, and a user interface for operators.

2010 Products

Product Title & Description	Planned Completion Date	Product Type
Distribution Fault Location and Characterization	12/31/10	Technical Update

P128.008 Reliability Metrics (069235)

Key Research Question

Distribution reliability continues to be an important part of utility customer service, and regulators are increasingly using reliability as a measure of utility performance. There are a number of areas where further research could help members improve reliability and better manage reliability programs, addressing questions such as:

- Is my hazard-tree program working?
- Where can we best apply reclosers?
- Can we show regulators the impact of a particularly severe storm season?
- Where should we target investment money?
- How do we compare with our utility peers?

Each of these areas is ripe for more research to help members plan for and improve reliability and infrastructure.

Approach

This project provides guidelines and cost/benefit analysis tools for improving reliability. The project will also track regulatory issues and standards development around the world to understand priorities for benchmarking and characterizing performance. New methods for applying statistical characterization methods and normalizing results will be addressed, as will a number of other areas such as:

- Targeting reliability improvement projects: Using data and input from participating utilities to develop ways to evaluate and target reliability improvement projects.
- Benchmarking: A number of reliability benchmarking programs exist within the industry (from IEEE, EEI, and others). EPRI will look to fill in gaps and augment those activities based on the needs of participating members.
- Best use of outage data: EPRI can help members make better use of outage data to evaluate reliability programs and target areas for improvement.
- Information Exchange: Exchange of information on how each utility applies reliability-improvement projects.

This program will use results from research on inspection approaches and equipment testing conducted through Project Set 128A.

Impact

- Reduce customer interruptions (e.g. SAIFI, MAIFI)
- Improve restoration times (SAIDI, CAIDI)
- More efficiently meet regulatory requirements
- More efficiently apply reliability-improvement programs (inspections, automation, lightning protection, and more)

How to Apply Results

Members can use the results of project research to support regulatory filings. Approaches to reliability improvement can further be used to refine and target existing reliability programs.

2010 Products

Product Title & Description	Planned Completion Date	Product Type
Reliability Metrics	12/31/10	Technical Update

PS128C Potential Electric Hazard Issues (067429)

Project Set Description

This collaborative research Project Set provides the latest techniques for understanding and dealing with virtually all related concerns at readily accessible human and animal contact locations. The main goal of the project in 2009 is twofold. First, the project will continue to provide research that enhances state-of-the-art understanding of how to deal with induced voltages, urban stray voltages, and the range of elevated neutral-to-earth voltage (NEV) concerns. Second, the wealth of material developed in prior years will be consolidated into a single resource to support staff training, industry awareness, regulatory inquiries, and overall understanding of related subject matter. As in previous years, contributors will prioritize the final scope of work based on a selection of priorities and options.

Project Number	Project Title	Description
P128.005	NEV and Urban Contact Voltage Issues and System Design	This collaborative research project provides the latest techniques for understanding and dealing with virtually all related concerns at readily accessible human and animal contact locations. The main goal of the project in 2010 is twofold. First, the project will continue to provide research that enhances state-of-the-art understanding of how to deal with induced voltages, urban stray voltages, and the range of elevated NEV concerns. Second, the wealth of material developed in prior years will be consolidated into a single resource to support staff training, industry awareness, regulatory inquiries, and overall understanding of related subjects. As in previous years, contributors will prioritize the final scope of work based on a selection of priorities and options.

P128.005 NEV and Urban Contact Voltage Issues and System Design (062118)

Key Research Question

Elevated neutral-to-earth voltages (NEV) and voltages on other conductive objects cause concerns for humans and animals at contact locations such as dairy farms, swimming pools, gas pipelines, street poles, and other installations at or near electric power distribution points. This is a highly visible subject, with a wide range of concerns and issues involving regulators, transmission companies, distribution companies, and their customers.

Approach

This collaborative research project provides the latest techniques for understanding and dealing with virtually all related concerns at readily accessible human and animal contact locations. The main goal of the project in 2010 is twofold. First, the project will continue to provide research that enhances state-of-the-art understanding of how to deal with induced voltages, urban stray voltages, and the range of elevated NEV concerns. Second, the wealth of material developed in prior years will be consolidated into a single resource to support staff training, industry awareness, regulatory inquiries, and overall understanding of related subjects. As in previous years, contributors will prioritize the final scope of work based on a selection of priorities and options.

Impact

- Lowers the risks and costs of potential problems, providing savings on future engineering investigations by providing evaluation methods and field-proven solution methodologies
- Reduces the possibility of humans and animals experiencing perceptible levels of elevated voltage at potential contact locations
- Enhances members' ability to comply with existing or anticipated regulatory limits related to stray voltage

How to Apply Results

Project members can use this work to develop comprehensive methodologies and processes for handling customer complaints and regulatory inquiries about elevated NEV and urban stray voltage; prioritize and standardize the means by which they repair or provide mitigation solutions for identified voltage concerns and how they support customer-initiated remediation; and develop training tools and standardized investigation procedures for their staff that result in a well-defined, structured process from the initial complaint to final follow-up.

2010 Products

Product Title & Description	Planned Completion Date	Product Type
NEV and other Contact Voltage Issues	12/31/10	Technical Report

PS128D Distribution Technology Transfer and Knowledge Development (065441)

Project Set Description

EPRI's Distribution Knowledge-Based Services cost-effectively support utility distribution engineering managers and staff with exclusive technical resources, training, and standards information. Members have access to the best distribution engineering expertise in the industry to deal with specific challenges in a timely manner and stay informed on key technical developments. The project includes:

- **Standards Exchange:** A web-based repository of utility design, operations, and maintenance standards in a default PDF format. Members can submit standards and access standards submitted by other utilities. All documents are accessible through a full-text search based on customized queries.
- **Member Forum:** A web-based forum for utilities, with topics covering any issue related to distribution system design and operations including equipment problems, maintenance strategies, application of equipment, reliability problems, and more. Members access the forum via website or e-mail. All messages can be queried with a search engine.
- **Updates on important new developments in the industry-standards community:** Updates on activities in IEEE standards development affecting distribution systems, including reliability standards, distribution equipment standards, and distribution operations standards.

Project Number	Project Title	Description
P128.007	Distribution Technology Transfer and Knowledge Development	EPRI's Distribution Knowledge-Based Services cost-effectively supports utility distribution engineering managers and staff with exclusive technical resources, training, and standards information. Members gain access to the best distribution engineering expertise in the industry to deal with specific challenges in a timely manner and stay informed on key technical developments.

P128.007 Distribution Technology Transfer and Knowledge Development (065442)

Key Research Question

Distribution companies face a variety of pressures and technical challenges. Utility planners, engineers, and operators must stay familiar with the latest technologies, software tools, standards, and procedures for optimizing distribution system performance. At the same time, many utilities are losing valuable experience as the aging workforce retires.

Approach

EPRI's Distribution Knowledge-Based Services cost-effectively support utility distribution engineering managers and staff with exclusive technical resources, training, and standards information. Members gain access to the best distribution engineering expertise in the industry to deal with specific challenges in a timely manner and stay informed on key technical developments. The project includes the following:

- **Distribution Hotline Access:** Members will have access to a distribution hotline, gaining quick-response access to EPRI's power system experts to help answer technical questions related to distribution

engineering, operations, and maintenance. Sanitized versions of hotline calls and responses will be available via a website.

- Member Forum: A web-based forum, with topics covering any issue related to distribution system design and operations such as equipment problems, maintenance strategies, application of equipment, reliability problems, and more. Members access the forum via a website. All messages can be queried via search engine.
- Updates on important new developments in the industry standards community: Updates on activities in IEEE standards development affecting distribution systems, including reliability standards, distribution equipment standards, and distribution operations standards.

Impact

- Increases the productivity and technical expertise of staff
- Represents members' interests with respect to standards development
- Provides cost-effective and timely updates on industry developments

How to Apply Results

Utility managers and staff can immediately use the knowledge provided by this program to improve distribution system design, maintenance, and troubleshooting practices. The service is provided through a standards exchange and member forum, which allows for easy access to knowledge, discussions, and expert staff.

2010 Products

Product Title & Description	Planned Completion Date	Product Type
Distribution Technology Transfer and Knowledge Development	12/31/10	Technical Resource