TRANSFORMER SURGE ARRESTER AGE ASSESSMENT AND PROACTIVE REPLACEMENT PROGRAM

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ABSTRACT

Leading surge arrester manufacturers estimate the expected life of surge arresters is between 25 and 30 years, primarily due to moisture ingress problems. LCRA's experience aligns with the manufacturers' suggested life expectancy on surge arresters. Silicon carbide surge arrester technology, once prevalent, became an obsolete technology for the industry approximately 30 to 40 years ago due to reliability concerns. As a result, MOV surge arrester technology became the industry's preferred choice. But now the electric power utility industry is experiencing unplanned arrester failures and fault events from aging MOV surge arresters that have exceeded expected service life. This paper outlines LCRA's proactive replacement program for these surge arresters.

INTRODUCTION

The surge arrester is arguably the single most important asset, designed to limit voltage on equipment by discharging or bypassing surge current to the ground, thus protecting the equipment installed in parallel. It functions as an insulator under normal conditions and as a conductor during voltage surges. Surge arrester failure has many causes. It is important to note that not all surge arrester failures are detrimental, as some occur as the arrester sacrifices itself to protect other assets. However, arresters can sometimes contribute to the very equipment failures they are meant to prevent. This paper explores surge arrester failure causes and reviews strategies to mitigate transformer surge arrester failures.

H2 Arrester Venting Event Caused H1 and H3 Bushing Failures
Figure 1

SURGE ARRESTER FAILURE CAUSES

Surge arrester failures can occur from various causes.

- manufacturing defects
- damage from shipping and mishandling
- external influences while in service
    - lightning surges
    - temporary overvoltages
    - switching surges
    - external contamination
    - wildlife contact
- internally driven moisture ingress

Surge arrester failures due to voltage surge events may deserve positive recognition because they are externally driven and demonstrate how surge arresters can perform a protective role. However, surge arrester failures due to moisture ingress require more examination because the moisture ingress is internally driven and can lead to self-destructive behaviors.

APPLYING “THE 5 WHYS” ANLAYSIS TO THE MOISTURE INGRESS PROBLEM

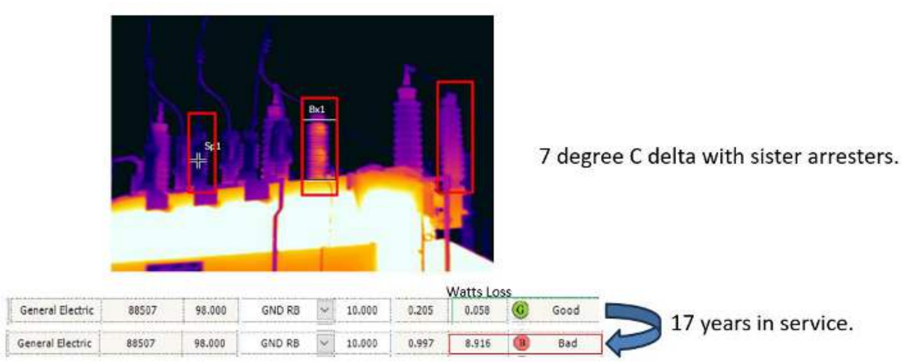
Moisture ingress is the leading cause of surge arrester failures. Using “The 5 Whys” analysis [1], a technique developed by Toyota in the 1930s, can help identify the root causes and contributing factors of this problem. The analysis takes a simple approach by asking ‘why’ five times to get to the root cause.

Here are questions generated using “The 5 Whys” analysis:

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

Case Study 1: Transformer Surge Arrester with a Hot Spot

LCRA replaced three surge arresters due to thermography inspection abnormalities. A Doble watts loss test showed major concerns on one of the surge arresters (Figure 2).



Thermography and Watts Loss Tests for a 24-year-old Surge Arrester
Figure 2

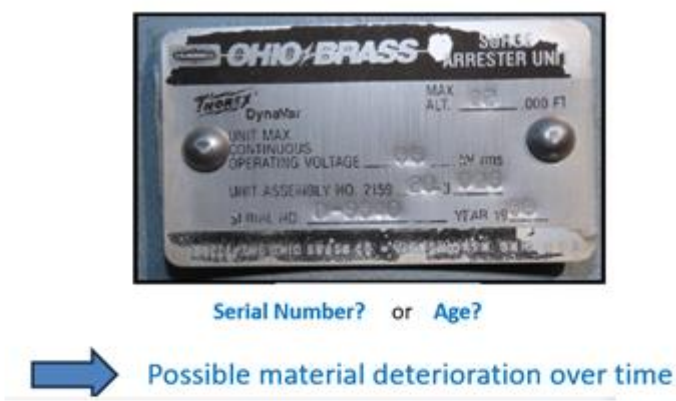
Rusted components from moisture. Electrical tracking along the MOV Blocks Red dye penetrated through the top diaphragm.

Moisture Ingress in a 24-year-old Surge Arrester
Figure 3

Failure analysis concluded that the top diaphragm had a fatigue failure, allowing the moisture to be presented in the surge arrester (Figure 3). Material deterioration took place over the life of the surge arrester (24 years).

Case Study 2: Surge Arrester Failure Commonalities

LCRA experienced in-service transformer arrester failures with commonalities in serial number and model number. Nine autotransformers had surge arrester failures on clear days. The transformer surge arrester failures occurred between 26 and 29 years in age. LCRA believes the MOV surge arrester failures were due to equipment age and material failure, which occurs near the end of service life.



Repeated Venting Events Between 26- and 29-year-old Surge Arresters
Figure 4

SURGE ARRESTER SERVICE LIFE

Leading surge arrester manufacturers (GE, Ohio Brass, and ABB) estimate the expected life of surge arresters to be between 25 and 30 years, predominantly due to moisture ingress. LCRA experience aligns with the manufacturer suggested life expectancy on surge arresters. Silicon carbide surge arrester technology became obsolete for the industry about 30 to 40 years ago due to reliability concerns, and that's when MOV surge arrester technology became the industry-dominant choice. After 30 years, many of LCRA's in-service surge arresters have surpassed the suggested life expectancy. Without a proactive replacement program, LCRA could experience sporadic surge arrester failures that negatively affect our operations and reliability metrics (SAIFI and SAIDI). Surge arrester failures can also result in subsequent asset failures. The risk is elevated for surge arresters on in-service power and autotransformers because transformer bushings are close to the surge arresters.

Vision, Plan and Challenges

LCRA created a vision to reduce/eliminate unplanned transformer outages from surge arrester failures. However, our plan to perform a transformer surge arrester age assessment and begin a proactive surge arrester replacement program faced the following challenges:

- Insufficient data for surge arrester age assessment. Internal asset management did not have reliable age data to support the assessment. In other words, there was no Year of Manufacture field in Doble Test Assistant (DTA) software for surge arresters.
- Transformer outage often requires a mobile support, significantly increasing the project cost.

Overcoming the Challenges

Missing Surge Arrester Age Records:

- Since DTA does not include a field for the year of manufacture for surge arresters, the first arrester test date can provide an estimate of its age.
- Similar asset number or serial number assessment can also provide a reasonable age estimate.

Reducing Cost through Coordination Optimization:

- The LCRA transformer preventive maintenance interval is every six years. Some transformers will experience planned outages each year for routine maintenance.
- Transformer surge arrester replacement can be coordinated during a routine transformer PM (every six years) for efficiency and cost optimizations.

ANNUAL PROJECT IMPLEMNETATION

In 2022, LCRA initiated its first annual transformer surge arrester replacement project, updating estimated manufacture dates in our asset management system and addressing reliability risks in our transformer surge arrester fleet. Our assessment found many in-service transformer surge arresters that were past expected end of life and were reliability risks for LCRA TSC if no action was taken.

Table 1
Recommended Test Voltages

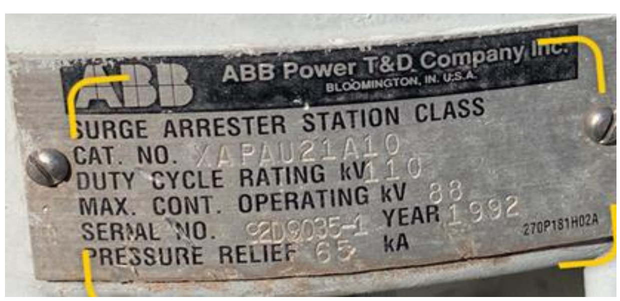
Artificial substation names using Texas Slangs	AUTO/PWT	SA Age	SA Location
Fixin	AUTO	44	SA8 (88MCOV)
Heart	PWT	30	SA4 (88MCOV)
Git	PWT	30	SA3 (88MCOV)
Howdy	PWT	26	SA15 (88MCOV)
Y'all	PWT	33	48kV, 8.4kV, 2.55kV MCOV
Icebox	PWT	27	SA10 (88MCOV)
All hat and no cattle	PWT	29	SA1 (88MCOV)
Might could	PWT	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 Closeout Records

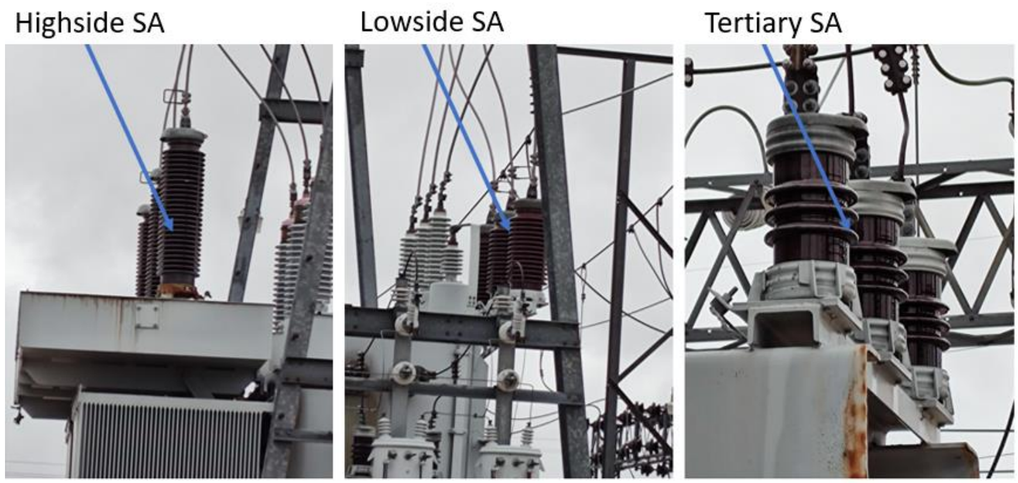
LCRA replaced 97 transformer surge arresters from 22 transformers in 3 years.

- FY2022 – 48 surge arresters replaced from 12 transformers
- FY2023 – 16 surge arresters replaced from 6 transformers
- FY2024 – 33 surge arresters replaced from 4 transformers
- FY2025 – Pending annual project initiation

Replaced Nine 39-year-old Surge Arresters
Figure 5



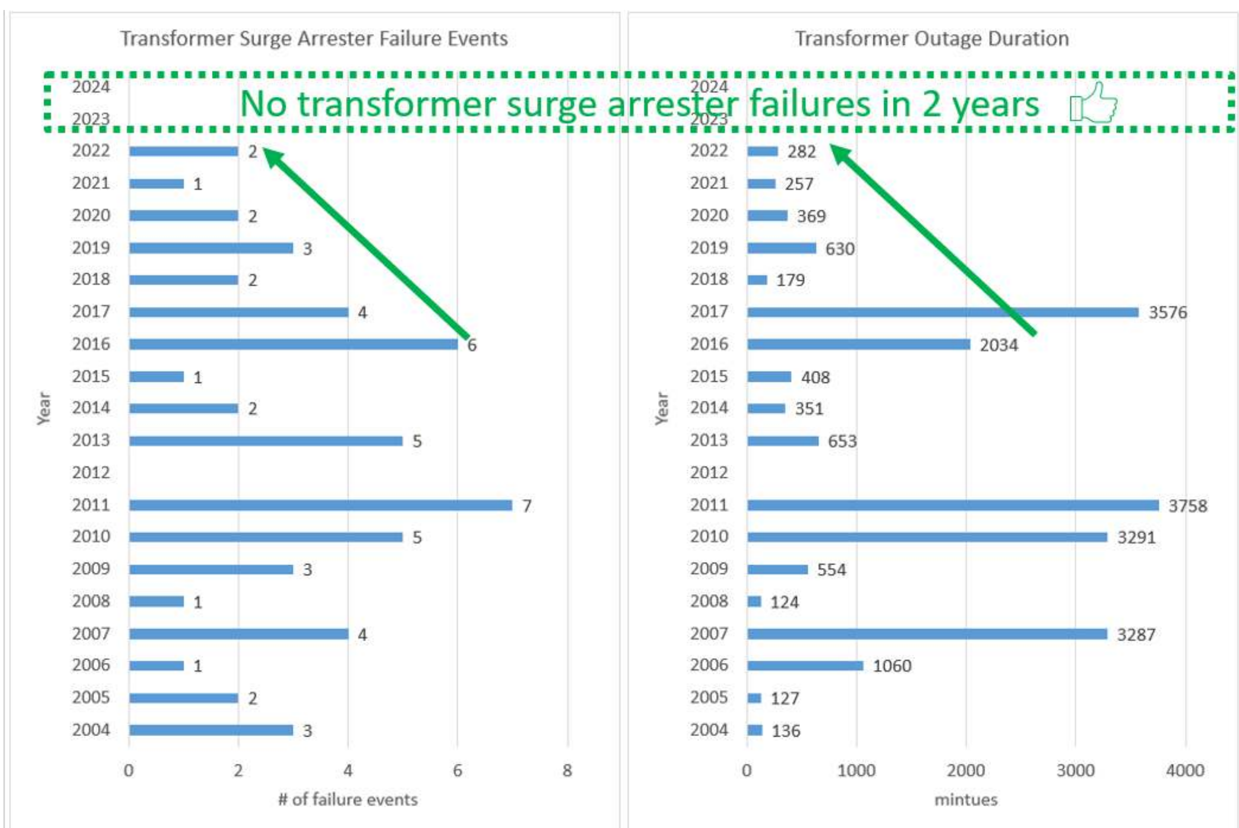
Replaced Three 30-year-old Surge Arresters
Figure 6



Replaced Nine 53-year-old Silicon Carbide Surge Arresters
Figure 7

Project Benefit Evaluation

LCRA experienced the first two consecutive years without a transformer surge arrester failure in 20 years.



LCRA Transformer Outage Durations Due to Surge Arrester Failures, 2004 - 2024
Figure 8

Benefits & Results

- Improved grid reliability through surge arrester failure preventions on our 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.
- Replaced 97 transformer surge arresters with high reliability risks from 22 transformers in three years.
- Two consecutive years without an unplanned transformer surge arrester failure.

CONCLUSIONS

Surge arresters play a critical role in protecting electrical infrastructure, but are susceptible to failure due to externally and internally driven causes. Proactive replacement programs, based on end-of-service-life assessments and coordinated with routine maintenance, can prevent unplanned transformer outages and equipment damage, and offer significant benefits to utility owners.

REFERENCES

[1] Article, "Five Whys," *Wikipedia*, https://en.wikipedia.org/wiki/Five_whys

BIOGRAPHY

Nick Choi has been employed at the Lower Colorado River Authority since 2015. He is a Substation Maintenance Engineer and a Licensed Professional Engineer in the state of Texas. He earned a B.S. in Mechanical Engineering from the University of Illinois at Urbana-Champaign. He is serving as the Chair of Doble Engineering's ACCA Committee.