

TRANSFORMER SURGE ARRESTER AGE ASSESSMENT AND PROACTIVE REPLACEMENT PROGRAM

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2024

91 YEARS

91ST International
Conference of Doble Clients



Agenda

- Arrester Fun Facts
- Surge Arrester Failure Causes
- 'The 5 Whys' Analysis
- Case studies
- Surge Arrester Life Expectancy
- LCRA Transformer Surge Arrester Replacement Program
- Overcoming Challenges
- Project Examples
- LCRA SAIFI and SAIDI Metric Improvements
- Benefits & Quality Statement

What is a Surge Arrester?



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Images sourced from a Hubbell Catalogue

Surge Arrester Fun Facts

- Arguably the single most important asset.
- Limits voltage on equipment by discharging or bypassing surge current to the ground protecting the equipment installed in parallel.
- Diverts the lightning. Does NOT stop or absorb lightning.
- Looks like an insulator, and acts like an insulator under a normal condition.
- Looks like an insulator, and acts like a conductor under a voltage surge event.
- Surge Arrester can experience failures outside of voltage surge events.
- Surge Arresters have expected service life (not immortal).
- Surge Arrester does NOT always protect, but it can cause failures of equipment it's trying to protect.

AT1 Arrester Venting Damages Bushings

H3 Bushing



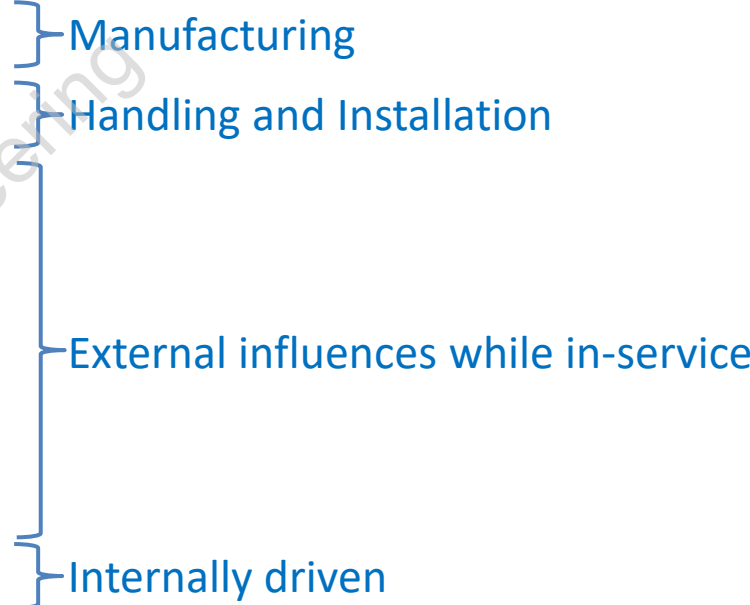
Arrester for H2



H1 Bushing



Surge Arrester Failure Causes

- Manufacturing Defects
 - Damage from Shipping and Mishandling
 - Lightning Surges
 - Temporary Overvoltages
 - Switching Surges
 - External Contamination
 - Wildlife Contact
 - Moisture Ingress
- Manufacturing
- Handling and Installation
- External influences while in-service
- Internally driven
- 
- The diagram uses blue brackets on the right side of the list to group the failure causes into four categories: 'Manufacturing' (covering Manufacturing Defects), 'Handling and Installation' (covering Damage from Shipping and Mishandling), 'External influences while in-service' (covering Lightning Surges, Temporary Overvoltages, Switching Surges, External Contamination, and Wildlife Contact), and 'Internally driven' (covering Moisture Ingress).

Not All Surge Arrester Failures are 'BAD'

- Manufacturing Defects
 - Damage from Shipping and Mishandling
 - Lightning Surges
 - Temporary Overvoltages
 - Switching Surges
 - External Contamination
 - Wildlife Contact
 - Moisture Ingress
- Surge arrester served its purpose

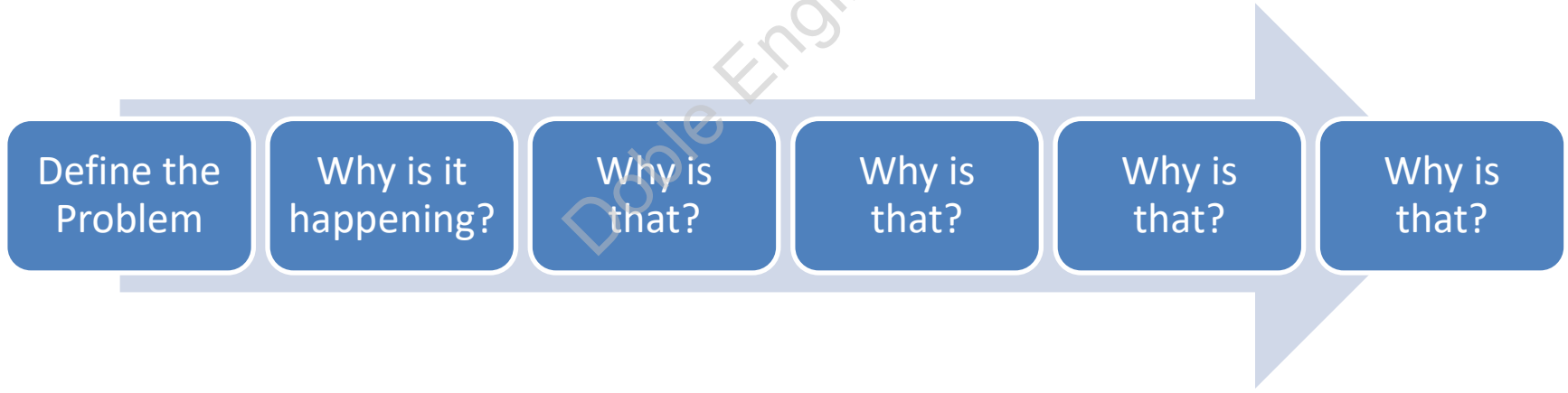
What is the Leading Cause of Surge Arrester Failures?

- Manufacturing Defects
- Damage from Shipping and Mishandling
- Lightning Surges
- Temporary Overvoltages
- Switching Surges
- External Contamination
- Wildlife Contact
- Moisture Ingress

} Internally driven

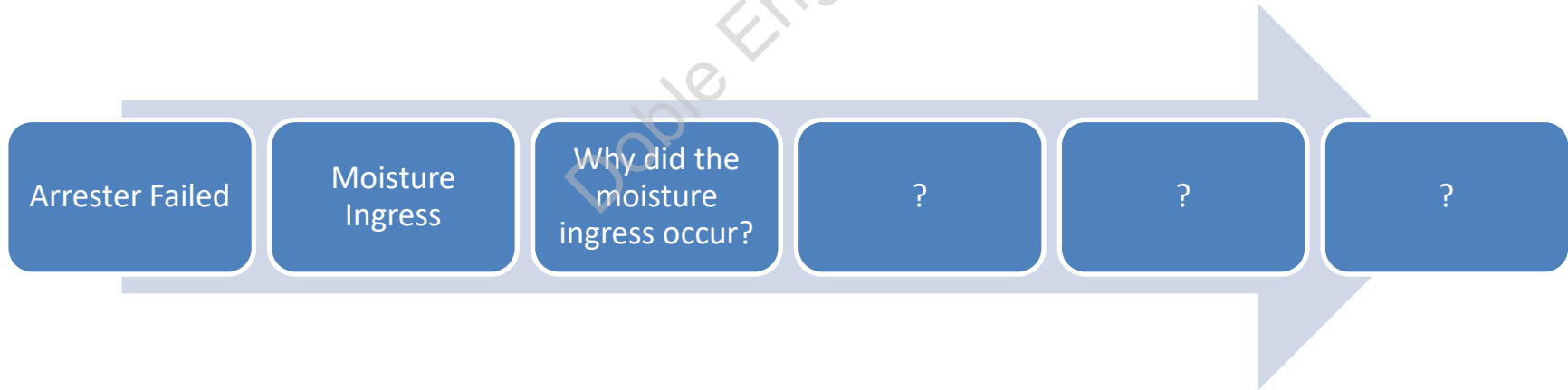
The 5 Whys

- FACT : Sometimes things go wrong.
- Sometimes you need more than a quick fix.
- The 5 Whys by asking why 5 times to find the root cause of your problem.



The 5 Whys – Moisture Ingress in Arrestor

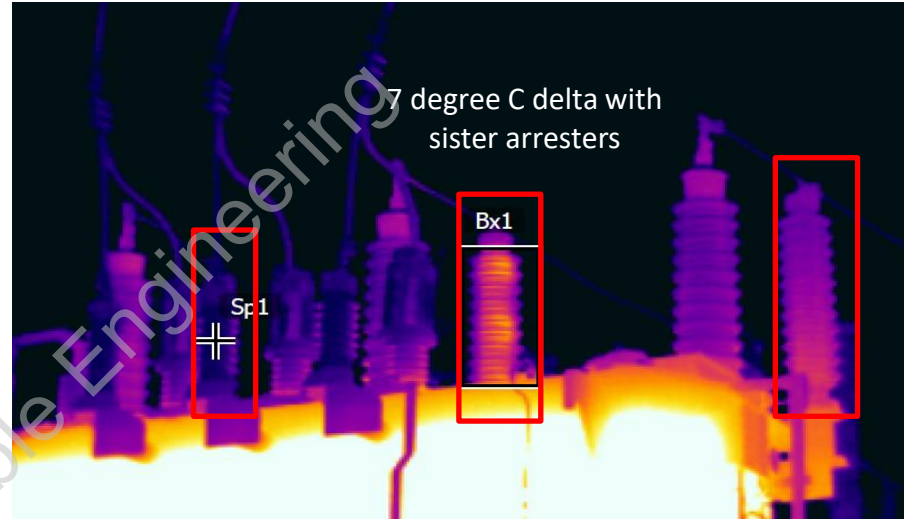
- **Why** does a surge arrester experience moisture ingress?
- **What** is the mechanism allowing moisture ingress?
- **When** does a surge arrester experience moisture ingress?
- **Can** we prevent surge arrester failures due to moisture ingress?



Case Study 1: Transformer Surge Arrester with a Hot Spot

Infrared Imaging Program

The surge arrester was 24 years old.
All three surge arresters were replaced.



General Electric	88507	98.000	GND RB	10.000	0.205	0.058	GOOD
General Electric	88507	98.000	GND RB	10.000	0.997	8.916	BAD



3rd Party Arrester Failure Forensics Service



Rusted components from moisture



Electrical tracking along the MOV Blocks



Figure 10 Arrester top diaphragm outside showing location of crack found with red die.



Dye test confirmed an opening at the top diaphragm

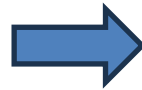
Root Cause Analysis



Figure 10 Arrester top diaphragm outside showing location of crack found with red die. .

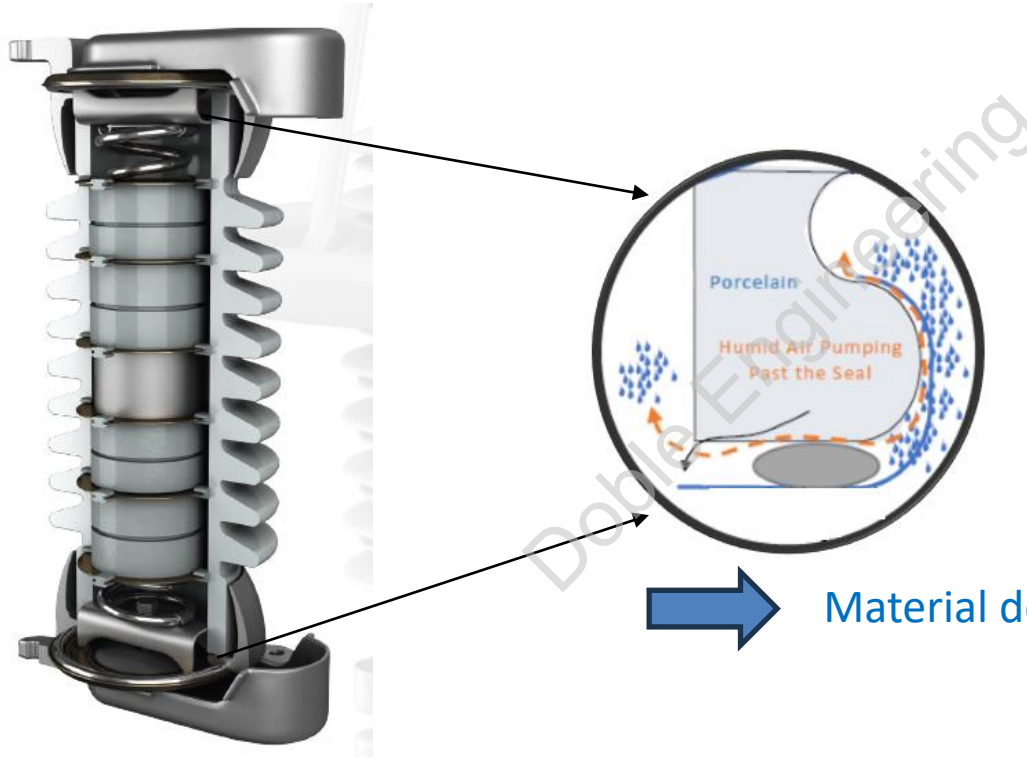


The diaphragm failure is likely due to daily and seasonal temperature/pressure cycle resulting in a mechanical fatigue failure after 24 years.



material deterioration over time

Other Mechanism Leading to Moisture Ingress

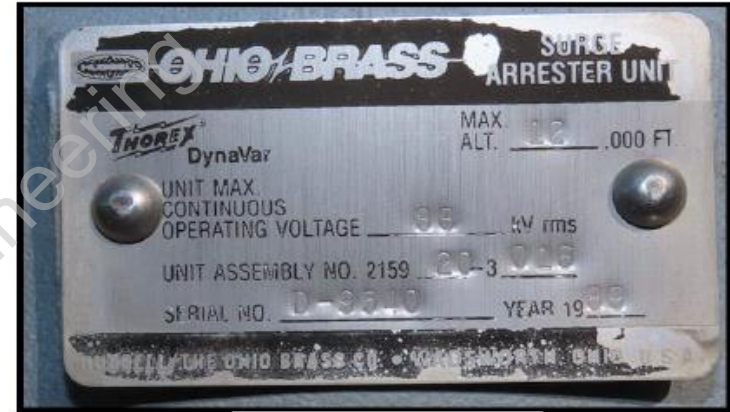


- Lost elasticity
- Cracking
- Embrittlement
- Seal failure

Material deterioration over time

Case Study 2 : What is the Failure Commonality?

LCRA experienced repeated surge arrester failures on nine autotransformers on clear days. Failures occurred between 26 and 29 years in age.

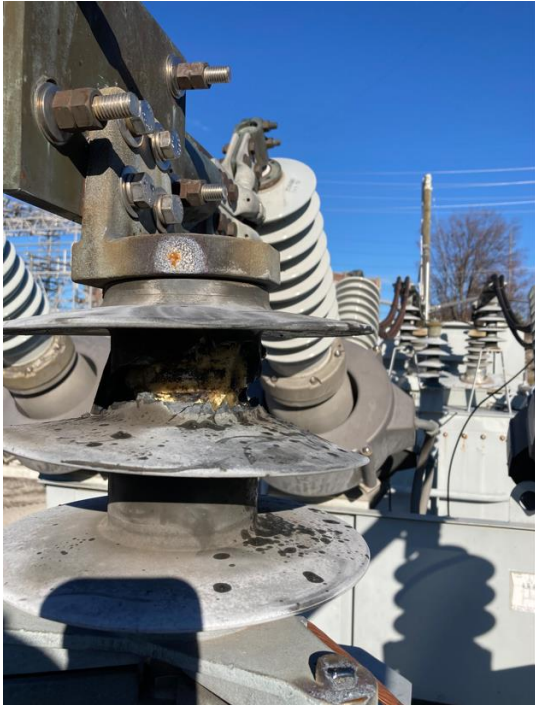


Serial Number? or Age?



Possible material deterioration over time

Case Study 3: Mobile Transformer Failure



- 28-year-old B-phase 8.4-kV MCOV lowside arrester faulted
- LV fault current became 3-phase fault in the HV side
- Transformer main tank pressure relief device operated
- Offline test concluded a complete winding failure

So...how old is too old?

Surge Arrester Service Life

- Surge arrester manufacturers (GE, Ohio Brass and ABB) estimate the expected life of surge arresters to be between 25 and 30 years
- LCRA's surge arrester failure history aligns with the MFG suggested life expectancy
- Silicon carbide surge arrester technology became obsolete from the industry 30 to 40 years ago due to reliability concerns; MOV surge arrester technology became the industry-dominant choice that replaced the obsolete surge arrester technology

Key points :

- MOV surge arresters are designed to last 25 to 30 years.
- Oldest in-service MOV surge arresters are 30+ years old in electric power industry.
- Old MOV surge arresters will likely experience moisture ingress and inevitably fail in service if surge arrester life cycle is unmanaged.

Transformer Surge Arrester Replacement Program



Goal :

Reduce/eliminate unplanned transformer outages caused by surge arresters

Plan :

- Conduct a transformer surge arrester age assessment
- Initiate a proactive surge arrester replacement program based on the age

Challenge :

- Insufficient data for surge arrester age assessment
 - Surge arresters weren't always documented as an asset.
 - No MFG date field in Surge Arrester Doble DTA (will be fixed in the next update)
- Transformer outages needed to replace arresters often require mobile support that can substantially increase the overall project cost

Overcoming Challenges



Lack of Surge Arrester Age Data :

- LCRA had all transformer surge arrester test records as part of Doble Transformer test files
- Doble test data does not include surge arrester MFG date. **However**, the first arrester test date provided an estimation on arrester MFG date
- Similar asset number / serial number assessment also provide a reasonable age estimation

Project Coordination :

- The project is integrated with the routine transformer six-year preventive maintenance to eliminate the need for additional mobile installs.

Annual Project Implementation

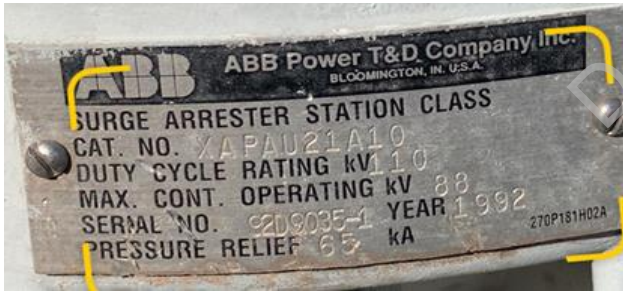
- Identified all surge arrester age data on 175 LCRA-owned transformers.
- Updated transformer surge arrester age field in our asset management tool.
- LCRA executed the 1st annual transformer surge arrester replacement project in 2022.

Artificial substation names using Texas Slangs	AUTO/PWT	SA Age	SA Location
Fixin	AUTO	44	SA8 (88MCOV)
Heart	PWT	30	SA4 (88MCOV)
Git	PWT	30	SA3 (88MCOV)
Howdy	PWT	26	SA15 (88MCOV)
Y'all	PWT	33	48kv, 8.4kv, 2.55kv MCOV
Icebox	PWT	27	SA10 (88MCOV)
All hat and no cattle	PWT	29	SA1 (88MCOV)
Might could	PWT	24	SA2 (88MCOV)
Lit	PWT	27	SA2 (88MCOV)
Whup	AUTO	39	SA2 (88kv MCOV), SA4(48kv MCOV), and SA5(15.3kv MCOV)
Right quick	PWT	29	SA1 (88MCOV)
Skeeters	PWT	29	SA1 (88MCOV)

Project Execution Examples



Replaced nine 39-year-old surge arresters.



Replaced three 30-year-old surge arresters.

Nine 53-year-old Silicon Carbide Surge Arresters

High-side SA



Low-side SA



Tertiary SA



Annual Project Closeout Records



FY 2022 - 48 surge arresters replaced from 12 transformers

FY 2023 - 16 surge arresters replaced from 6 transformers

FY 2024 – 33 surge arresters replaced from 4 transformers

FY 2025 – Pending annual project initiation

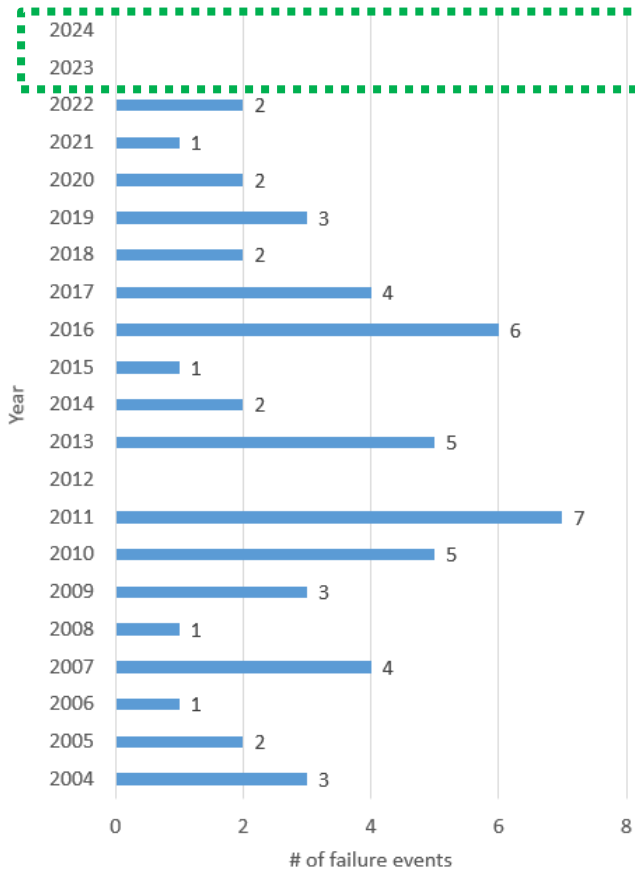
Replaced **97** transformer surge arresters from **22** transformers in three years



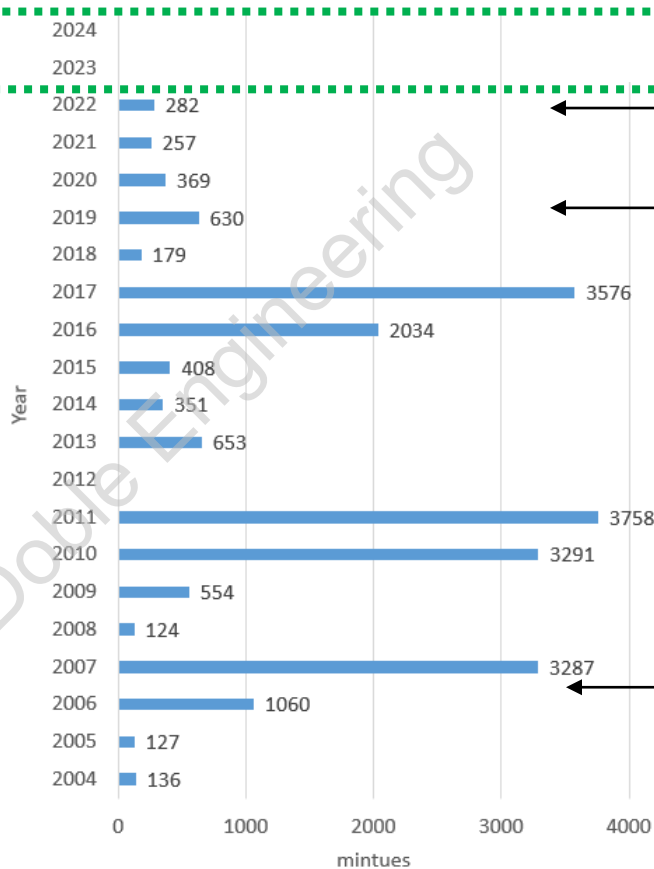
LCRA SAIFI Metric Raw Data

LCRA SAIDI Metric Raw Data

Transformer Surge Arrester Failure Events



Transformer Outage Duration



Transformer SA replacement program Implementation

New practice implemented to replace SA as a set

30 years from the first MOV surge arrester introduction

Benefits and Results

Benefits/Savings

- Improved grid reliability through arrester failure prevention on LCRA transformers
- Value-added activity focusing on customers
- Low-dollar, high-impact approach. SAIDI and SAIFI metric improvements.
- Optimized coordination does not require mobile substation for the project.

Results/Quality Statement

- Replaced 97 surge arresters from 22 transformers in 3 years
- LCRA is approaching two consecutive years without a transformer arrester failure.

Q & A



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