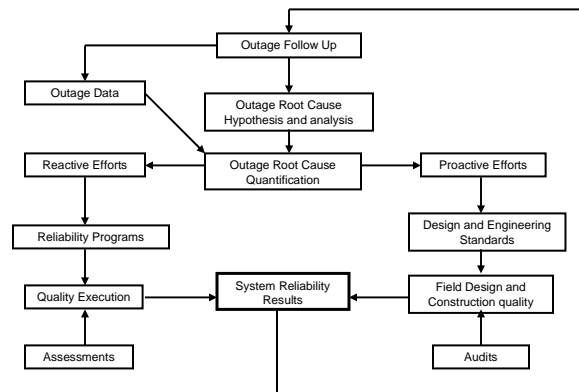




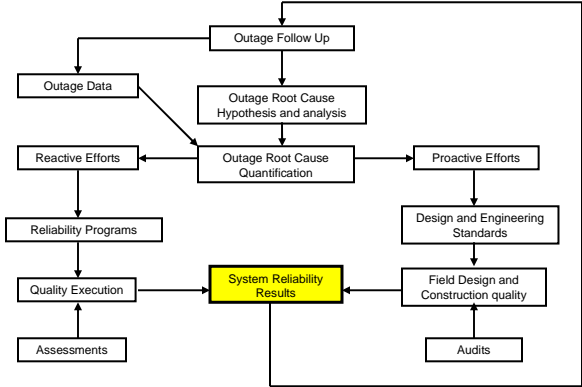
Construction Quality Assurance

Lee Taylor – Consulting Engr - Duke Energy
2008 IEEE T&D Conference and Exposition
April 23, 2008 - Chicago, Illinois

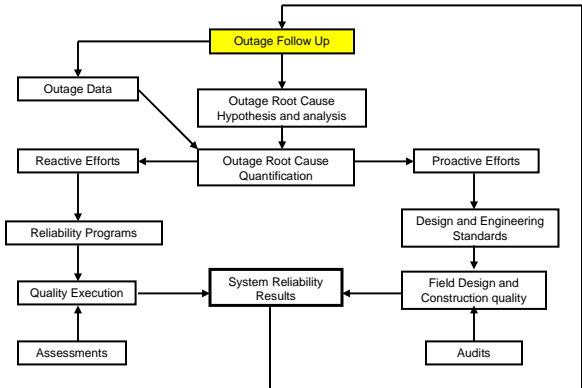
Distribution Reliability



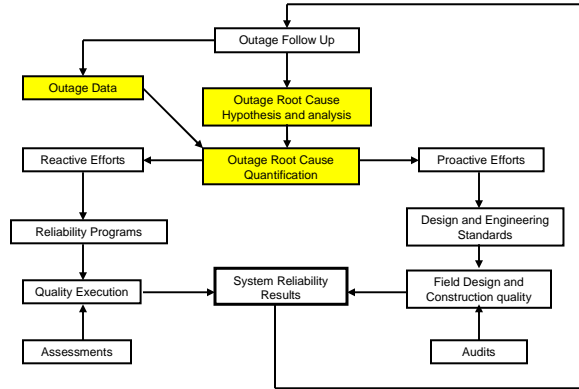
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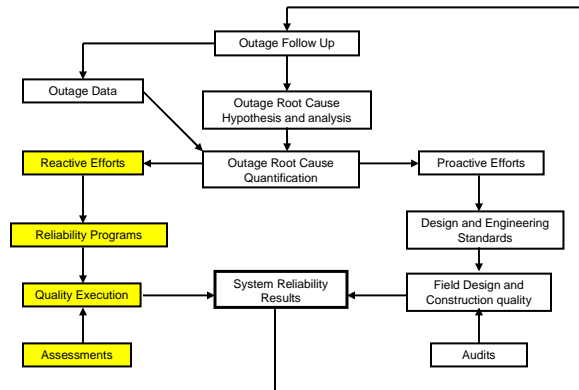
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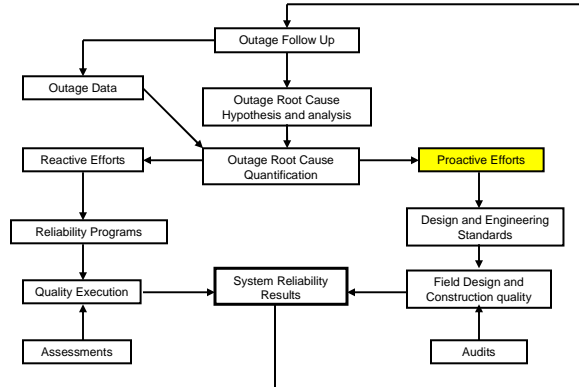
Distribution Reliability



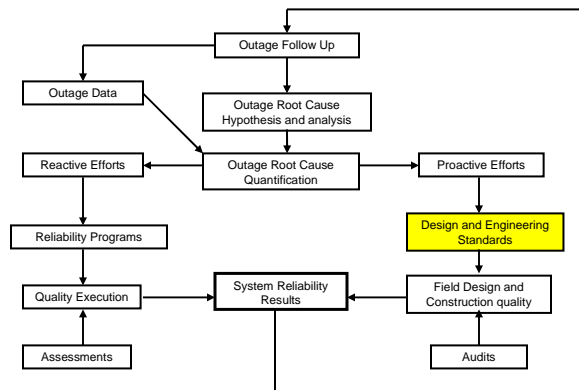
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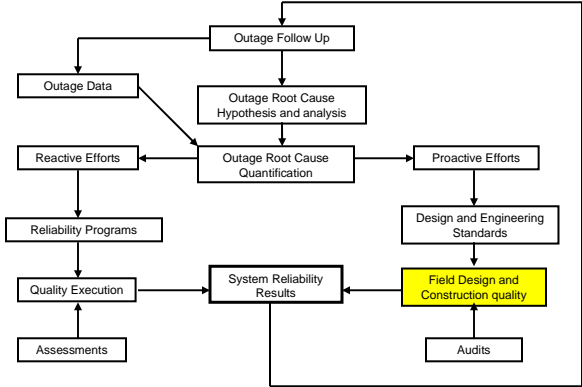
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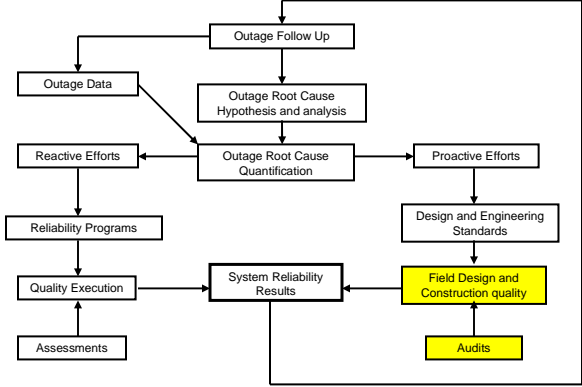
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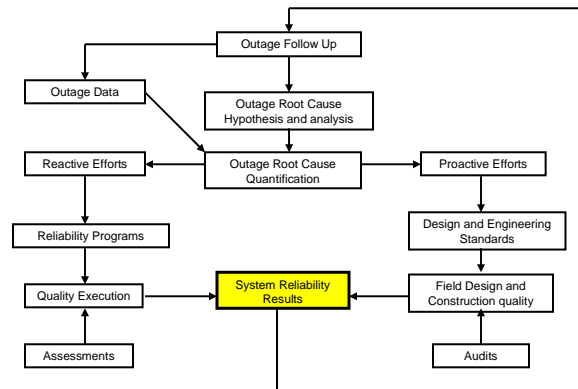
Distribution Reliability



Distribution Reliability



Distribution Reliability



New and Improved Construction Techniques?? – NOT EASY

- Mean time to failure of a construction error that causes a customer interruption...
-is eleven years (DE).
- Objective evidence (inspection) is the only way to determine if the system is being built correctly.
- Establish accountability, penalties.
- Independent auditors required.
- Not negotiable.

The Long Road to Construction Quality

- Anecdotes and Hypothesis -1985 to 1995
- Quantification – 1996
- Action Taken – 1999
- Sustainment and Culture– 2000 to 2005
- New Challenges in 2006 – Merger and Acquisition

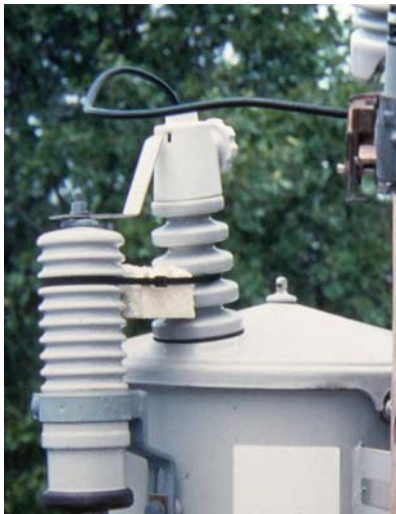
Anecdotes and Hypothesis

1985 to 1995

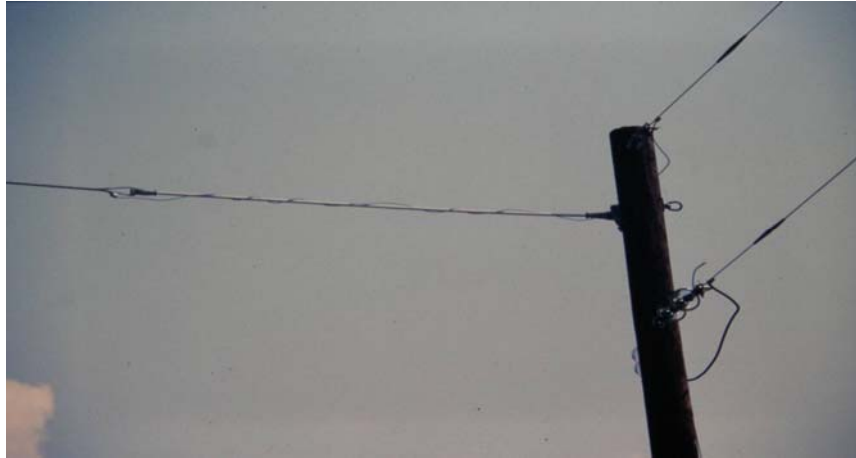
“How do you like these low cost, primary dead-ends?”



“Here’s a time saver – just leave the packing material and keep going.”



“I’m going to bond that guy wire,
no matter what.”



“I can fix anything with a hard
head.”



“This plastic thing they sent is a lot less expensive than an insulated plug!”



1996 - Quantification

- Central, Process Organization created.
- Management creates initiative to determine the top five root causes of outages.
- Task force of reliability experts investigates several hundred outage sites in the field to determine all the root causes.
- Errors in new construction is found to be one of the top five.

Failed to install animal guard on lightning arrester.



The same error causes and outage on an entire feeder.



Failed to remove bonded ground wire at top of pole.



Same error killed this cat.



Failed to install animal guard on transformer bushing.



Failed to install fuse and animal guard on transformer when set up on pole.



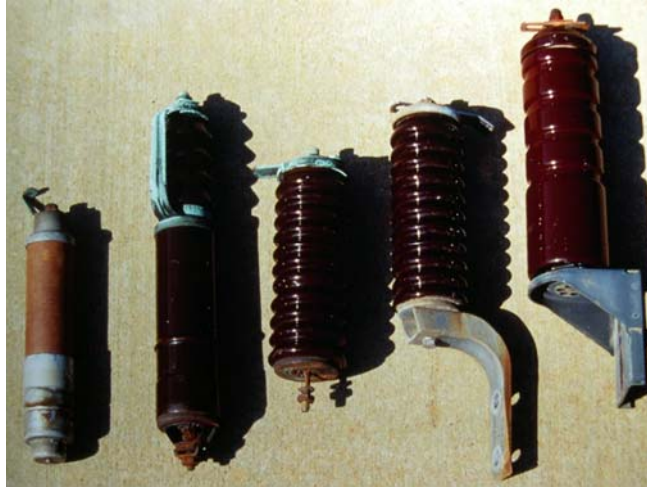
Before: Bonded guy plate near gapped arrester – no animal guards.



Six months later: Same pole, arrester, and bushing have been in a bad flash.



Technology from the 1930's – expulsion arresters allow power follow arcs.



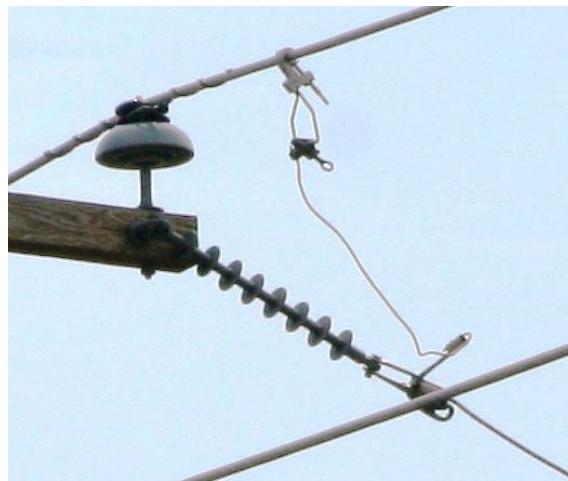
Melted metal means power follow arcs.
These arresters have joined the other side!



Overdutied Wire feeding 140 Amp Line Recloser



Overdutied Wire feeding 140 Amp Line Recloser



Construction error causing birds to “connect phases” = 50 trips per year on this circuit.



Unfused taps are a common cause of circuit lockouts. Engineer error.



Remains of Balloon on Tap



Street light installed above primary.



Need to install a guy insulator.



...but it will not do any good unless you also remove the pole ground.



Avoid placing close conductors in the same horizontal plane.



No



Yes

Installing middle phase on crossarm.

- Lowers BIL (CFO) by 40%
- Increases mid span faults by magnetically induced subsequent faults (MISFAULT)
- Increases line to line tree faults.
- Mandatory 3 point deduction

Two circuits on one ten foot arm often results in mid-span conductor faults.



Two circuits on one ten foot arm
ALWAYS
results in mid-span conductor faults.



Buried guy preforms rust off and often result in broken poles.



Buried Preform – Use Anchor Extension



Guyed on one end and not on the other.



The original guy lead was too short,
and the pole fell on Jan. 3 1999.



Results of 1996 Study

- A computer program was implemented to record the results and provide reports.
- Management committed to allowing the quality compliance specialists to do quality checks in addition to their other work.
- Checklists were developed to help quality compliance specialists audit jobs.

1999 - ACTION

- Reliability assessments by central reliability and integrity group (R&I) found that errors in construction continued to occur.
- Outages were being caused by new construction.
- R&I performed an audit of DPS jobs (Deliver Products and Services) using the same scoring system that was used to grade reliability jobs.

**Sample of 6 jobs in one zone -
May 1999**

- Pole change out - Hand ties on covered wire
- Move 2 poles - 55' pole 5' in ground, not guyed, OH transformer, no fuse or animal guard.
- Install 2 poles and primary - cutout was fused by mistake
- Set pole in line - used steel extension link, rather than fiberglass
- Make line 3 phase - failed to fuse and animal guard OH transformers
- New circuit - 336 AAC span 360 ft long, failed to fuse and animal guard transformers

**Sample of 6 jobs
in one Zone**

Quality Score = 37%

Who is at Fault?

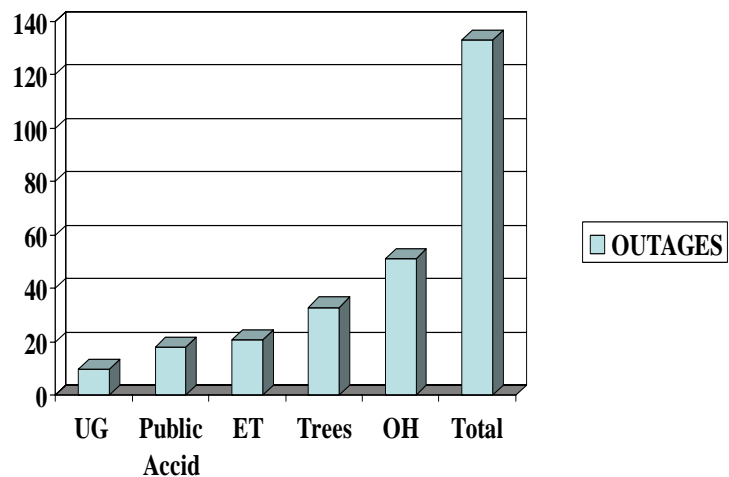
- Coordinators?
- Supervisors?
- Utility Engineers?
- Utility Crews?
- Contract Engineers?
- Contract Crews?
- Utility Management?
- Quality Compliance Specialists?
- ???

1999 Assessment of Construction Quality Audit Process

State of Existing Quality Audits in 1999

- Process Coordinators and Quality Compliance Specialists were held accountable only for **QUANTITY** of audits performed
- 85% of audits were performed on UG construction
- 11% of audits were performed on OH construction

Distribution System Categories of Outage Minutes



Reliability or NESC Errors on OH Construction Audit Sheet (1996)

- Pole set too shallow
- Pole not properly tamped
- Improper guy and anchor installations

Additional Reliability or NESC Errors being made in the field

- Non-standard framing
- Transformer wo/animal guard or fuse
- No guy insulator on primary guy
- Pole ground not stripped
- Conductor span too long
- Use of hand ties on covered wire
- No guy installed on tension span

Additional Reliability or NESC Errors being made in the field

- Crew changed job making reliability worse
- Crew failed to do reliability work specified
- Automatic splice in slack span
- Unfused tap off backbone or main feeder
- Wire too small for main line or feeder
- Wire out of sag

Additional Reliability or NESC Errors being made in the field

- Primary connector installed incorrectly
- Line recloser installed with cracked bushing
- Poor fuse location or solid blade in cutout
- Neutral on crossarm (multiple poles)
- Failure to remove old static wire
- Un-coordinated protective devices

Additional Reliability or NESC Errors being made in the field

- NESC construction grade violations
- Obviously did not build to standards as distribution manual clearly shows a different structure
- Bare leads in cutouts
- Pole set too shallow

1999 Findings – Construction Quality Audit Process

- Quality compliance specialists were doing too few OH construction audits.
- Existing OH audits were missing most of the problems causing faults and interruptions.
- There was no accountability for poor OH design or construction.
- There was no motivation to build the system correctly.
- Saving money was given as the reason for poor construction.

2000: Implementation of a New Measure

- In each of 10 zones ,a sample of new construction jobs would be selected for audit each quarter.
- A small team of OH construction auditors based in the G.O. would use the major problems list to score each job.
- The quality score would be a scorecard measure for all supervision, management, and engineers.

SUSTAINMENT

2001 to 2006

How the audits are conducted

- For a zone, 12 completed jobs are selected at random, and 2 or 3 alternates.
- A notice is sent to the zone the day before the audit so that the job prints can be found.
- An engineer and construction expert from the G.O. arrives first thing and conducts the audit. It usually takes all day.

Scoring results and errors are shared as each job is audited.



Only 3 people are needed for the audit. Why are the others here?



Scoring for a Job

- There are 12 jobs scored per quarter per zone.
- Each job is worth 5 points, total of 60 pts for a day.
- 1 point is deducted for every error that can cause an outage to a small number of customers (or is a clear NESC code violation).
- 2 points are deducted for every error that can cause an outage to a recloser subfeeder.
- 3 points are deducted for every error that can cause an outage to a station breaker.
- You cannot score less than zero points for a job.

Publishing Audit Results

- The results of the audit are posted in a measures spreadsheet, and copies of the score sheet for each job are sent to the zone management and supervision.
- The results of the audits are published each month in the Monthly Distribution Reliability Report.
- The audit results are scorecard measures for employees designated to receive them.

Scoring Conventions

76% or less - Clearly Below Expectations

77% to 81% - Occasionally Meets Expectations

82% to 87% - Meets Expectations

88% to 93% - Exceeds Expectations

94% + - Significantly Exceeds Expectations

Annual Results – OH Construction Quality

Year	Score	Frequency
1999	59%	Baseline audits
2000	79%	Quarterly audits
2001	85%	Quarterly audits
2002	89%	Quarterly audits
2003	88%	Semi-Annual audits
2004	91%	Semi-Annual audits
2005	91%	Semi-Annual audits
2006	94%	Semi-Annual audits
2007	91%	Semi-Annual audits

Why audits finally succeeded.

- Strong support from management.
- Results counted on scorecards.
- Auditors were independent of regions.
- Scoring was based on real reliability problems.
- Scoring guidelines were firm, fair, and published for all to see on the company intranet.
- **After several years, the value of the focus on construction quality became apparent.**

Lessons, Culture, and the Future

- Mid 2003 - Change from centralized process organization to regional functional organization did not eliminate audits.
- Unlike before 2000, when you ride around the system today, you see lines being built correctly.
- 2004 - 2005 – Asset Management and Standards continue to conduct the audits, and the regions continue to use the published results.
- 2006 – Cinergy-Duke Power merger.
- 2008 - Construction Quality Audits to begin in the Midwest Regions.

**“You don’t get what
you expect....**

**...you get what you
inspect!”**

Vance Martin

Pole hit on 3 span tap feeding one customer – 1,951 Customers Out



Side view - pole where follow-up engineer specified fused cutouts to be placed.



Side view of pole hit by truck last year.

This photo was also taken April 10, 2008.



Full view of unfused span
on April 10, 2008





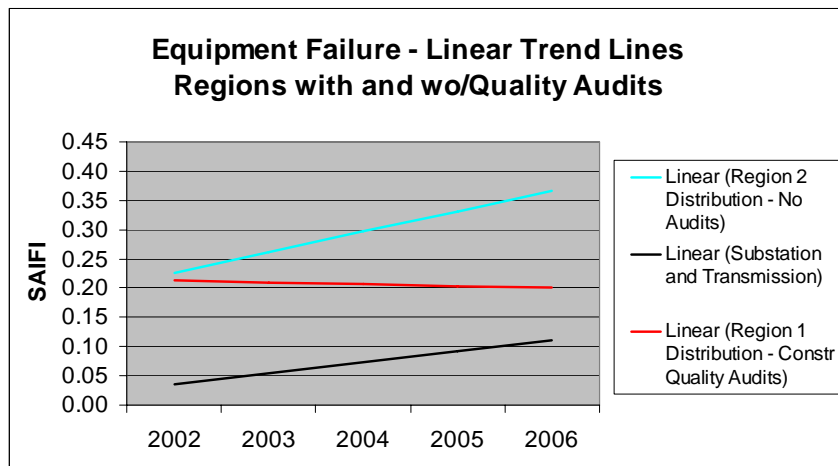
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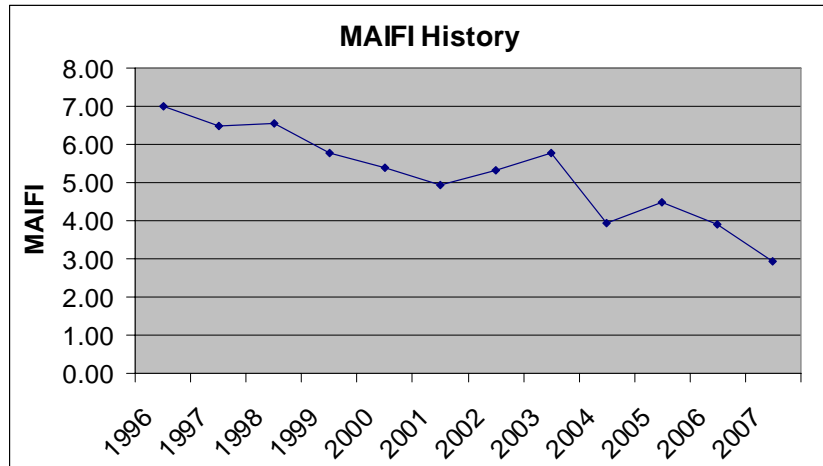
Istaylor@duke-energy.com

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Equipment Failure Trends



Duke Energy Region with Quality Audits



Duke Energy Region with Quality Audits

