Risk Mitigation of Aging Electrical Infrastructure

Pennsylvania AWWA
American Water Works Association

2014 66th Annual Conference

2pm Tuesday May 8th, 2014

Presented by Dick McDonnell

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Schneider Electric

About the Presenter

Dick McDonnell

Dick McDonnell is a Business Development Manager for Schneider Electric's Water Wastewater Competency Center.

Dick has more than 30 years experience helping engineers, OEMs and end users specify controls, automation and SCADA solutions.

Mr. McDonnell also provides help identifying and implementing new system architectures for automation, security, power distribution and data acquisition with a strong emphasis on achieving operational and energy efficiencies.

- **Who has electrical equipment that is ….?**

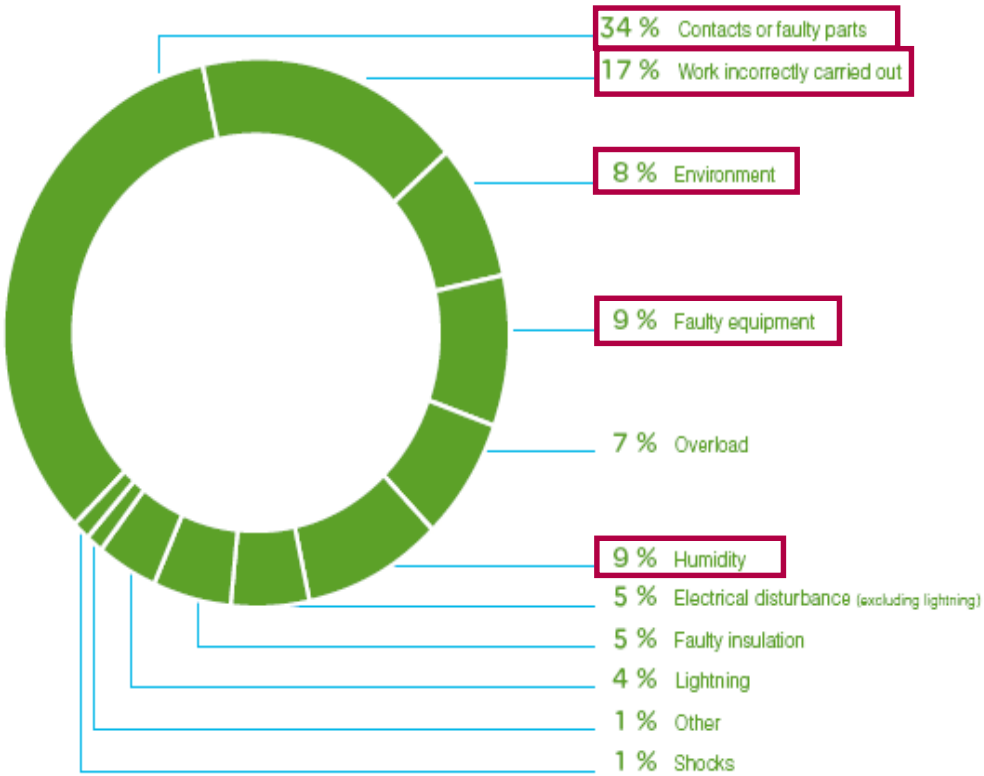
If you had seats this comfortable you would just fall asleep.

- **Who knows if their electrical equipment has …?**

… been Arc Flash Labeled?
… been opened for inspection?
… had the interior and exterior cleaned?
… had the connections tightened?
… had the grounds tested?
… had mechanical maintenance?
… had a Themographic Survey (IR)

What are the main causes of equipment breakdown?

Source: Schneider Electric expert assessment & Hartfold Boiler Steam



According to IEEE, the rate of electrical component failures is three times higher in facilities that do not perform preventive maintenance on their electrical systems.

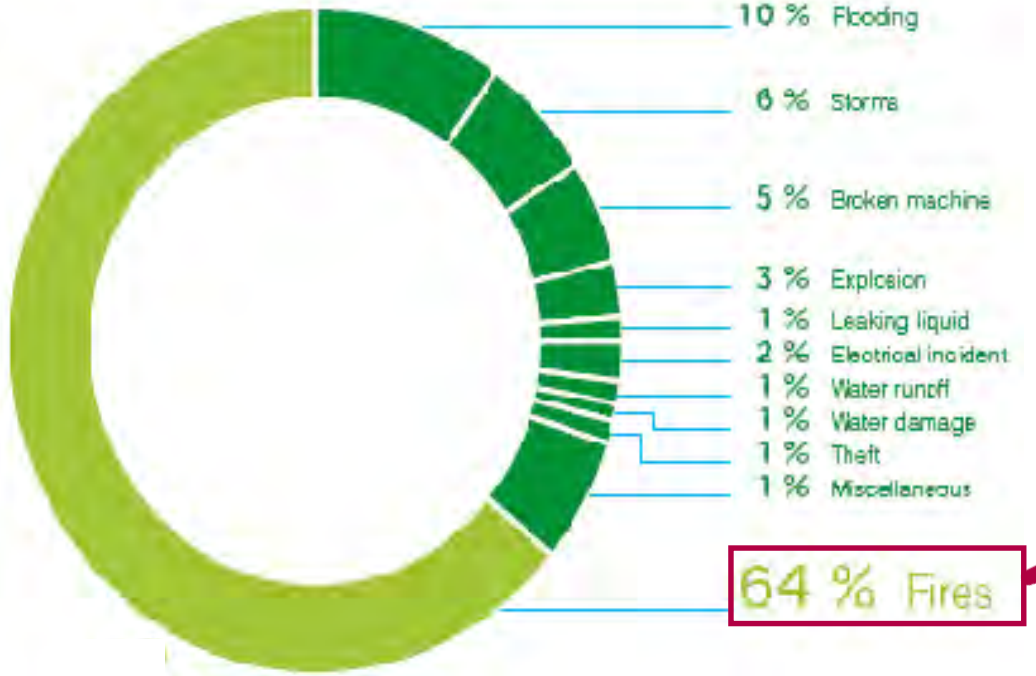
3X

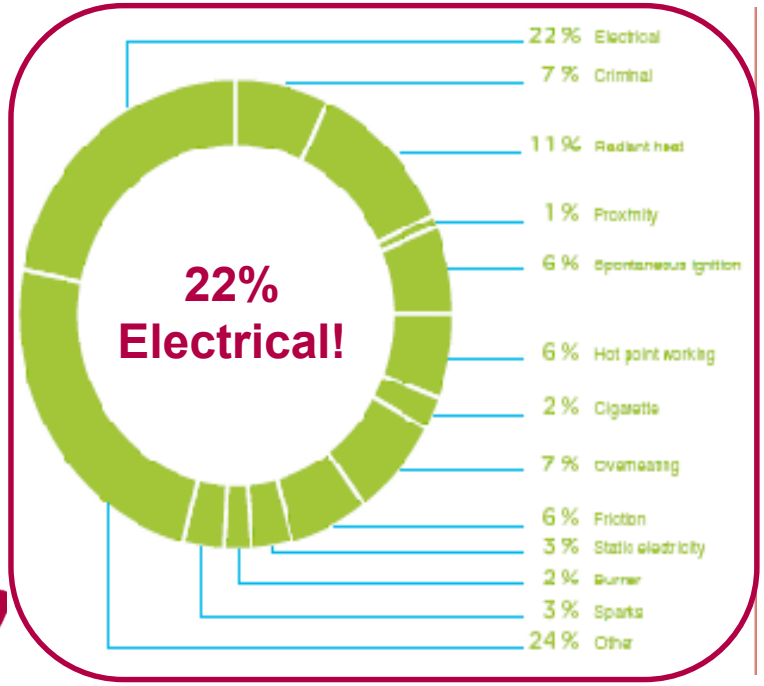
When is electrical distribution equipment operating?

- When it is energized?
- When it is performing its function?
- What equipment do you know of that is turned on for 20+ years without being turned off?

What are the major causes of facility damages?

Source : FM Global insurance company





How Dangerous is Electrical Equipment?

- Load Power?
- Feeder Power?
- Supply Power?
- Fault Energy?

Roughly 1A @ 480VAC = 1hp

Are You a Gambler?

- How much do you put at risk?
- Do you know the rules?
- Do you know the odds?
- What would you do to better the odds?

ELECTRICAL EQUIPMENT

FORENSIC PHOTOGRAPHS TELL A STORY

A Rodent got squished when circuit breaker racked in. Luckily this was on load side. I it had been on the line side, there would have been a fault or an arc flash.

Loose Connection
Fluctuating loads caused stresses and loosened the connection
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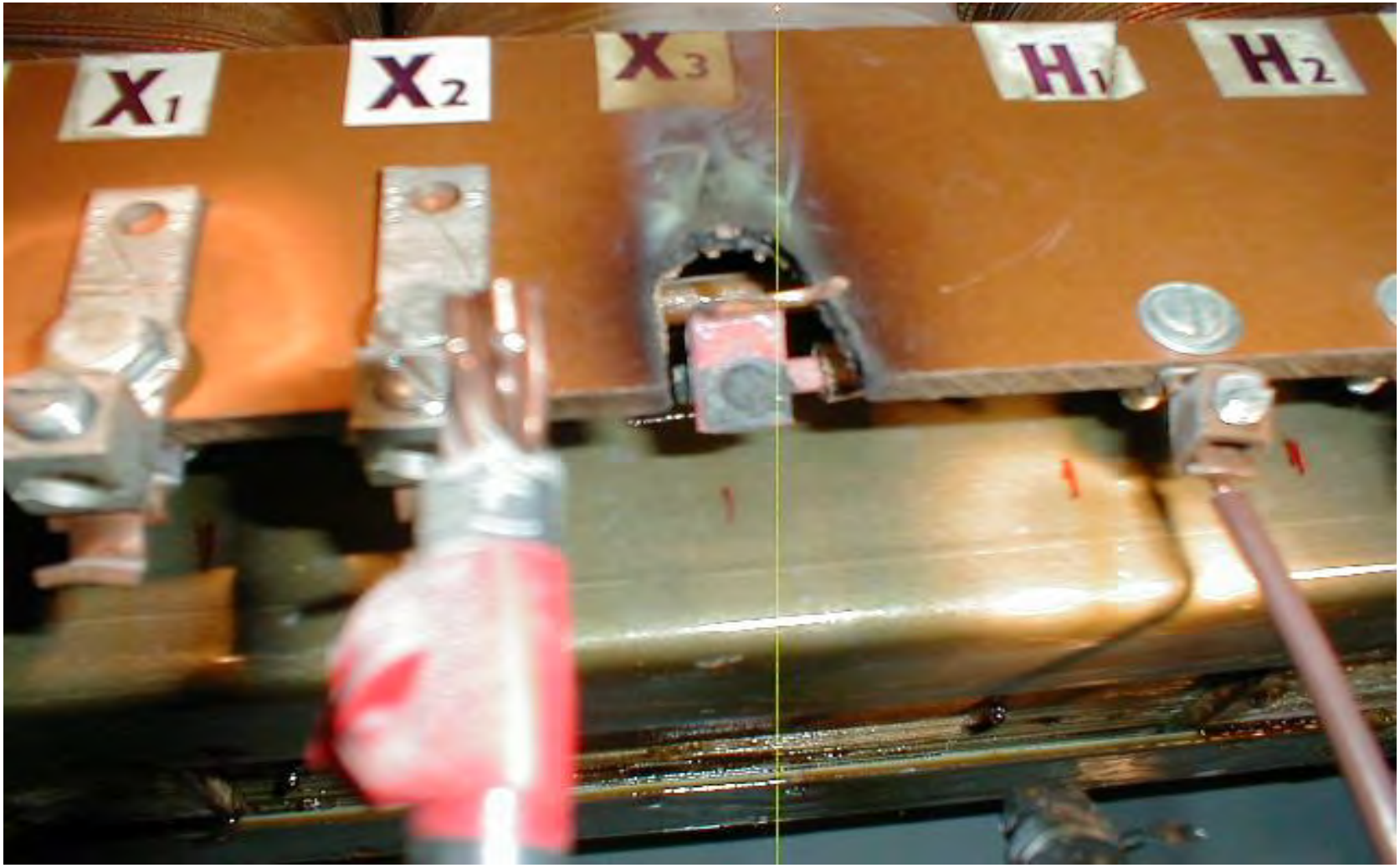
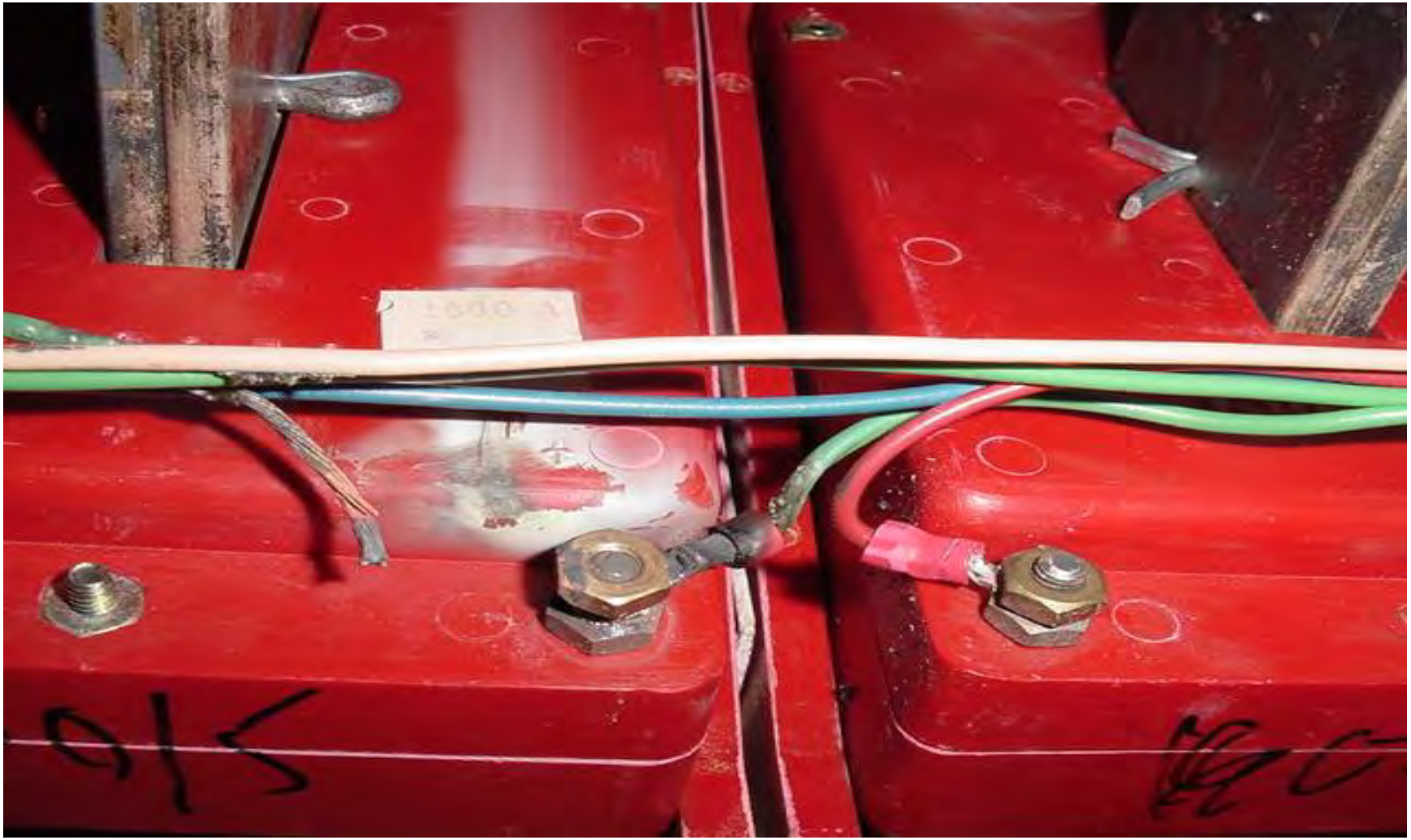


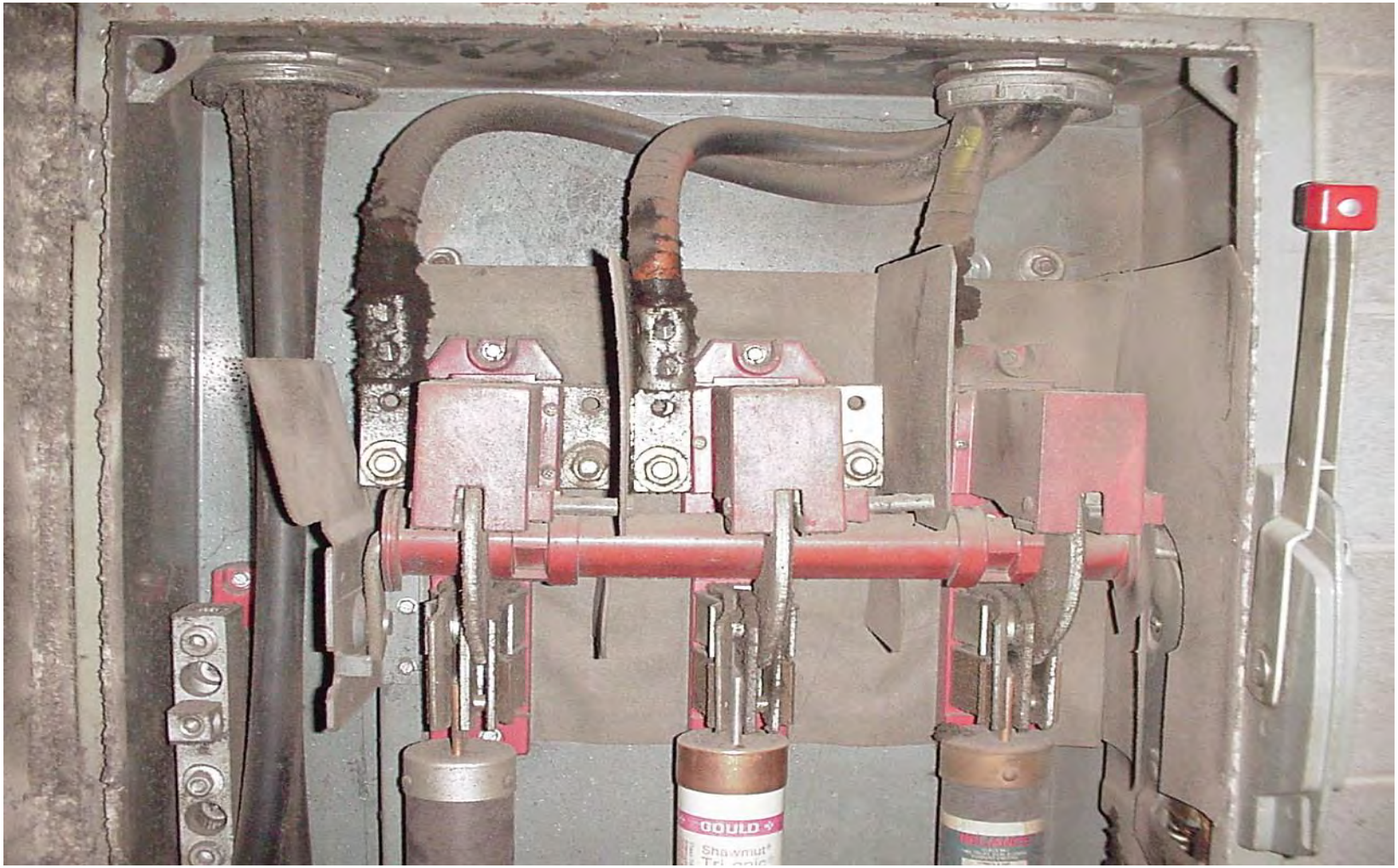
A 2000 amp circuit breaker did not operate due to a terminal failure. A ring terminal should have been used, not a forked terminal.



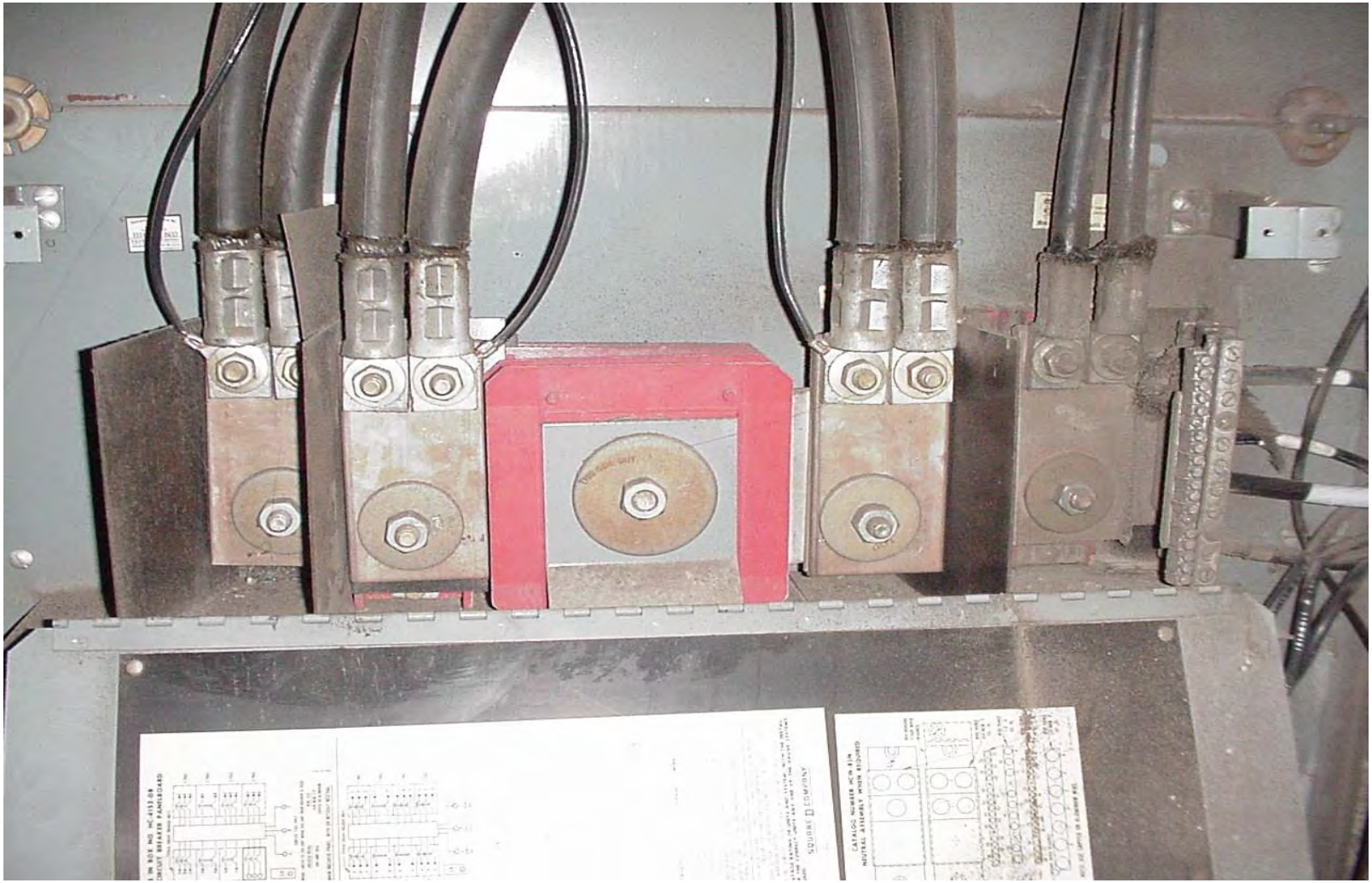
Water pooled in empty bolt holes
-The Insulator broke down from copper, dust, electrons on fiberglass

Outside generator 2.5MW
Bussing from the manufacturer was not correctly sized
Lots of dust with corrosion starting to happen on relatively new generator

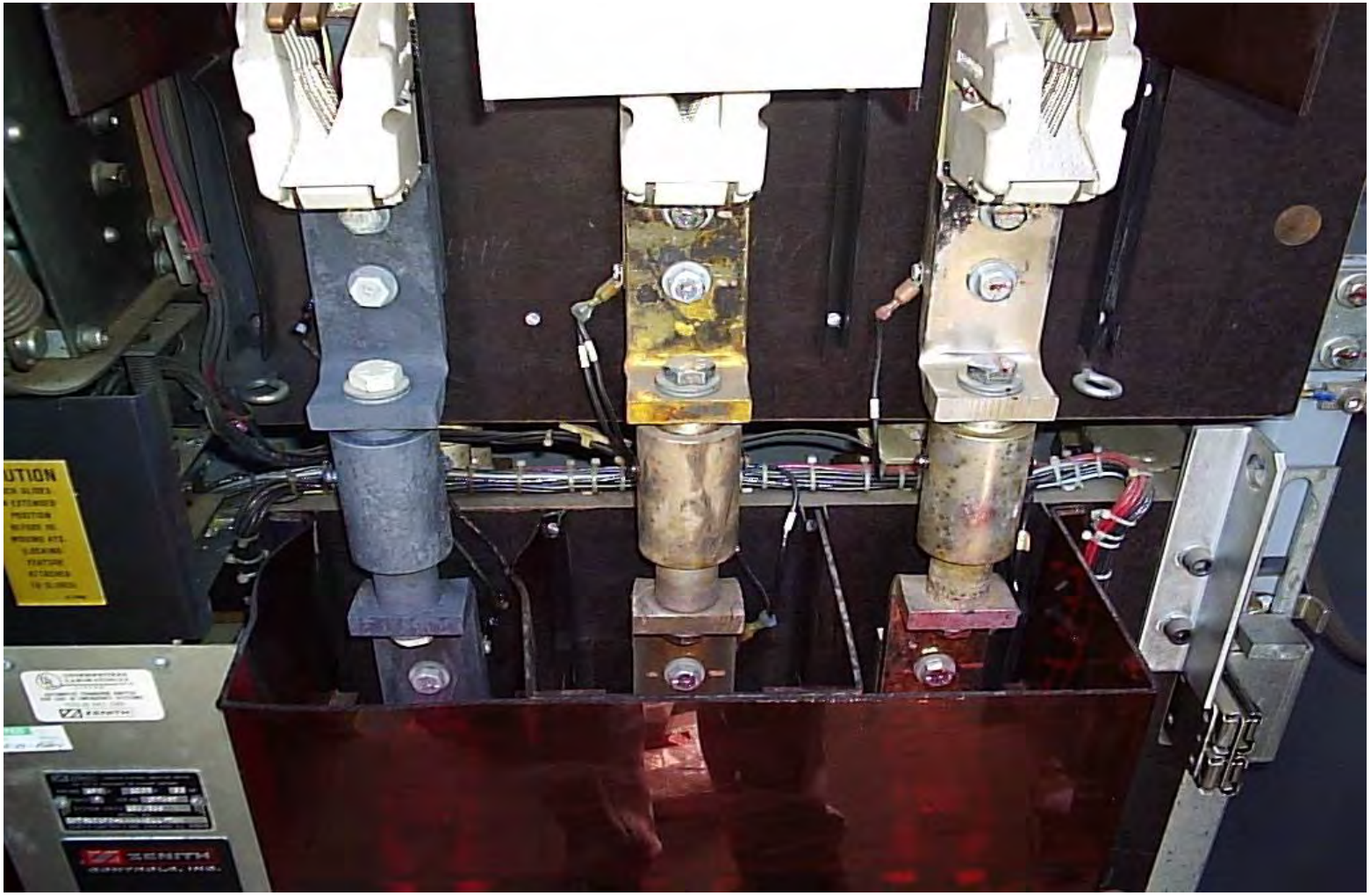
Top of previous slide
Although there was no fault yet, carbon from dust and engine exhaust from the outside was coming in through conduit



Upper right corner had spare open conduit where dust and carbon from nearby railroad landed on neutral conductor



Transfer switch has loose connections on left causing silver to be burned off and then other phases are discolored. The control wiring insulation is also burning off



4160 Volt
Debris and inadequate loosely connected ground wire. (arrow). The Breaker would not operate because there was too much resistance in ground path


GENERAL ELECTRIC

ELECTRICAL EQUIPMENT

THE GREY BOXES

Electrical Distribution Equipment

- Active Components
  - Circuit Breakers
  - Trip Units
  - Relays
  - PLC's, TVSS
  - Fuses
  - Racking Mechanisms
  - Monitoring Components
- Passive Components
  - Structure
  - Bussing
  - Lugs/Lug Pads
  - Bracing

Electrical Distribution System
Active Components

- Mechanical Components
  - Involve moving parts, therefore they must be maintained in order to operate as intended
  - Will wear out over time
  - Some components require replacement upon use
- Solid State Components
  - The rise in utilization of solid state components gives rise to another mode of failure that cannot be easily detected
  - Typically cannot be maintained and must be replaced upon failure
  - Obsolescence is a key consideration

Electrical Distribution System
Passive Components

- Structural Components
  - Require minimal maintenance (more monitoring)
  - If properly cleaned and monitored in a controlled environment, the passive components do not wear over time, however:
    - Dust, dirt and moisture build-up can affect the insulation system
    - Loose connections due to improper torque and/or vibration over time can lead to excessive heat and failure
  - If well maintained, these components substantially outlast the life span of the Active Components in a piece of electrical distribution equipment

ELECTRICAL EQUIPMENT MAINTENANCE AND CARE

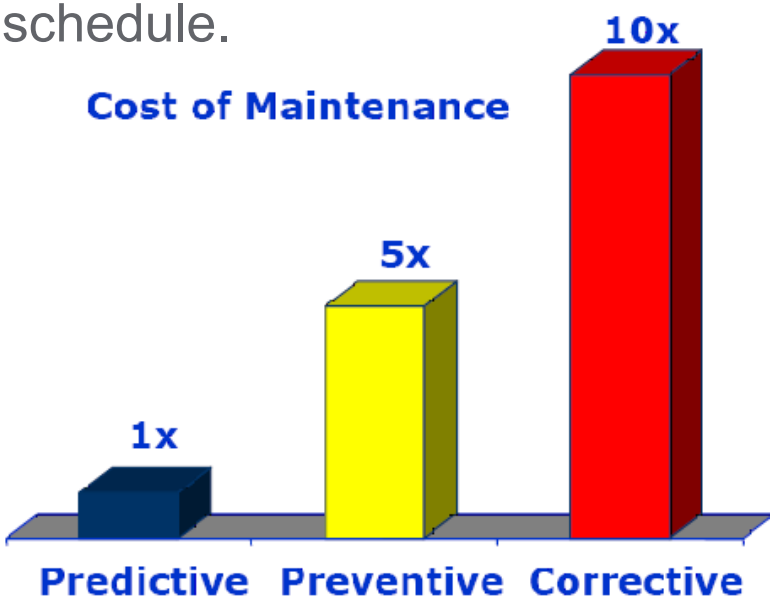
WHAT CAN I DO?

ELECTRICAL EQUIPMENT MAINTENANCE AND CARE

- Maintenance
  - Corrective
  - Preventative
  - Predictive
- Inspections
  - Visual
  - Infrared Camera
- Assessments
  - Testing
  - Themographic Survey (IR)
  - Forensic Analysis
  - Report by a Specialist

Approaches to Maintenance

- Corrective Maintenance
  - Repair work conducted after a failure or breakdown.
- Preventive Maintenance
  - A specified list of inspections, cleaning, testing and part replacement during a pre-defined, time-based schedule.
- Predictive Maintenance
  - Scheduled based on diagnostic evaluations. Also factors in equipment age, environmental stresses, criticality of equipment, etc to decide on schedule.



Inspections and Assessments

Common Causes of Electrical Equipment Failure

- Thermal Stresses
- Mechanical Stresses
- Insulation Breakdown or Dielectric Deterioration
- Vibration (internal and external)
- Contamination (dust, dirt, foreign particles, animals, critters)
- Exposure to Chemicals (liquid or vapor)
- Inadvertent Contact
- Loose Connections
- Moisture and Water Damage
- Corrosion, Oxidation, Reduction
- Corona and Electron Tracking
- Protective Devices that do not Operate and Designed and Intended
- Lack of a Regular Scheduled Preventive Maintenance Program

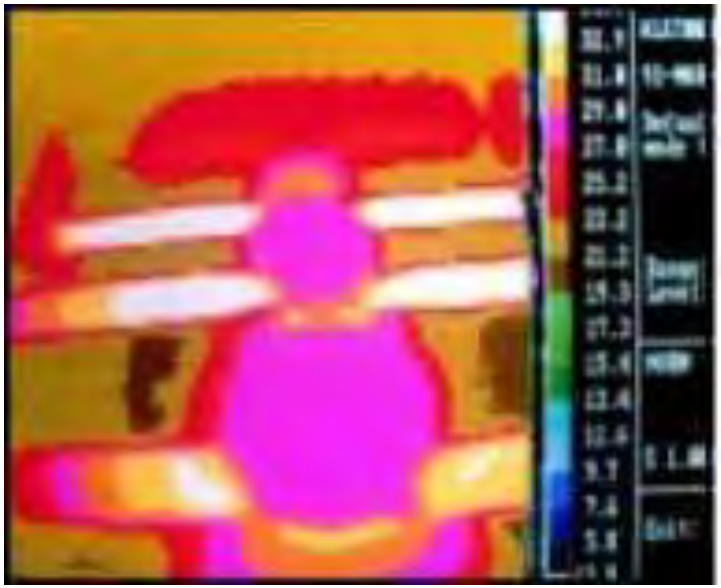
Inspections and Assessments

Common Causes of Electrical Equipment Failure

The vast majority of all anomalies and dysfunctions of power distribution system can be directly related to ineffective or deteriorated bonding and grounding system.

Summary
Themographic Survey

- A Themographic Survey employs infrared imaging to only detect ”relative” heat rise or “hot spots” on the surface of equipment and can detect heat rise within the interior of equipment.
- Hot spots are often an indication of loose connections or overload conditions.
- TS can be routinely performed without power interruptions.
- In order to perform a TS proper PPE must be employed, maintained, and worn.
- A TS does NOT reveal all abnormal conditions.
- A TS does NOT reveal all deteriorate conditions.
- A TS should NOT be employed in lieu of a regular PM Program.



RISK PREVENTION AND MITIGATION

WHAT IF IT IS TOO LATE?

RISK PREVENTION AND MITIGATION

- Maintain
- Replace
- Modernize / Upgrade

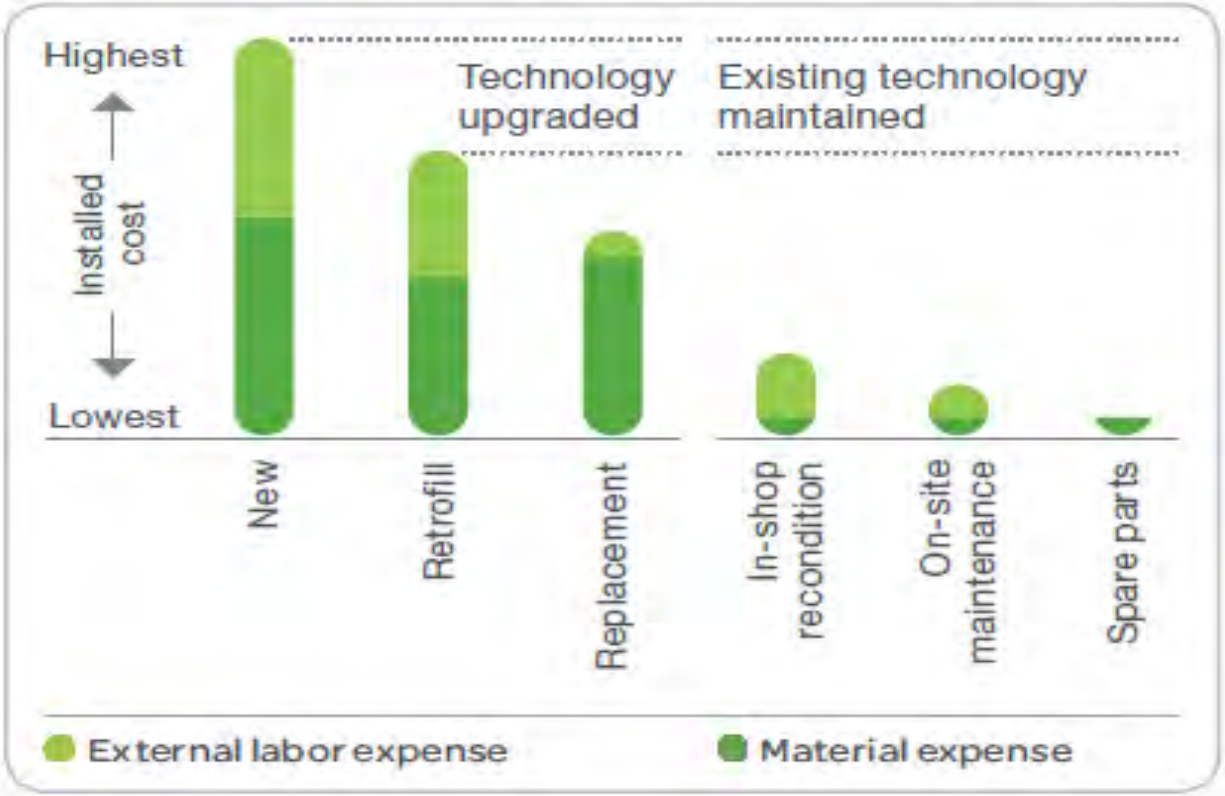
Maintain Equipment vs. Modernize?

- Even properly maintained equipment is subject to two key phenomena:
  - Ultimately degrades and reaches the end of its useful life
  - No longer sustainable solution due to technological advances

- Factors to consider:
- Age of equipment
- Operating environment
- Availability of spare parts
- Reliability of system components
- Cost of ongoing maintenance
- Emerging technology
- Worker safety

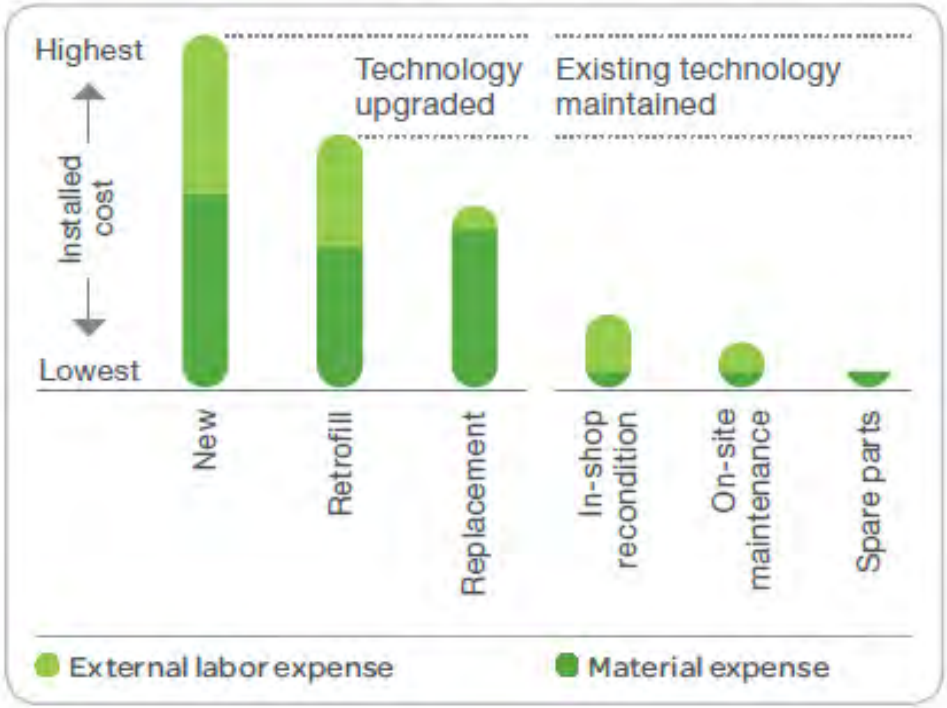
Replace Equipment vs. Modernize?

- Downtime Costs
- Reliability of System Components
- Risk Catastrophic Failure
- Parts Obsolete/Parts Availability
- Equipment Location
- Safety Issues
- Designs per ANSI and IEEE standards



Modernization Solutions

- Cost-effective options
  - Reconditioning
  - Replacement
  - Retrofill
- Benefits
  - Reduced maintenance and operating costs
  - Improved reliability
  - Increased capabilities
  - Less downtime and cost for installation vs. new equipment



Bar chart compares the total installed costs for low-voltage switchgear installations. Costs are representative of price differences. Actual cost differences depend on the content and circumstances of each project.

Modernization Project Example

- LV direct replacement breakers and monitoring system install
- Each feeder/main breaker trip unit communicates data for energy analysis
- Enhanced safety features of upgrade and improved system reliability
- Existing asset upgraded at reduced cost/downtime compared to a new install

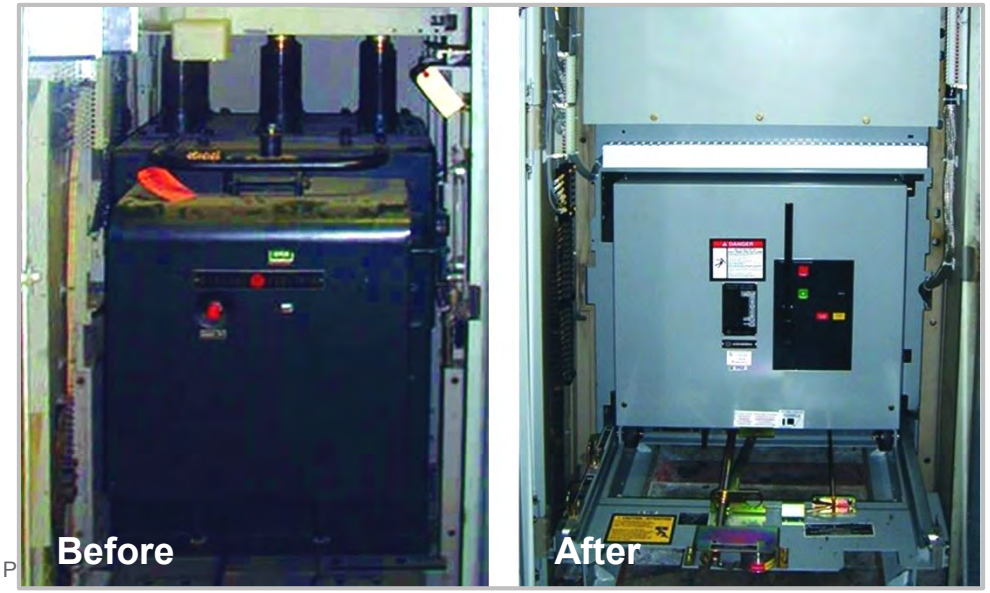
Before

After (180° view)

Modernization Project Example

- Retrofill outdated MV switchgear with 19 circuit breakers and solid-state digital relays
- New circuit breakers' vacuum bottles prevent exposure to an arc
- More consistent trip unit reaction time
- Old elevator-type racking system was eliminated, reducing risks to electricians
- More reliable electrical distribution system
- Significant cost savings as opposed to a total switchgear replacement

Did You Know? New switchgear is usually smaller than the equipment it is designed to replace. The existing conduit may need to be moved and cabling replaced or spliced. Both are expensive and time consuming tasks, often costing more in labor and material than the cost of the new equipment.



Circuit Breaker Options

- Reconditioning, Refurbishing, Retrofit-Conversions
- Direct Replacement Circuit Breakers
  - LV and MV
- Retrofill Solutions
  - LV and MV
- Replacement Switchgear
  - Custom
  - Match-in-Line
  - Standard

Before

After

Available for any manufacturer's equipment.

Why Choose Reconditioning?

- Upon completion of reconditioning, the circuit breaker performs to manufacturer's original specifications or "like new" condition
- The circuit breaker's condition is extensively documented, i.e., "As Found" and "As Left" inspection completed for each unit
- Many companies offer warranties for parts and workmanship




Direct Replacement Breakers (LV)

- 15 – 30 minute circuit outage required
- Modern technology – all new electrical/mechanical parts
- No disruption to existing cables
- Lower installed cost when compared to new switchgear option
- Greatly reduced spare parts inventory. One style of replacement breaker will replace many different existing equipment designs: ITE, Westinghouse, GE, FPE, Allis Chalmers, etc

Direct Replacement Breakers (LV)

- Reduced Maintenance requirements
- Most parts from the complete spectrum of replacement breakers are interchangeable
- Can be used to reduce Arc Flash incident energy levels within system

Building Installation - LV System upgrade

- LV direct replacement breakers and monitoring system install
- Each feeder/main breaker trip unit communicates data for energy analysis
- Enhanced safety features of upgrade and improved system reliability
- Existing asset upgraded at reduced cost/downtime compared to a new install

Before

After 180° view

Retrofill Breakers

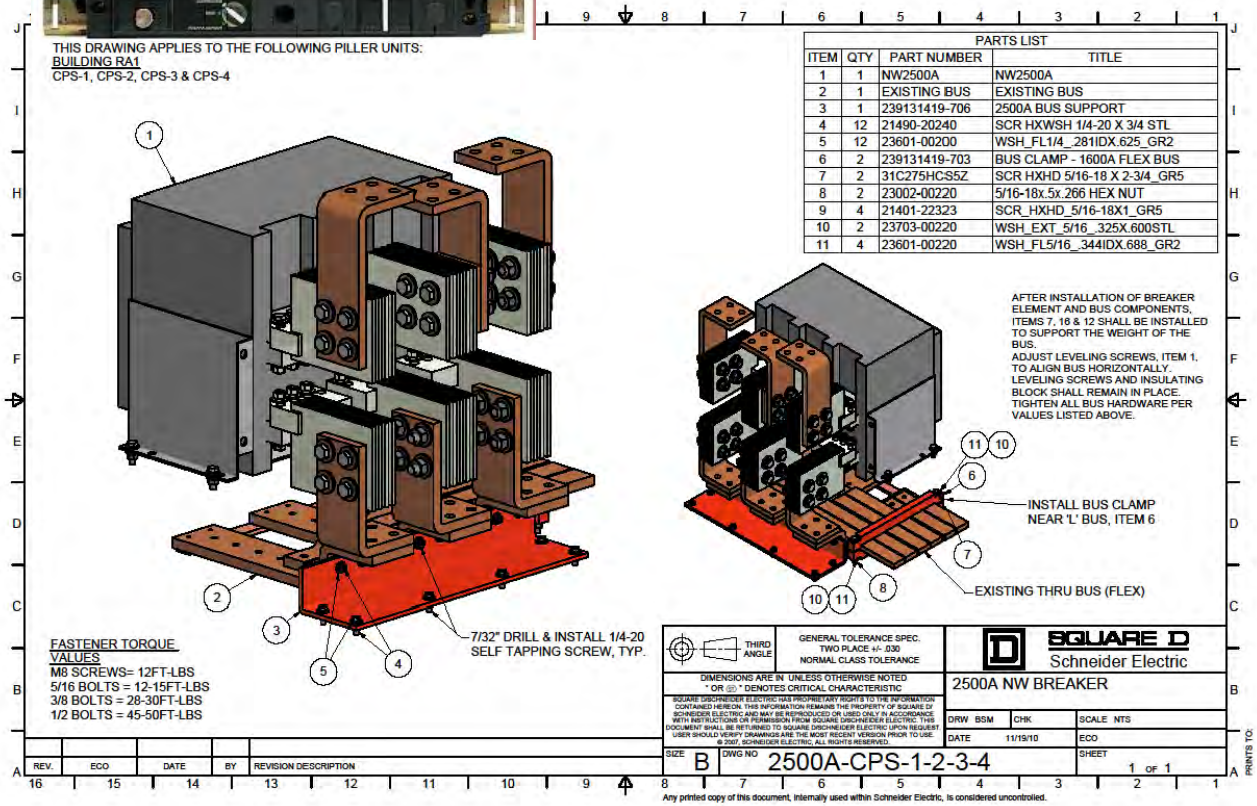
- A brief initial outage to confirm key dimensions shall be required
- The retrofill process consists of replacing the existing circuit breaker and it's related components
- A pre-engineered "erector kit" is manufactured
- Typical applications would be the Main/Tie breakers along with switch-to-breaker upgrade
- Installation then requires an extended bus outage which may range from 8 – 16 hours
- Switch-to-breaker conversions require a mini-study for trip unit settings

Retrofill cutaway side view

Completed Retrofill installation: front-view

Typical Retrofill Example

- Masterpact M/MP/MC breakers used in OEM equipment
- Breaker is obsolete and parts limited availability
- Engineered solution to modernize the device



- Outage to obtain critical dimensions
- Engineered to maintain proper equipment ratings
- Improve reliability
- Outage to install
- Upgrade with communications and monitoring features
- Maintain existing asset

Options for MCC Upgrade

- Allen-Bradley: Centerline® 2100
- General Electric: 7700 Series
- ITE – Gould – Telemecanique: Series 5600*
- Square D Model 4
- Westinghouse and Cutler-Hammer: Type W

480-volt MCC bucket Direct Replacements

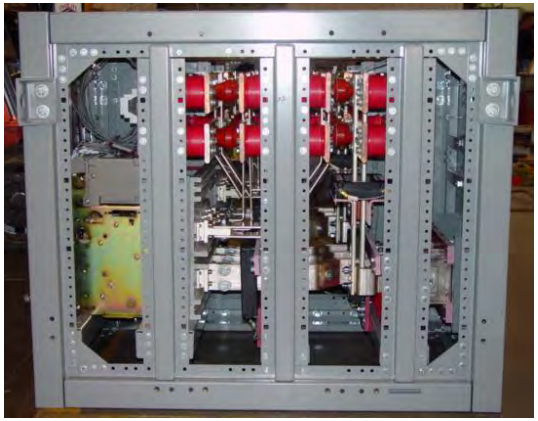
Front View of MCC

- Solid-state overload
- Upgrade to an intelligent MCC with door mounted display
- Solid-State Starter (Soft-Start)
- Variable Frequency Drives
  - ☑Upgrade processes
  - ☑Improve energy efficiency

Rear View of bucket w/ stab assembly

New Equipment and Custom Switchgear and Integration

- Non-Standard Dimension
  - Reduced height, depth, or width
- Non-Standard Ratings
  - Interrupting Ratings
  - Continuous Current
- Custom Footprints
  - Match existing cutouts
  - Match existing cable connection locations
  - Meet space restrictions
- Add in Line
  - Exactly match existing cubicles
  - Doors, relays, wiring
- Custom modifications and wiring
  - Third Party Integration
  - High Complexity, Compressed Lead Times



RISK PREVENTION AND MITIGATION

ARC FLASH MITIGATION UPGRADE SOLUTIONS

Remote Operation

- Switching – creates a potential hazard
- Hard to avoid completely
- Do you have to do it “in the line of fire”?
- Several remote options available:
  - Pendant
  - Permanently-mounted remote control panel
  - SCADA system

- Remember, energy drops roughly as 1/d2

Remote Racking

- Even more opportunity for things to go wrong when racking a breaker
- Many types of switchgear – can rack with the door closed
- Still requires worker to be in close proximity
- Remote racking – similar principle to Remote Operation – remove worker to outside the flash protection boundary

Infrared Viewing Windows

- Removes worker from danger zone
- Infrared scan cables and bus connections without opening equipment doors
- Helps Limit Arc Flash Injuries
- Available for new and retrofit switchgear, switchboards, MCCs, transformers, etc

Remote Voltage Indication

- Part of lockout/tagout process is to verify equipment dead
  - Equipment considered energized until verified dead
  - Have to open up equipment to verify!
- Can be problematic when arc-flash levels are high
- Products on market now to give remote indication

Time Delay Switches

- Fits into existing breaker switch mounts
- No special wiring or relaying
- Local control of 10 sec delay
- Can be programmed for longer delays
- May not be suitable for all applications

Arc Flash Circuit Breakers

- Specifically designed to limit high level arcing fault currents.
- Provide protection comparable to current limiting fuses for high level faults but provides better protection than fuses at lower current levels.

Summary

- Electrical Equipment Preventive Maintenance
- Electrical Equipment Ages and will eventually Fail
- Routine Maintenance will:
  - Improve Reliability,
  - Enhance Safety,
  - and Save Money
- Cost Effectives Options are Available to Modernize Aging Equipment:
  - Equipment Reconditioning
  - Equipment Modernization
  - Equipment Replacement
- LV/MV Equipment
- LV Motor Control Equipment

Are You Willing to Roll the Dice? The House Always Wins Eventually!

Questions?

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