

## **128 Distribution Systems**

### **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 utilities 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 over the next 10 years and to assure that its research focus is aligned with those objectives. The strategic plan provides the basis for research in Distribution Systems (Program 128). As a result, the program has four project sets, structured as follows:

**Inspection and Assessment of Overhead Distribution Systems (PS128A):** 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 each year.

**Fault Anticipation, Analysis & Location (PS128B):** EPRI research in this program and utility implementation has shown that fault location can be used successfully to reduce repair and restoration times.

**Potential Electric Hazard Issue (PS128C):** 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.

**Distribution Technology Transfer and Knowledge Development (PS128D):** EPRI's Distribution Knowledge-Based Services cost-effectively supports utility distribution engineering managers and staff with exclusive technical resources, training, and standards information. Subscribers 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.

#### **Industry Needs and Issues Addressed**

- Ensure safety of utility workers and public
- Ensure increased reliability of distribution systems
- Reduce operations and maintenance (O&M) costs
- Reduce design and construction costs of new distribution systems
- Integrate high-performance components
- Accommodate aging assets

#### **Impact**

- Improved management of aging distribution system components
- Improved assessment tools and techniques
- Optimized equipment application guidelines to improve investment decisions
- Enhanced prediction of distribution fault locations

- Distribution system reliability improvement
- Managing risk of stray voltages and other issues facing distribution planners and operators

**Key Accomplishments**

- Distribution system component testing and application guides development
- Fault location technology development and field performance assessment
- Stray voltage issue understanding and support of standards development

**Current Year Objectives**

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

**Industry Involvement**

- Estimated 2009 funding: \$1.8M

**Program Technical Lead**

Matthew Olearczyk, 704-595-2257, molearcz@epri.com

**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 each 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 the 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.

The information gained from this work will be published in yearly test reports and also incorporated into a Distribution Component Reliability and Specification guidebook. This information will also be part of a broader knowledge base that contributes to distribution inspection guides, procurement guides, field books, and other training materials.

This project set also aims to reduce utility expenditures and improve system reliability related to vegetation-induced outages. These goals are met by providing the utility reader with information regarding optimized utility vegetation management (VM) practices.

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.

---

<b>Project Number</b>	<b>Project Title</b>	<b>Value</b>
P128.001	Component Reliability	Tools to optimize vegetation and wildlife management programs. Benefits include

---

Project Number	Project Title	Value
		<ul style="list-style-type: none"> <li>Enhanced system reliability</li> <li>Reduced operations and wildlife management expenditures</li> </ul>
P128.002	Vegetation Management	<ul style="list-style-type: none"> <li>Enhanced system reliability through reduced vegetation-related outages</li> <li>Reduced O&amp;M expenditures through optimized vegetation management processes and fewer vegetation-induced outages</li> </ul>
P128.003	Inspection and Assessment Technologies and Guidelines	Optimized distribution inspection technologies and procedures yield <ul style="list-style-type: none"> <li>Fewer service outages</li> <li>Improved power quality and reliability</li> <li>Reduced outage repair costs</li> </ul>

## Project Descriptions

### P128.001 Component Reliability (065443)

#### Issue

Distribution component reliability can be challenging for utilities to quantify, 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 moving forward and improve specification, purchasing, operation, and inspection criteria.

#### Description

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 each 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 the 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. The information gleaned from this work will be published in yearly test reports and also incorporated into a Distribution Component Reliability and Specification Guidebook. This information will also be part of a broader knowledge base that contributes to distribution inspection guides, procurement guides, field books, and other training materials.

#### Value

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. This information can be directly applied by utility personnel 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.

### 2009 Products

Product Title & Description	Planned Completion Date	Product Type
<b>Design of Overhead Distribution Systems – Component Reliability and Specification Guidelines: Cutouts:</b> This project will provide ongoing updates and expansions to the component reliability and specification guidebook as result of testing and evaluation projects prioritized by funders.	12/31/2009	Technical Update
<b>Design of Overhead Distribution Systems – Novel Approaches for Detecting Cracks in Porcelain Cutouts:</b> This guide will be updated annually based on new issues and priorities identified by funders.	12/31/2009	Technical Update
<b>Design of Overhead Distribution Systems - Pictorial Guide for Field Inspection of Porcelain and Polymer Cutouts</b>	12/31/2009	Technical Update

### Future Year Products

Product Title & Description	Planned Completion Date	Product Type
<b>Design of Overhead Distribution Systems – Component Reliability and Specification Guidelines: Capacitor Banks:</b> This project will provide ongoing updates and expansions to the component reliability and specification guidebook as result of testing and evaluation projects prioritized by funders. Components for future testing include	2010	Technical Update
<b>Design of Overhead Distribution Systems – Component Reliability and Specification Guidelines: Capacitor Banks:</b> This project will provide ongoing updates and expansions to the component reliability and specification guidebook as result of testing and evaluation projects prioritized by funders. Components for future testing include	2010	Technical Update

## P128.002 Vegetation Management (067464)

### Issue

Vegetation interactions with distribution systems are a leading cause of unplanned service interruptions for many utilities, causing both momentary and long-duration interruptions. Trees affect power delivery systems to such a degree that vegetation management is often the largest expenditure in a utility's operating and maintenance budget. It is essential that a utility's vegetation management programs operate as efficiently and effectively as possible.

### Description

This project focuses on reducing utility expenditures and improving system reliability related to vegetation-induced outages. These goals are met by providing the utility reader with straightforward information regarding optimized utility vegetation management (VM) practices. The guidebook will focus on Integrated Vegetation Management (IVM) in the distribution environment including: pruning practices and cycle optimization, hazard trees, tree growth regulators, herbicide chemistry and application, mechanical methods, and slash disposal. In addition to the fundamentals of performing utility VM, the guidebook will also examine the management of VM programs including: contracting, auditing VM work, rights-of-way, customer and public relations, and other issues of concern to utility arborists.

### Value

- Enhanced system reliability through reduced vegetation-related outages
- Reduced O&M expenditures through optimized vegetation management processes and fewer vegetation-induced outages
- Enhanced worker and public safety through optimized vegetation management processes

### How to Apply Results

The information compiled in the VM guidebook can be used directly by utility personnel involved in their company's vegetation management program. This information will be useful both for applying sound VM practices and for properly managing all aspects of a VM program. The goal of this work is to provide utility personnel with a one-stop source for concise information pertaining to all aspects of distribution-level vegetation management.

### 2009 Products

Product Title & Description	Planned Completion Date	Product Type
<b>Distribution Vegetation Management Guidebook; Integrated Vegetation Management</b>	12/31/2009	Technical Update

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

### Issue

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 that utilities can use to reduce failures on their circuits and minimize customer outages. By identifying problems for repair before they develop into failures, inspection programs can be a cost-effective method for enhancing the quality and reliability of electric service.

### Description

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.

The information learned from this work will be published in yearly technical reports and also incorporated into a Distribution Circuit Inspection and Assessment Guidebook. This information will also be part of a broader knowledge base that contributes to distribution inspection field guides, procurement guides, and other training materials.

### Value

Optimized distribution inspection technologies and procedures yield the following:

- 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. This information can be directly applied by utility personnel 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.

### 2009 Products

Product Title & Description	Planned Completion Date	Product Type
Distribution Circuit Inspection and Assessment	12/31/2009	Technical Update
Infrared Inspection Guide	12/31/2009	Technical Update

### PS128B Fault Anticipation, Analysis & Location (067428)

#### Project Set Description:

EPRI has developed and tested systems to make fault location systems easier for utilities to install and use. Such systems allow operators to view an estimated location of a fault, which helps operators direct crews to do switching and locate faults faster. The main goal in 2009 is to see if it is possible to extend the capabilities of those systems.

Project Number	Project Title	Value
P128.004	Distribution Fault Location and Characterization	<p>Helps utilities implement widespread fault-location systems. Benefits include</p> <ul style="list-style-type: none"> <li>Improved restoration time for dramatically enhanced system average interruption duration index (SAIDI) and customer average interruption duration index (CAIDI)</li> <li>Improved storm response and repair times</li> <li>Reduced repeated momentary faults</li> <li>Reduced susceptibility to cascading failures</li> <li>Evaluation of the potential to locate incipient faults using fault location algorithms</li> </ul>

## Project Descriptions

### P128.004 Distribution Fault Location and Characterization (062119)

#### Issue

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.

### Description

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

The main goal in 2009 is to see if it is possible to extend the system capabilities to include the following:

**Fault precursor location:** Previous EPRI work on the distribution fault anticipator (DFA) has found that it is possible to identify many types of precursors that indicate future full equipment failures. One common type of precursor is a half-cycle blip that is common when splices fail, and it is also seen in other failures, like arresters. This project will merge work done on DFA signature identification with other work done on location. Preliminary work indicates that it might be possible to locate some of these precursors to failure. This task will use fault data provided by utilities and data from the DFA project to evaluate different algorithms to see if it is possible to locate these blips accurately.

**Waveform signatures:** Certain faults likely have common waveform signatures. EPRI will use the fault data provided by utilities to see if fault cause or equipment failure type can be determined. Is it possible to distinguish splices from cables on underground systems? How about trees versus animals on an overhead system? Some waveform characteristics that may help provide distinctions include phasing, arcing, current-zero spikes, noise, and others. These waveform characteristics, along with time of day and season, could be used with pattern classification approaches, which may allow for a strong estimate of fault type.

The project will also continue to investigate other ways to improve existing substation-based fault location and explore ways to use other metering data to locate faults.

### Value

- Improve restoration time for dramatically 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
- Provide locations to 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 provides a user interface for operators.

### 2009 Products

Product Title & Description	Planned Completion Date	Product Type
Distribution Fault Location and Characterization	12/31/2009	Technical Report

## PS128C Potential Electric Hazard Issues (067429)

**Project Set Description:** 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 2009 is twofold. First, the project will continue to provide research that enhances the state-of-the-art in 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 workscope based on a selection of priorities and options.

Project Number	Project Title	Value
P128.005	NEV and Urban Stray Voltage Issues and System Design	<p>Promotes standardized methods and effective solutions for identifying and dealing with NEV levels and energized metallic object concerns. Benefits include</p> <ul style="list-style-type: none"> <li>• Lowers risks and costs of potential problems</li> <li>• Reduces the possibility of humans and animals experiencing perceptible levels of elevated voltage</li> <li>• Enhances capability to comply with existing or anticipated regulatory limits</li> </ul>

## Project Descriptions

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

#### Issue

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 area with a wide range of concerns and issues involving regulators, transmission companies, distribution companies, and their customers.

#### Description

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 2009 is twofold. First, the project will continue to provide research that enhances the state-of-the-art in 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 subject matter. As in previous years, contributors will prioritize the final workscope based on a selection of priorities and options.

#### Value

- Lowers risks and costs of potential problems, providing substantial savings on future engineering investigations by providing evaluation methods and field-proven solution methodologies
- Reduces possibility of humans and animals experiencing perceptible levels of elevated voltage at potential contact locations
- Enhances capability 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/or the way 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.

### 2009 Products

Product Title & Description	Planned Completion Date	Product Type
<b>Elevated NEV and Urban Stray Voltage Guidebook Updates:</b> Guidebook material is intended to document the state-of-the-art in all aspects of contact voltage concerns. Subject matter will include evaluation processes, modeling and simulation examples and recommendations, mitigation technologies and case studies, and recommendations on new distribution system design optimization.	12/31/2009	Technical Report
<b>Elevated NEV and Urban Stray Voltage Website Updates:</b> Web materials are intended to provide credible and unbiased understanding of the subject matter to support investigation and remediation of contact voltage complaints. Included are public domain tutorials, IEEE published documents, and case studies to support various types of concerns.	12/31/2009	Technical Resource

### 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. Subscribers 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 a website or email. 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	Value
P128.006	Overhead Distribution Technology Transfer and Knowledge Development	<p>Provides distribution engineering expertise in the form of technical resources, training, and standards information. Benefits include the following:</p> <ul style="list-style-type: none"> <li>Increases productivity and technical expertise of utility staff</li> <li>Represents utility interests with respect to standards development</li> <li>Provides cost- and time-effective updates on industry developments</li> <li>Provides hotline services for direct support of utility distribution engineers on specific problems and issues</li> </ul>

## Project Descriptions

### **P128.006 Overhead Distribution Technology Transfer and Knowledge Development (065442)**

#### **Issue**

Distribution companies face a variety of pressures and technical challenges. Personnel such as utility planners, engineers, and operators must keep up to date with the latest technologies, software tools, standards, and procedures for optimizing distribution system performance.

#### **Description**

EPRI's Distribution Knowledge-Based Services cost-effectively supports utility distribution engineering managers and staff with exclusive technical resources, training, and standards information. Subscribers 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 a website or email. 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.

#### **Value**

- Increases productivity and technical expertise of utility staff
- Represents utility 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.

### **2009 Products**

---

<b>Product Title &amp; Description</b>	<b>Planned Completion Date</b>	<b>Product Type</b>
<b>Subscription to EPRI's Distribution Knowledge-transfer electronic publications and resources (see above)</b>	12/31/2009	Technical Update

---