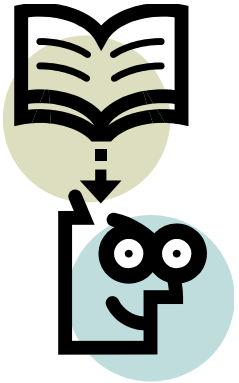
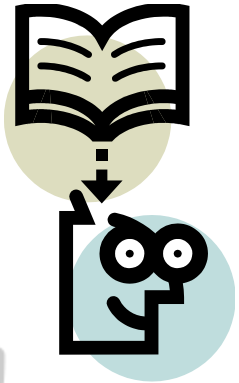
# Agenda

- Municipal Power Admin Situation
  - VLF testing, distributed energy storage, segue to LV
- Why EDPM & EDPdM
- How best to EDPM
- Energy Conservation
- NFPA 70E Arc Flash Safety

# Thank you Scott Adams & Dilbert

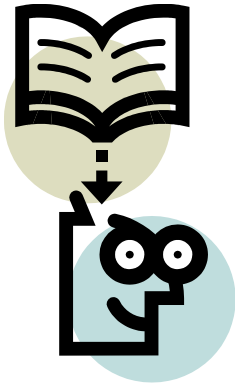


I don't think my informational message is getting through to my audience



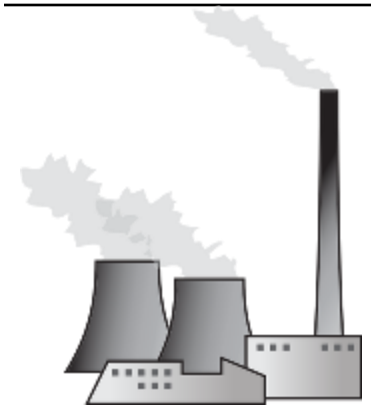
I can't make them pay attention to anything I say

Have you tried not being boring?



Good idea. I'll make fifty slides of pure excitement.

# Farm to Table



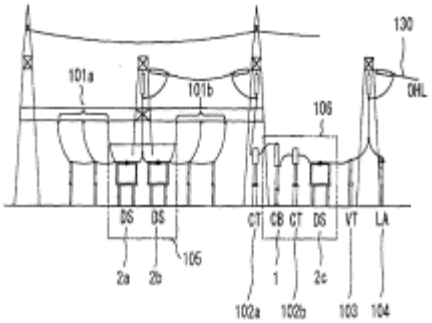



FIG. 1 PRIOR ART

At the risk of being a fish
(electric eel?) out of water...

# Distributed Energy Storage sonnen and Johnson Controls up to 2 MW

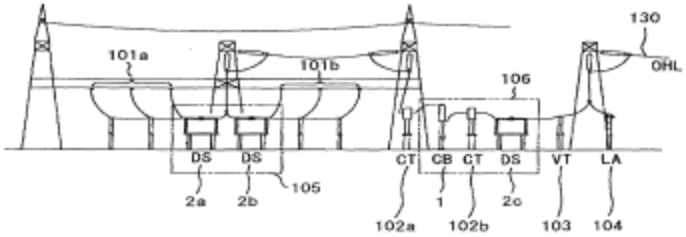



FIG. 1 PRIOR ART

Energy Storage Can Provide Multiple Operational Benefits Along With Cost Savings and Revenue Opportunities

Examples of potential value:

- Power Quality Improvement
- Power Factor Correction
- Voltage Support
- Back Up Power
- Demand Charge Management
- Load Shift
- Frequency Regulation
- Capacity Demand Response
- Renewable Energy Support

# Very Low Frequency (VLF) Testing

(I'm a little more comfortable now, thank you for your patience)

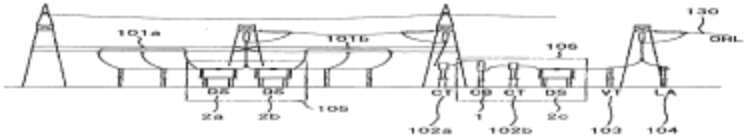



FIG. 1 PRIOR ART

- IEEE Std. 400.2 establishes criteria for assessment
- Considered fast & economical in the withstand test world
- AC sine wave applied in frequency range of .01-.10 Hz for 15-60 min.
- Uncover insulation losses & faults at much higher survivor rates vs. hi-pot, and maximizes useful life

# Let’s Dive into the Mess that is Low Voltage

# PLANT SERVICES MAGAZINE

***"Regular preventive maintenance is the best protection you can have against sudden and costly power outages."***

**Source: Plant Services Magazine**

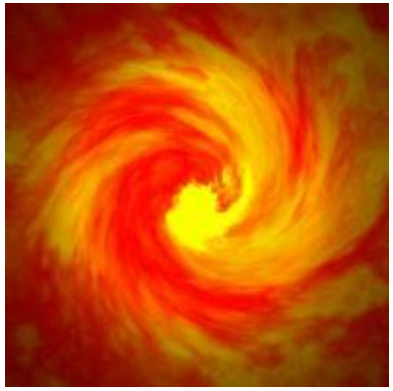
# You may be asked to address:

- Municipal buildings
- Convention centers
- Sports arenas and parks
- Waste water treatment facilities
- Water plants
- Pump and lift stations

# The Second Law of Thermodynamics...

…states that in a natural **thermodynamic** process, there is an increase in the sum of the entropies of the participating systems

***For a prize…*** ***(hint)***

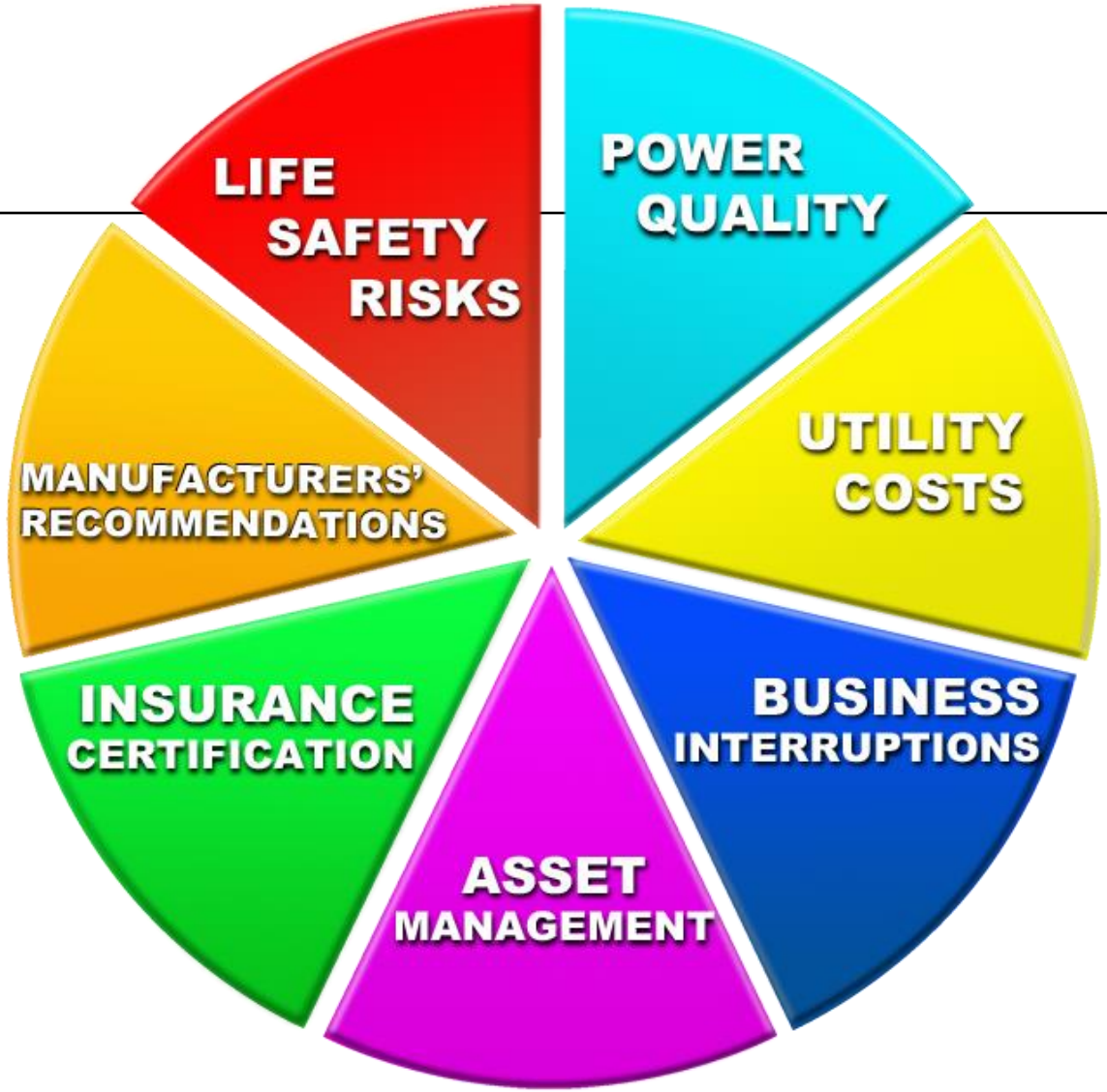


**Who can tell us the First Law of Thermodynamics?**

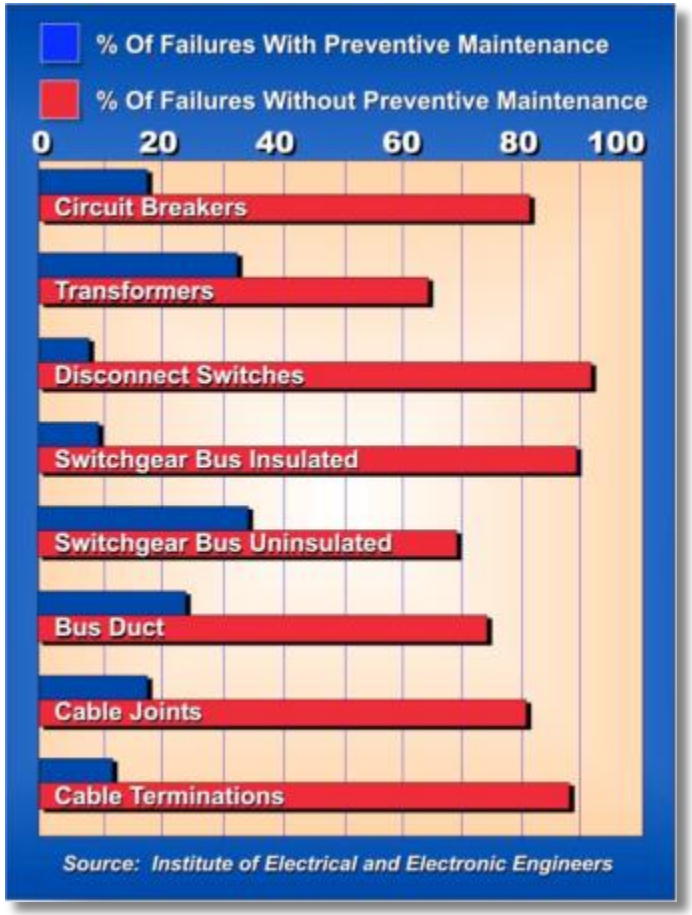
## This law has direct and measurable impact on energy consumption

- The first law of thermodynamics is a version of the law of conservation of energy (and) states that the total energy of an isolated system is constant; energy can be transformed from one form to another, but cannot be created or destroyed.

# Why We Do It


LIFE SAFETY RISKS
POWER QUALITY
UTILITY COSTS
BUSINESS INTERRUPTIONS
ASSET MANAGEMENT
INSURANCE CERTIFICATION
MANUFACTURERS' RECOMMENDATIONS

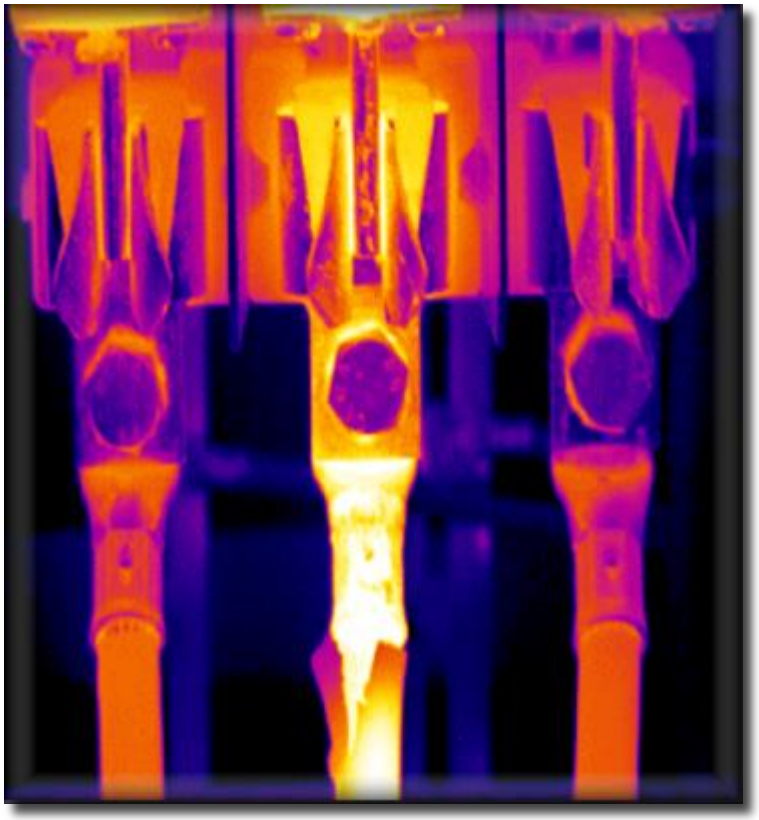
# Institute of Electrical and Electronic Engineers




**Without preventive maintenance, the failure rate of electrical system components is three times higher.**

Source: Institute of Electrical and Electronics Engineers

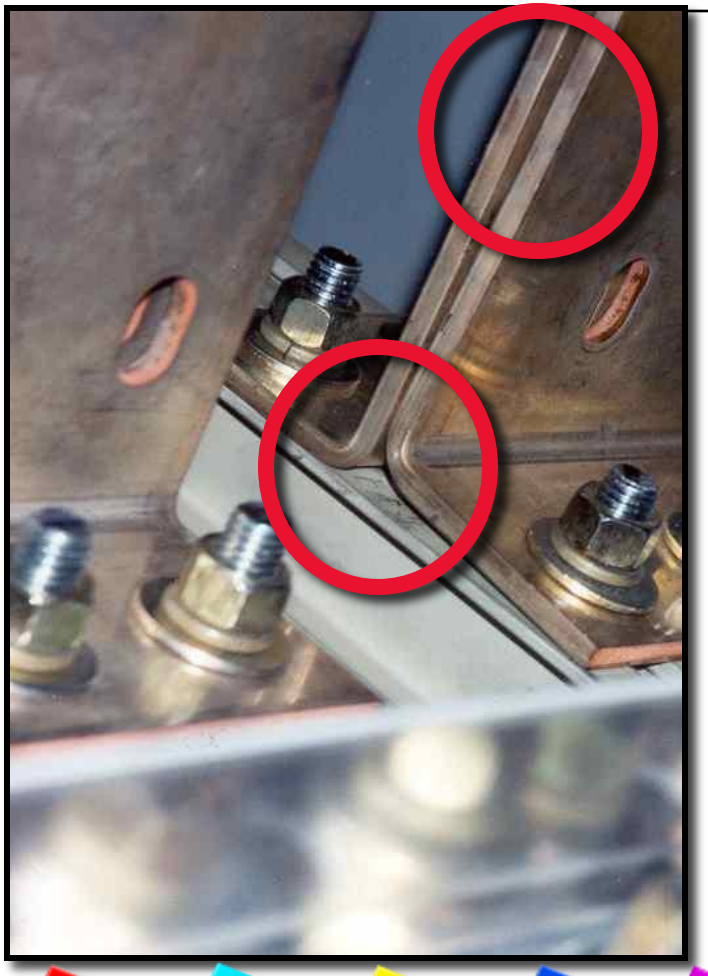
# Improper Torquing not twerking all of that is improper



***"There are an average of 16 hot spots in an average size commercial property."***

**Maintenance Technology Magazine, June 2001; Infrared Research, Inc., Rossville, GA**

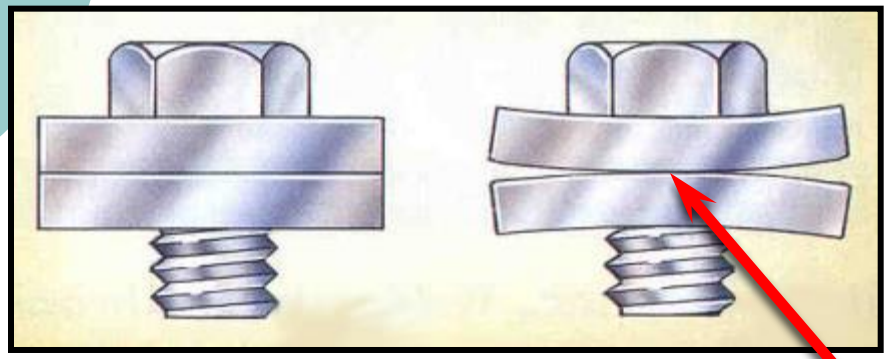
# Improper Torquing



***A High Percentage Of These Are Loose Connections.***

# Improper Torquing

**ELECTRICAL CONNECTIONS CAN BE DEFORMED BY OVERTIGHTENING**



**CORRECTLY TIGHTENED**

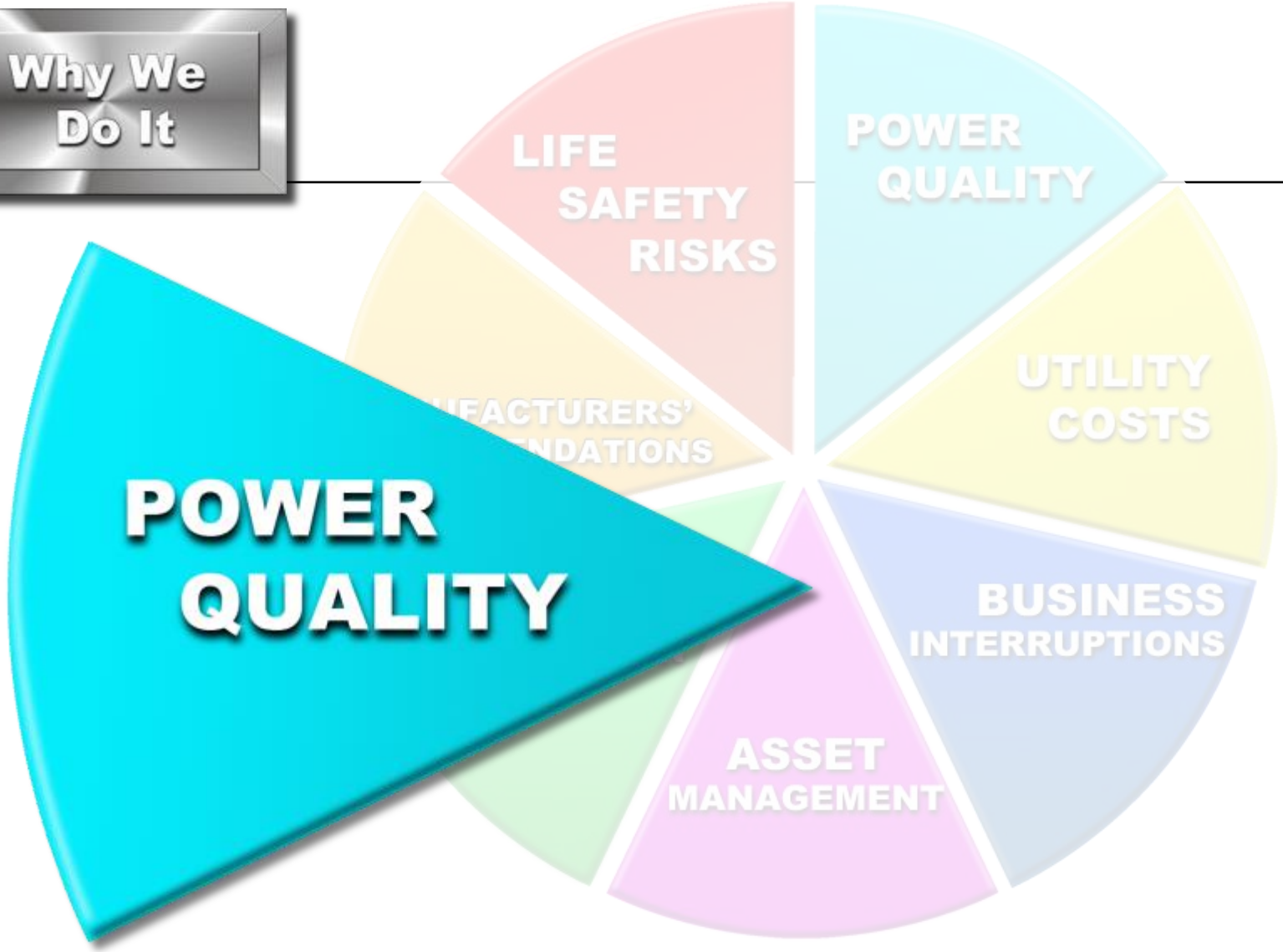
**OVER-TIGHTENED**

## However, a High Percentage of These Are <u>OVER-</u> Tightened Connections!

**Over-tightening Leads To More Hot Spots!**

Source: Maintenance Technology Magazine, February, 1998

# Why We Do It


LIFE SAFETY RISKS
POWER QUALITY
UTILITY COSTS
BUSINESS INTERRUPTIONS
ASSET MANAGEMENT
POWER QUALITY

# ELECTRIC POWER RESEARCH INSTITUTE

**"A 5% phase imbalance can cut the life of a motor by one-half and increase operating costs by $1,200 per year for a 100 hp motor."**

**Source: Electrical Power Research Institute, Washington, D.C., www.epri.com**

# From NEMA standard MG1-14.35

- The effect of unbalanced voltages on polyphase induction motors is equivalent to the introduction of a "negative sequence current" having a rotation opposite to that occurring with balanced current.
- This negative sequence voltage produces in the air gap a flux rotating against the rotation of the rotor, tending to produce high currents. A small negative sequence current may produce in the windings currents considerably in excess of those present under balanced current conditions.

# Causes of Power Quality Problems:

- ✓ **Natural Phenomena**
- ✓ **Utility Operations**

] 20%

- ✓ **Customer Operations**
- ✓ **Neighboring Customers**

] 80%

Source: Edison Electric Institute, Washington, D.C.

# From NEMA standard MG1-14.35

## Some of the more common causes of unbalanced voltages are:

- Unbalanced incoming utility supply
- Unequal transformer tap settings
- Large single phase distribution transformer on the system
- Open phase on the primary of a 3 phase transformer on the distribution system
- Faults or grounds in the power transformer
- Open delta connected transformer banks
- A blown fuse on a 3 phase bank of power factor improvement capacitors
- Unequal impedance in conductors of power supply wiring
- Unbalanced distribution of single phase loads such as lighting
- Heavy reactive single phase loads such as welders

# Other Poor Power Quality Causes as provided by Edison Electric Institute:

- ✓ Harmonic Distortion
- ✓ Voltage Transients
- ✓ Voltage Sags and/or Surges
- ✓ Disruption of Power
- ✓ Radio Frequency Interference (RFI)
- ✓ Electro-Magnetic Interference (EMI)

Source: Edison Electric Institute, Washington, D.C.

# Example – Reactive v Proactive Maintenance on Induction Motors

- Run to failure: repair or replace damaged equipment when obvious problems occur
  - Cost: $18/hp/yr
- Utilize predictive/preventive maintenance with root cause analysis
  - Includes history for redesign
  - Avoids unplanned maintenance
  - Cost: $6/hp/yr

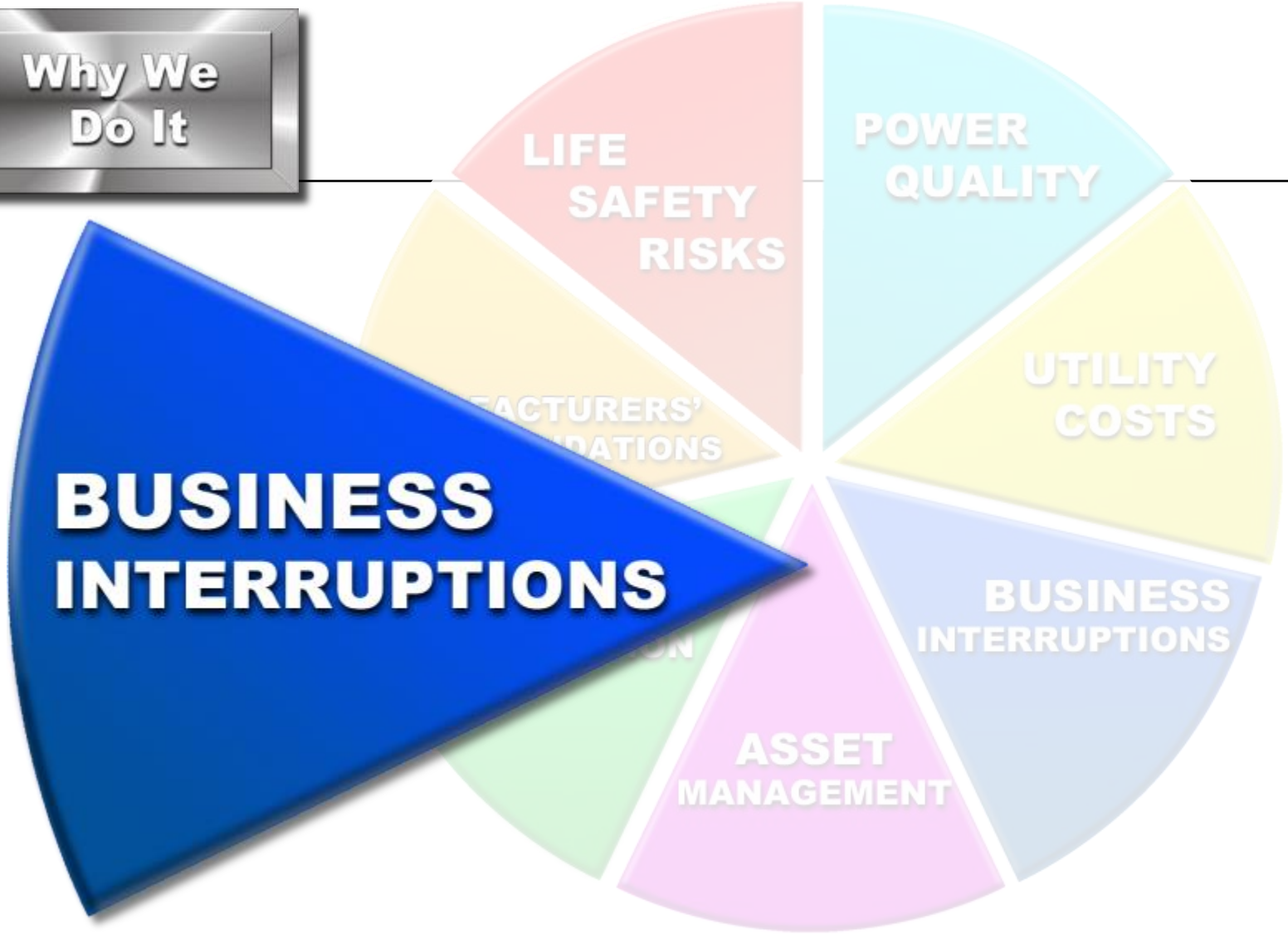
# *For another prize….*

- Without electrical preventive maintenance, the risk of electrical failure is *how many* times higher?

# Show of Hands, Please
# Who is now performing LV preventive maintenance

- De-energized only?
- Infrared thermography (or other)?
- Asset documentation?
- Predictive ultrasonic?
- Root cause analyses?
- Power quality analyses?
- Is anyone now or pursuing NFPA 70E arc flash compliance?

# Why We Do It


LIFE SAFETY RISKS
POWER QUALITY
UTILITY COSTS
BUSINESS INTERRUPTIONS
ASSET MANAGEMENT
BUSINESS INTERRUPTIONS

# Water Operations are regulatory driven, so from an electrical point of view:

- Redundant electric utility feeds
- Emergency power
- Redundancy on critical subsystems
- Fail/safe operations

# Cost of business interruptions WWTF's and Water Plants

- Typically have redundant feeds, emergency power, redundant systems
- Need assurance that fail/safe systems work when called upon
- If they don't:
  - Risk of violations
  - Fines
  - "Under the microscope"

# Cost of business interruptions
# Sports arenas and ballparks

- Games interrupted or cancelled if illumination levels aren’t maintained
- What happens if the HVAC goes out
  - Reputation damaged
  - Dangerous heat for athletes and guests
  - Again, games cancelled or postponed, what does that cost?

# Another reason for preventive maintenance

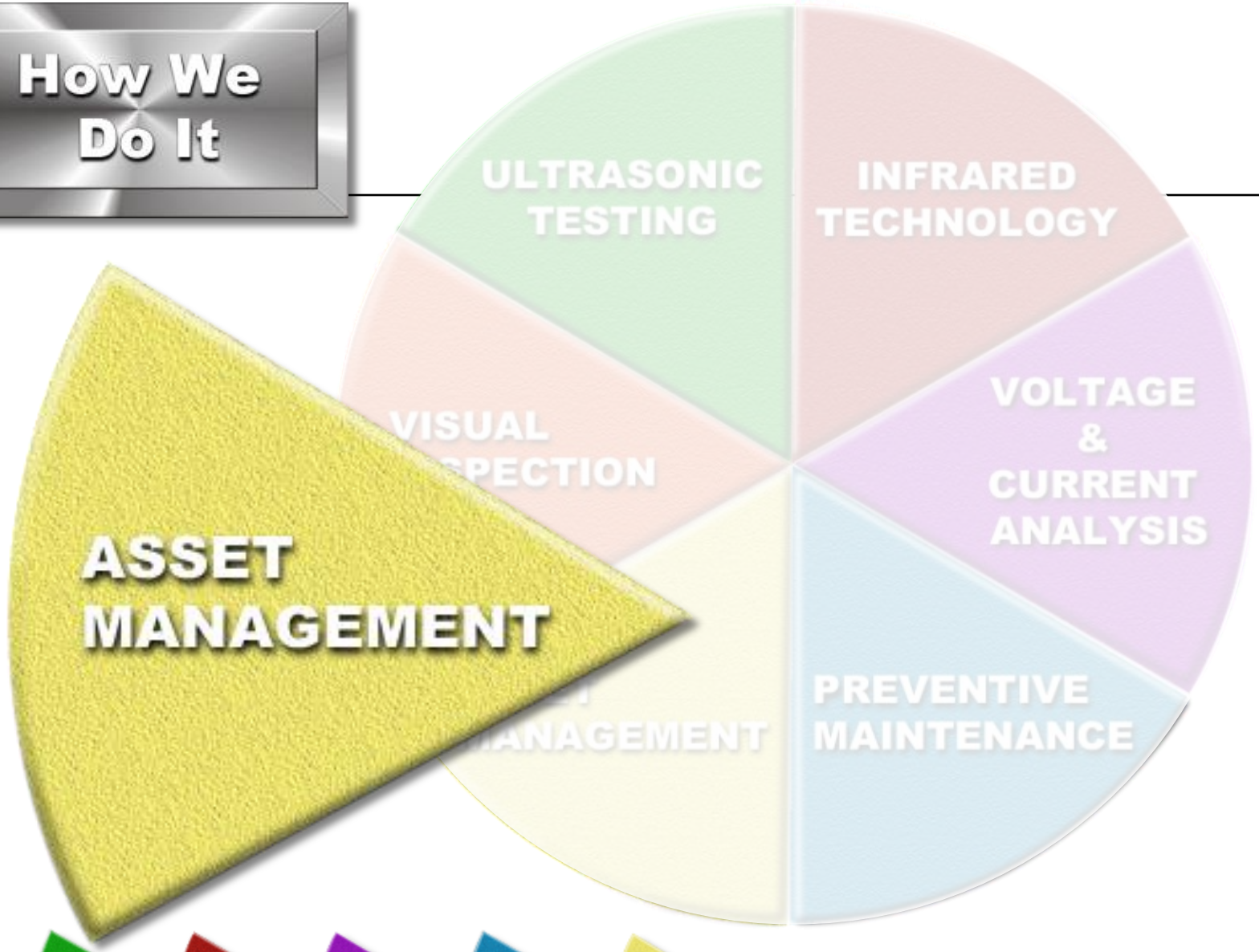
- Reduce expensive emergency repairs
  - Overtime/Overnight freight/Prioritizing supply of OEM parts
  - Run to failure increases maintenance costs as a percent of revenue
  - Unplanned maintenance costs over 50% more than planned maintenance
  - Also, “It’s cheaper to fix it than to buy a new one”

# *A neutron walks into a bar…*

…and asks, “How much is a beer?”

Bartender says: “For you, no charge.”

# How We Do It

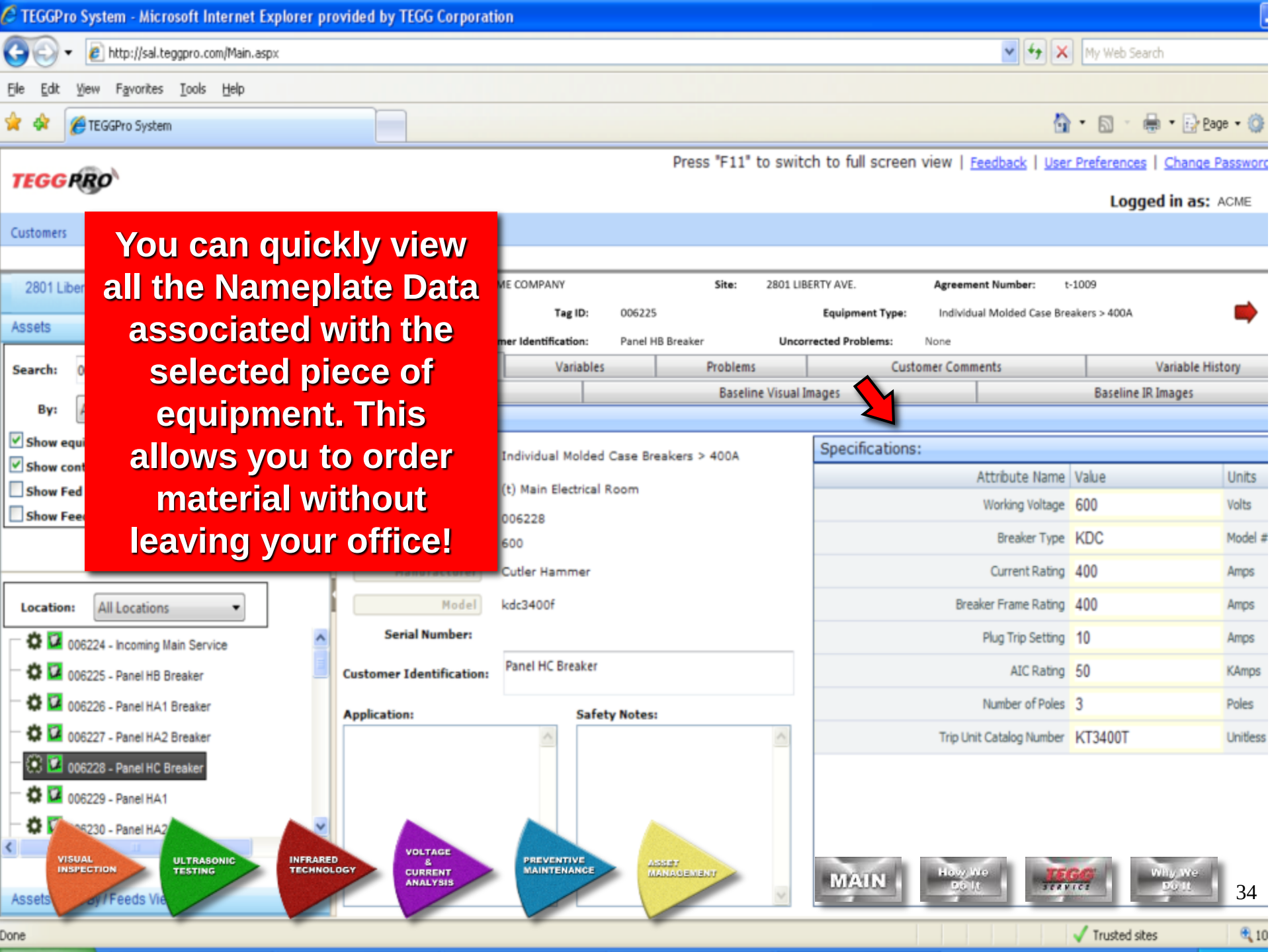



VISUAL INSPECTION | ULTRASONIC TESTING | INFRARED TECHNOLOGY | VOLTAGE & CURRENT ANALYSIS | PREVENTIVE MAINTENANCE | ASSET MANAGEMENT

MAIN | How We Do It | TEGG Service | Why We Do It

# ASSET MANAGEMENT

**Proactive Care Extends The Life Of The Equipment And Delays Costly Capital Expenditures!**


TEGGPro System - Microsoft Internet Explorer provided by TEGG Corporation
http://sal.teggpro.com/Main.aspx
File Edit View Favorites Tools Help
TEGGPro System
Press "F11" to switch to full screen view | Feedback | User Preferences | Change Password
TEGGPRO
Logged in as: ACME
Customers
You can quickly view all the Nameplate Data associated with the selected piece of equipment. This allows you to order material without leaving your office!
Site: 2801 LIBERTY AVE.
Agreement Number: t-1009
Tag ID: 006225
Equipment Type: Individual Molded Case Breakers > 400A
Uncorrected Problems: None
Variables
Problems
Customer Comments
Variable History
Baseline Visual Images
Baseline IR Images
Assets
Search:
By:
Location: All Locations
006224 - Incoming Main Service
006225 - Panel HB Breaker
006226 - Panel HA1 Breaker
006227 - Panel HA2 Breaker
006228 - Panel HC Breaker
006229 - Panel HA1
Individual Molded Case Breakers > 400A
(t) Main Electrical Room
006228
600
Cutler Hammer
Model
kdc3400f
Serial Number:
Customer Identification:
Panel HC Breaker
Application:
Safety Notes:
Specifications:
Attribute Name | Value | Units
Working Voltage | 600 | Volts
Breaker Type | KDC | Model #
Current Rating | 400 | Amps
Breaker Frame Rating | 400 | Amps
Plug Trip Setting | 10 | Amps
AIC Rating | 50 | KAmps
Number of Poles | 3 | Poles
Trip Unit Catalog Number | KT3400T | Unitless
VISUAL INSPECTION
ULTRASONIC TESTING
INFRARED TECHNOLOGY
VOLTAGE & CURRENT ANALYSIS
PREVENTIVE MAINTENANCE
ASSET MANAGEMENT
MAIN
How We Do It
TEGG SERVICE
Why We Do It
Done
Trusted sites

TEGGPRO

Press "F11" to switch to full screen view | Feedback | User Preferences | Change Password | Logout

Logged in as: ACME COMPANY

Customers | Equipment | Site Visit | Document Site Visit | Reports

2801 Liberty Ave

Assets

Show Search Options

Legend

Location: All Locations

- 006228 - Panel HC Breaker
- 006229 - Panel HA1
- 006230 - Panel HA2
- 006231 - Panel HB
- 006232 - Panel FP
- 006233 - Panel LD Contactor
- 006234 - Panel LD
- 006235 - Panel LE
- 006236 - Panel LF
- 006237 - Panel LU1
- 006238 - Uninterruptable Power Supply UPS
- 006239 - Rear EPI Contactor Panel
- 006240 - Panel HC
- 006241 - Transformer TR
- 006242 - Transformer TD
- 006243 - Transformer TE
- 006244 - Panel LX
- 006245 - Panel LY
- 006246 - Panel LW

Customer: ACME COMPANY | Site: 2801 LIBERTY AVE. | Agreement Number: t-1009

Tag ID: 006225 | Equipment Type: Individual Molded Case Breakers > 400A

Customer Identification: Panel HB Breaker | Uncorrected Problems: None

Nameplate | Variables | Problems | Customer Comments | Variable History

Attachments | Baseline Visual Images | Baseline IR Images

Nameplate

Equipment Type: Individual Molded Case Breakers > 400A

Location: (t) Main Electrical Room

Tag ID: 006228

Specifications:

| Attribute Name | Value | Units |
|---|---|---|
| Working Voltage | 600 | Volts |
| Breaker Type | KDC | Model # |
| Current Rating | 400 | Amps |
| Breaker Frame Rating | 400 | Amps |
| Plug Trip Setting | 10 | Amps |
| AIC Rating | 50 | KAmps |
| Number of Poles | 3 | Poles |
| Trip Unit Catalog Number | KT3400T | Unitless |

**A hazard sign next to the component tag ID indicates there was a problem identified with this piece of equipment.**

VISUAL INSPECTION | ULTRASONIC TESTING | INFRARED TECHNOLOGY | VOLTAGE & CURRENT ANALYSIS | PREVENTIVE MAINTENANCE | ASSET MANAGEMENT

MAIN | How We Do It | TEGG Service | Why We Do It

Assets | Feeds View

Trusted sites | 100%

TEGGPRO

Press "F11" to switch to full screen view | Feedback | User Preferences | Change Password | Log

Logged in as: Michelle Se

TEGG Maintenance Manager | Administration | Activities And Schedule | Companies | Proposal Log | Equipment | Document Site Visit | Tasking | Site Visit | Reports | Document Library

ACME COMPANY-2801 Liberty Ave
10/13/2009-10/25/2009 - Completed

Assets

Show Search Options
Legend

Location: All Locations

- ATS-0547 - APS-101 ATS-A2 Bus B 1200 Amp
- ATS-0553 - APS-107 ATS-A1 Bus A 1200 Amp
- ATS-0572 - Switch E 150 Amp
- BCP-0501 - Panel N 225 Amp
- BCP-0502 - Panel N-1 225 Amp
- BCP-0503 - Panel B 225 Amp
- BCP-0504 - Panel B-1 400 Amp
- BCP-0505 - Panel B-2 400 Amp
- BCP-0506 - Panel M 600 Amp
- BCP-0507 - Panel M-1 600 Amp
- BCP-0520 - Panel A-1 225 Amp
- BCP-0529 - Panel A 225 Amp MLO
- BCP-0530 - Panel A-2 600 Amp MLO
- BCP-0531 - Panel A-3 250 Amp MLO
- BCP-0532 - Panel AP-1L 400 Amp
- BCP-0533 - Panel AP-1R 400 Amp
- BCP-0566 - Panel AM 600 Amp
- BCP-0574 - Panel ER 125 Amp

Asset | Tasking

Assets - Fed By / Feeds View

Customer: ACME COMPANY | Site: 2801 LIBERTY AVE. | Agreement Number: t-1009

Tag ID: 006225 | Equipment: Individual Molded Case Breakers > 400A

Customer Identification: Panel HB Breaker | Uncorrected Problems: None

Nameplate | Visual Inspection | Safety | Tasking Instructions | Tasking | Variables | Problems | Technician Comments | Customer Comments

Variable History | Panel Legend | Fed By / Feeds | Contains | Attachments | Baseline Visual Images | Baseline IR Images

Problems

View Problem | Problem Images

| Corrected | Severity | Date Found | Date Corrected | Problem Class | Category | Description |
|---|---|---|---|---|---|---|
| Yes | Severe | 8/10/2006 | | IR | HEAT | "B" Phase breaker contact is displaying abnormal thermal pattern compared to "A" and "C" Phase contact and elevated contact resistance is confirmed by millivolt measurements. (Also Ultrasound noise was picked up on the breaker.) |
| No | | 2/24/2004 | | Electrical | EQUIPMENT | Inadequate working space. (NEC Sec. 110.26 a thru f) |
| No | Alert | 9/3/2008 | | IR | HEAT | Circuit has a temperature rise greater that 18 degrees F over the ambient air surrounding it under normal operating conditions. |
| No | Alert | 9/3/2008 | | Electrical | HOUSEKEEPING | Foreign debris and materials stored about electrical equipment and encroachin on the 36 inch clearance requirement. |
| No | Alert | 8/11/2005 | | Electrical | HOUSEKEEPING | Foreign debris and materials stored about electrical equipment and encroachin on the 36 inch clearance requirement. |
| Yes | Alert | 8/11/2005 | | IR | HEAT | Breaker contact is displaying abnormal thermal pattern compared similarly load breaker and elevated contact resistance is confirmed by millivolt measurements. |
| No | | | | | | Circuit #16 20Amp 1 pole circuit breaker. Millivolt drop test indicated elevated |
| No | | | | | | |

**The "Problems Tab" will show all problems ever identified for a piece of equipment.**

Customer Identification: Panel HB Breaker | Uncorrected Problems: None

VISUAL INSPECTION | ULTRASONIC TESTING | INFRARED TECHNOLOGY | VOLTAGE & CURRENT ANALYSIS | PREVENTIVE MAINTENANCE | ASSET MANAGEMENT

MAIN | How We Do It | TEGG SERVICE | Why We Do It

http://live.teggpro.com/?pagetype=edit&imageid=401066&equipmentid=401551&sitevisitid=400331&con - Microsoft Internet Explorer p

**Problem Lookup:**

Select Template...

**Problem Description:**

Circuit #16 20Amp 1 pole circuit breaker. Millivolt drop test indicated elevated contact resistance with 98 mv at 7.75amps, 202 mv at 80%

**Recommendations:**

Replace Circuit Breaker. Reverify with IR scan and millivolt drop test.

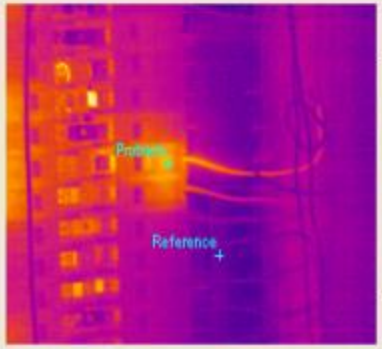
**Tag ID:** BCP-0503

**Equipment Type:** Branch Circuit Panel <= 400 amp

**Item Description:** Panel B 225 Amp

**IR Image**

Similar Ambient Indirect




84.7°F
80
75
70
69.3°F

**Image #:** 102701

C F **Prob:** 80.67 **Ref:** 72.92 **Diff:** 7.75 Line Draw

**File:** C:\Program Files\FLIRApplication\tempfiles\J1027-01.img

Associated Image

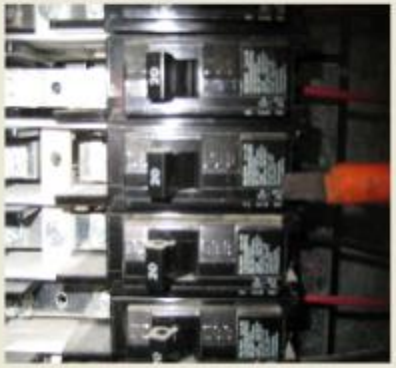


**Image #:** 2784

**File:** C:\Program Files\FLIRApplication\tempfiles\IMG_2784.JPG

Problem Measurements | Image Analysis | Severity Criteria

| Variables | Phase A | Phase B | Phase C |
|---|---|---|---|
| Circuit Number | Not Applicable | 16 | Not Applicable |
| Current Rating (Amps) | Not Applicable | 7.75 | Not Applicable |
| Current Draw (Amps) | Not Applicable | 20 | Not Applicable |
| THDC (%THD-F) | Not Applicable | 4 | Not Applicable |
| Voltage Drop (Volts) | Not Applicable | .098 | Not Applicable |

N/A

U/O

- [ ] Problem was corrected
- [ ] Tightened/Torqued Connection
- [ ] Excessive Current Harmonics
- [ ] Corroded/Discolored
- [ ] Stripped/Cross-threaded Hardware
- [ ] Overloaded C

VISUAL INSPECTION | ULTRASONIC TESTING | INFRARED TECHNOLOGY | VOLTAGE & CURRENT ANALYSIS | PREVENTIVE MAINTENANCE | ASSET MANAGEMENT

MAIN | How We Do It | TEGG Service | Why We Do It

TEGGPRO

Press "F11" to switch to full screen view | Feedback | User Preferences | Change Passw

Logged in as: M

TEGG Maintenance Manager | Administration | Activities And Schedule | Companies | Proposal Log | Equipment | Document Site Visit | Tasking | Site Visit | Reports | Document Library

ACME COMPANY-2801 Liberty Ave
10/13/2009-10/25/2009 - Completed

Assets

Show Search Options
Legend

Location: All Locations

- ATS-0547 - APS-101 ATS-A2 Bus B 1200 Amp
- ATS-0553 - APS-107 ATS-A1 Bus A 1200 Amp
- ATS-0572 - Switch E 150 Amp
- BCP-0501 - Panel N 225 Amp
- BCP-0502 - Panel N-1 225 Amp
- BCP-0503 - Panel B 225 Amp
- BCP-0504 - Panel B-1 400 Amp
- BCP-0505 - Panel B-2 400 Amp
- BCP-0506 - Panel M 600 Amp
- BCP-0507 - Panel M-1 600 Amp
- BCP-0520 - Panel A-1 225 Amp
- BCP-0529 - Panel A 225 Amp MLO
- BCP-0530 - Panel A-2 600 Amp MLO
- BCP-0531 - Panel A-3 250 Amp MLO
- BCP-0532 - Panel AP-1L 400 Amp
- BCP-0533 - Panel AP-1R 400 Amp
- BCP-0566 - Panel AM 600 Amp
- BCP-0574 - Panel ER 125 Amp

Customer: ACME COMPANY | Site: 2801 LIBERTY AVE. | Agreement Number: t-1009

Tag ID: 006225 | Equipment Type: Individual Molded Case Breakers > 400A

Customer Identification: Panel HB Breaker | Uncorrected Problems: None

Nameplate | Visual Inspection | Safety | Tasking Instructions | Tasking | Variables | Problems | Technician Comments | Customer

Variable History | Fed By / Feeds | Contains | Attachments | Baseline Visual Images | Baseline IR

Current Variables

Save

| Variable Name / Unit | Value | Comments | Test Mode |
|---|---|---|---|
| RMS Voltage Phase A-B / Volts | 486.9 | | |
| THDV % Phase A-B / %THD | 1.5 | | |
| RMS Current Phase A / Amps | 312 | | |
| THDC % Phase A / %THD | 3.1 | | |
| RMS Voltage Phase B-C / Volts | 484.4 | | |
| THDV % Phase B-C / %THD | 1.4 | | |
| RMS Current Phase B / Amps | 270.5 | | |
| THDC % Phase B / %THD | 4.9 | | |
| RMS Voltage Phase C-A / Volts | 484.4 | | Energized |
| THDV % Phase C-A / %THD | 1.5 | | Energized |
| RMS Current Phase C / Amps | 294.5 | | Energized |
| THDC % Phase C / %THD | 3.9 | | Energized |
| RMS Voltage Phase A-Neutral / Volts | 281.2 | | Energized |
| THDV % Phase A-Neutral / %THD | 1.4 | | Energized |

**The "Variables Tab" allows you to view all the information ("readings") captured during any of our visits.**

VISUAL INSPECTION | ULTRASONIC TESTING | INFRARED TECHNOLOGY | VOLTAGE & CURRENT ANALYSIS | PREVENTIVE MAINTENANCE | ASSET MANAGEMENT

MAIN | How We Do It | TEGG SERVICE | Why We Do It

Done | Trusted sites

# Electronic Panel Schedules

TEGGPRO

Press "F11" to switch to full screen view | Feedback | User Preferences | Change Password | L

Logged in as: Michelle

TEGG Maintenance Manager | Administration | Activities And Schedule | Companies | Proposal Log | Equipment | Document Site Visit | Tasking | Site Visit | Reports | Document Library

ACME COMPANY-2801 Liberty Ave
10/13/2009-10/25/2009 - Completed

Assets

Show Search Options
Legend

Location: All Locations

- ATS-0547 - APS-101 ATS-A2 Bus B 1200 Amp
- ATS-0553 - APS-107 ATS-A1 Bus A 1200 Amp
- ATS-0572 - Switch E 150 Amp
- BCP-0501 - Panel N 225 Amp
- BCP-0502 - Panel N-1 225 Amp
- BCP-0503 - Panel B 225 Amp
- BCP-0504 - Panel B-1 400 Amp
- BCP-0505 - Panel B-2 400 Amp
- BCP-0506 - Panel M 600 Amp
- BCP-0507 - Panel M-1 600 Amp
- BCP-0520 - Panel A-1 225 Amp
- BCP-0529 - Panel A 225 Amp MLO
- BCP-0530 - Panel A-2 600 Amp MLO
- BCP-0531 - Panel A-3 250 Amp MLO
- BCP-0532 - Panel AP-1L 400 Amp
- BCP-0533 - Panel AP-1R 400 Amp
- BCP-0566 - Panel AM 600 Amp
- BCP-0574 - Panel ER 125 Amp

Customer: ACME COMPANY
Tag ID: 006
Customer Identification: Pan

Nameplate | Visual Inspection | Safet
Variable History | Panel Legend | Fed By / Feeds | Contains | Attachments | Baseline Visual Images | Baseline IR Images

Equipment Item

1 PB | 2 PB | 3 PB | 1 PC | 2 PC | 3 PC | Trash | Print

NOTE: You must set the 'Possible Circuits' first if the panel is blank.

Single | Fill All | Default Amps: 20 | Possible Circuits: 16 | Set

Add new circuit | Refresh

| Position | A/B | Amps | Circuit Description |
|---|---|---|---|
| 1 | | 20 | Room 103 Work S... |
| 3 | | 20 | Room 103 Work S... |
| 5 | | 20 | Room 103 Work S... |
| 7 | | 20 | Room 103 Work S... |
| 9 | | 20 | Walker Duct |
| 11 | | 20 | Walker Duct |
| 13 | | 20 | Walker Duct |
| 15 | | 20 | Walker Duct |
| 17 | | 20 | Room 103 Work S... |
| 19 | | 20 | Room 103 Work S... |
| 21 | | 20 | Room 103 Work S... |
| 23 | | 20 | Room 103 Work S... |
| 25 | | 20 | EWH-2 |
| 27 | | 20 | Reference and Re... |
| 29 | | 20 | Tech-Teller Testing |
| 31 | | 20 | Receptacles 103, ... |
| 33 | | 20 | Receptacles 103,1... |
| 35 | | | |
| 39 | | | |

Add new circuit | Refresh

| Circuit Description | Amps | A/B | Position |
|---|---|---|---|
| Receptacle 105, 126 | 20 | | 2 |
| Receptacle Outsid... | 20 | | 4 |
| Receptacle Outsid... | 20 | | 6 |
| Receptacle 201 | 20 | | 8 |
| Receptacle 201 | 20 | | 10 |
| Receptacle 115 | 20 | | 12 |
| Receptacle 115 | 20 | | 14 |
| Receptacle 115, 149 | 20 | | 16 |
| Receptacle 115 | 20 | | 18 |
| Room 133 & Roo... | 20 | | 20 |
| Lights 110 | 20 | | 22 |
| Lights 110 | 20 | | 24 |
| Lights 201 | 20 | | 26 |
| Lights 201 | 20 | | 28 |
| Lights 103 | 20 | | 30 |
| Receptacle 103, 1... | 20 | | 32 |
| Lights 113 | 20 | | 34 |
| Fan Printer Room | 20 | | 36 |

VISUAL INSPECTION | ULTRASONIC TESTING | INFRARED TECHNOLOGY | VOLTAGE & CURRENT ANALYSIS | PREVENTIVE MAINTENANCE | ASSET MANAGEMENT

MAIN | How We Do It | TEGG SERVICE | Why We Do It

Trusted sites | 100%

# 2 atoms are walking down the street……..

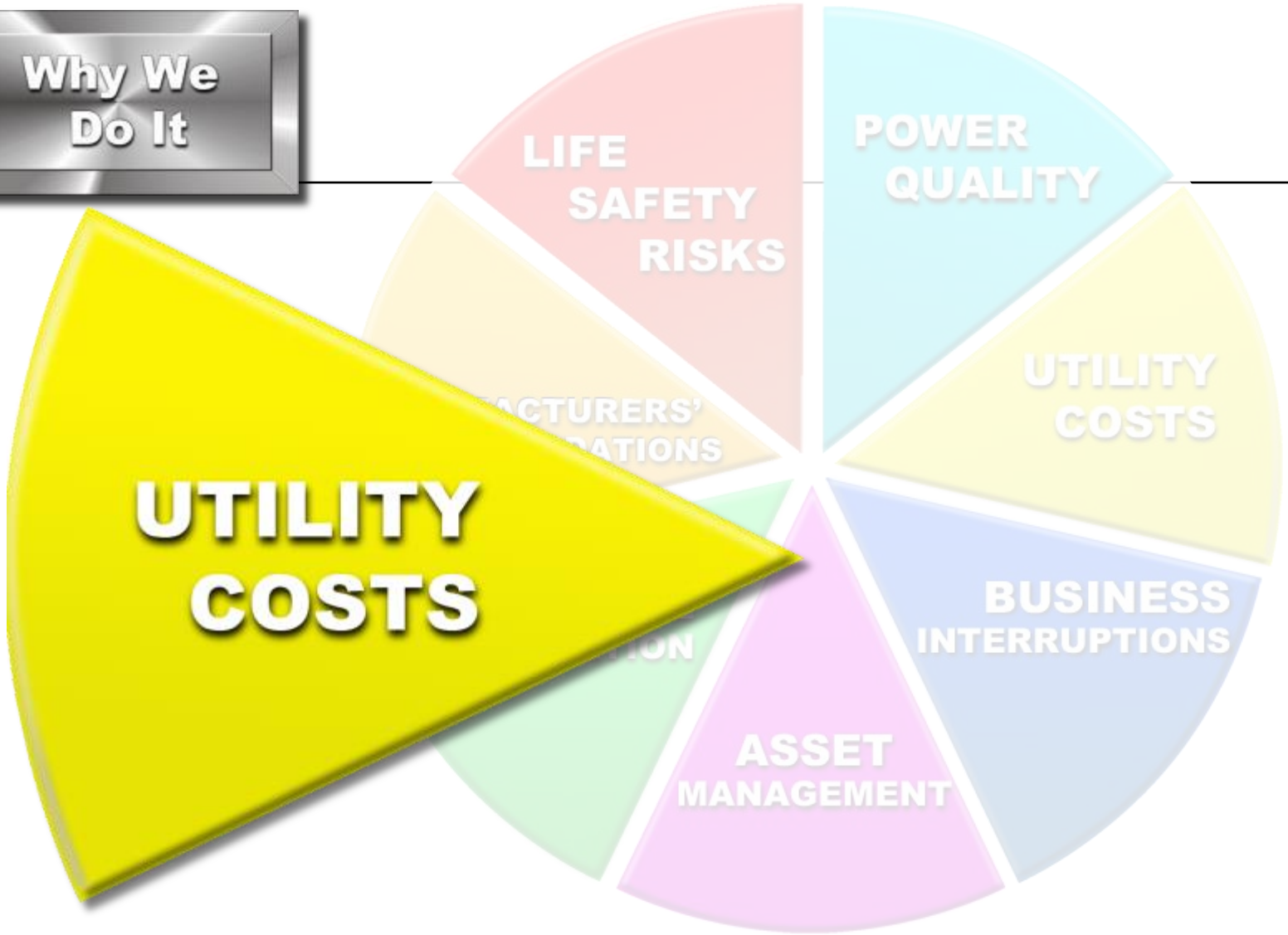
- One says to the other, ‘I lost an electron’
- The other says, ‘are you sure?’
- First one answers, ‘yes, I’m positive’

# Improving Asset Management Effects on Bottom Line

| RESULTS ABERDEEN GROUP SIGMA RELIABILITY STUDY | | | |
|---|---|---|---|
| | LOWER QUARTILE PERFOMERS | AVERAGE PERFORMERS | UPPER QUARTILE PERFORMERS |
| AVAILABILITY | 81.8 | 87.2 | 88.8 |
| YIELD | 79.2 | 81.9 | 84.2 |
| MAINT COSTS/SALES | 23.5 | 20.8 | 17.2 |

| INCOME STATEMENT | | | |
|---|---|---|---|
| SALES | 1,000,000,000 | 1,102,356,079 | 1,154,108,320 |
| COSTS | | | |
| COGS (assume 60%) | 600,000,000 | 661,413,647 | 692,464,992 |
| MAINTENANCE COSTS | ***235,000,000*** | ***229,290,064*** | ***198,506,631*** |
| FIXED COSTS | 100,000,000 | 100,000,000 | 100,000,000 |
| TOTAL COSTS | 935,000,000 | 990,703,711 | 990,971,623 |
| | | | |
| **EBITDA** | 65,000,000 | 111,652,368 | 163,136,697 |
| **EBITDA AS % OF LOWER QUARTILE PERFORMERS** | **100%** | **172%** | **251%** |

# Why We Do It


LIFE SAFETY RISKS
POWER QUALITY
UTILITY COSTS
BUSINESS INTERRUPTIONS
ASSET MANAGEMENT
UTILITY COSTS

# From NEMA standard MG1-14.35

- A 5.4% unbalance would result in an expected life of only 1/16 of normal due to the additional 40°C rise
- When unbalance exceeds only 1%, a motor must be de-rated for it to operate successfully; at the 5% limit established by NEMA for unbalance, a motor would be substantially derated to only about 75% of its nameplate horsepower rating.

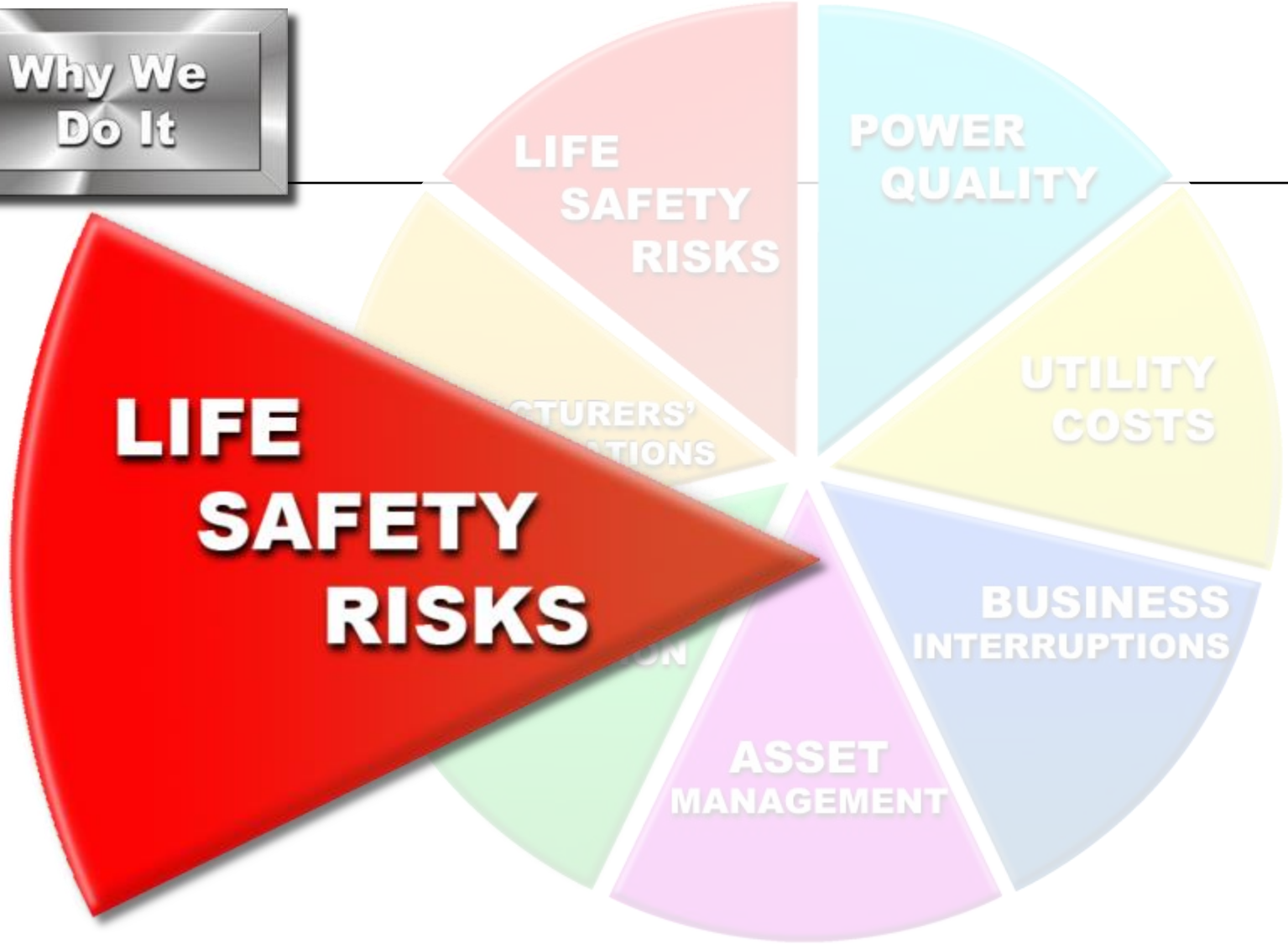
***The Cascading Effect:***

Imbalances exceeding 1% leads to overheating and loss of torque leads to significantly higher power consumption leads to horsepower de-rating leads to more overheating and higher power consumption and finally to premature failure

# Reference the First Law of Thermodynamics

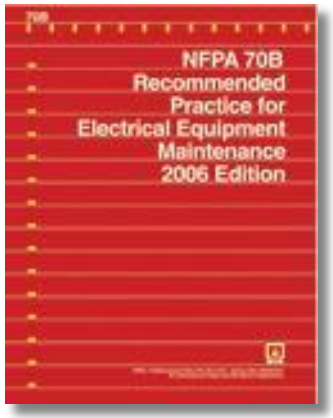
- Every hot spot consumes energy that should be doing work
- Every device with a winding heating up due to harmonics or poor power quality is losing energy
- Elevated contact resistance, whether detected by ultrasonic or infrared, is wasting energy

# Why We Do It


LIFE SAFETY RISKS
POWER QUALITY
UTILITY COSTS
BUSINESS INTERRUPTIONS
ASSET MANAGEMENT
LIFE SAFETY RISKS

# National Fire Protection Association

***"A well-administered electrical preventive maintenance program will reduce accidents, save lives, minimize costly breakdowns and unplanned shutdowns of equipment."***




**Source: National Fire Protection Association, NFPA-70B**

# *"Overheating caused by harmonic current is a threat to safety because of its potential to cause fires."*

**Source: *NFPA Journal*, National Fire Protection Association**

# THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO.

***The following equipment is ranked by frequency of loss claims, accounts for the most common equipment breakdowns and includes exposures found in <u>every</u> business and organization.***

***1. ELECTRICAL EQUIPMENT (ALL TYPES)***
***2. Air conditioning and refrigeration***
***3. Boilers, pressure vessels and piping***
***4. Machinery (all types)***
***5. Computer equipment***
***6. Motors (including air conditioning)***
***7. Pumps***
***8. Telecommunications***

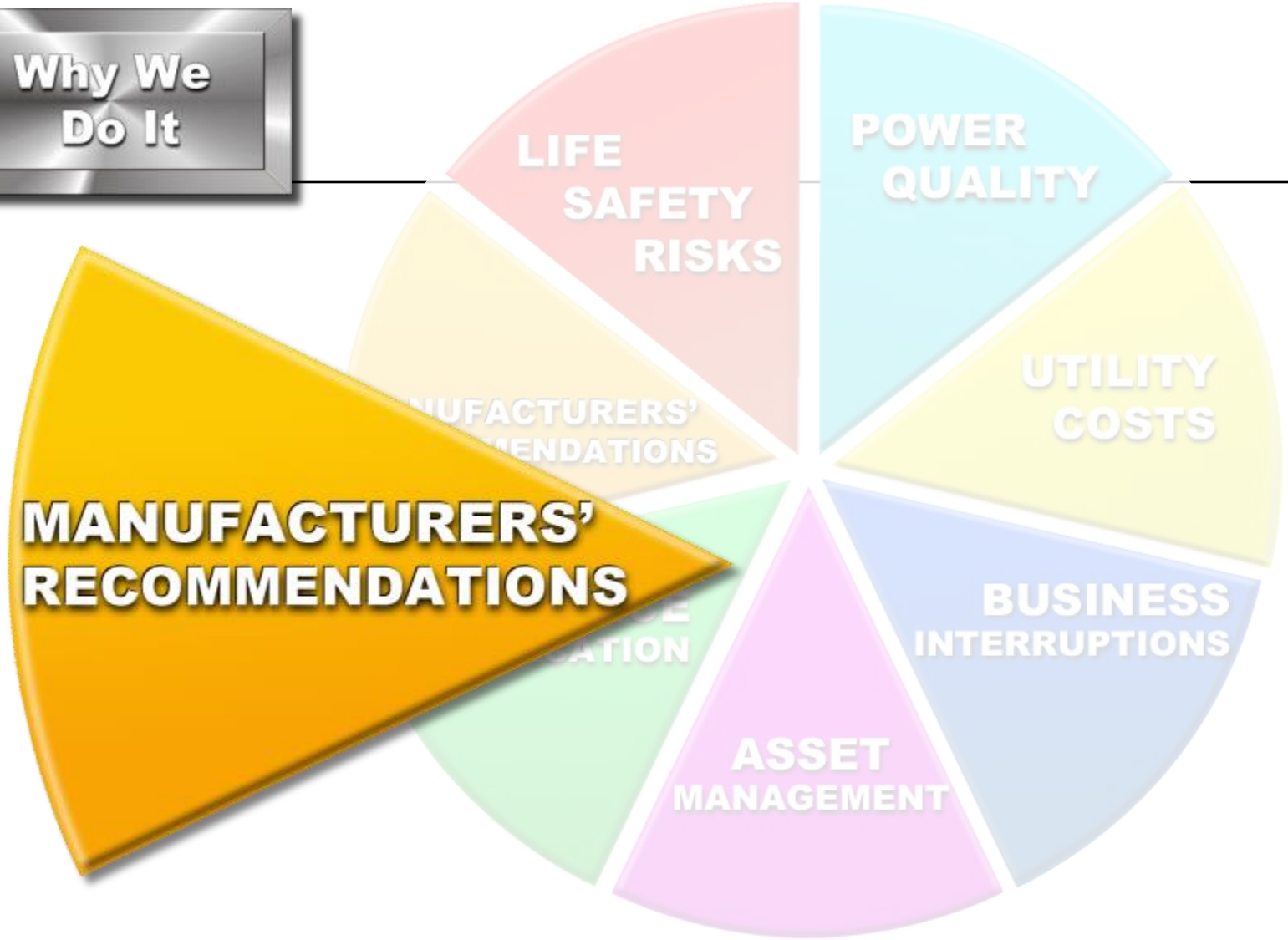
Whistle Stop Newsletter, Published by the Hartford Steam Boiler Inspection and Insurance Co., Hartford, CT, June 2003; HSB Is a leading global equipment breakdown insurer and reinsurer.

# Electrical Incident Summary

- The % of OSHA reported incidents from electrical hazards that resulted in serious injury or death is >30% of all reported incidents involving injury, serious injury, or death

- So when it happens, ***look out!***

# Why We Do It


LIFE SAFETY RISKS
POWER QUALITY
UTILITY COSTS
BUSINESS INTERRUPTIONS
ASSET MANAGEMENT
MANUFACTURERS' RECOMMENDATIONS

## SECTION 7—
## MAINTAINING THE SWITCHBOARD

**⚠ DANGER**

**HAZARD OF ELECTRIC SHOCK, BURN, OR EXPLOSION**

- Inspect and perform preventive maintenance only on switchboards and equipment to which power has been turned to the OFF position, disconnected, and electrically isolated (unless otherwise specified) so that no accidental contact can be made with energized parts.
- Follow safety related work practices as described in NFPA 70E, Part II at all times.

**Failure to follow these instructions will result in death or serious injury.**

Periodic maintenance on the switchboard includes cleaning, lubrication, and exercising component parts. The interval between maintenance checks can vary depending upon the amount of usage and environmental conditions of each installation. The maximum recommended inspection interval is one year. This definition for periodic maintenance applies throughout this manual, unless otherwise noted.

Always inspect the switchboard after a fault. (Refer to "Section 8—Adverse Circumstances", beginning on page 30). Service bulletins for the various disconnecting and overcurrent devices mounted in the switchboard are available through your local Square D field office.

**General Inspection and Cleaning**

1. Vacuum the switchboard interior to remove any dirt or dust deposits. Wipe all bus bars, insulators, cables, and so forth, with a clean, dry, lint-free cloth.
2. Check the switchboard interior carefully for moisture, condensation build-up, or signs of any previous wetness. Moisture can cause insulation failures and rapid oxidation of current carrying parts. Inspect all conduit entrances and cracks between the enclosure panels for dripping leaks. Condensation in conduits may be a source of moisture and must not be allowed to drip onto live parts or insulating material. Take the necessary steps to eliminate the moisture and seal off all leaks.
3. Inspect the switchboard for any signs of overheating. Discoloration and flaking of insulation or metal parts are indications of overheating.
   *NOTE: If overheating occurs, be sure that all conditions that caused the overheating have been corrected. Loose or contaminated connections can cause overheating.*
4. Check for signs of rodent nesting in the switchboard. If required, use a good exterminating technique in the general area of the switchboard.
   *NOTE: Do not place or use exterminating substances and chemicals inside the switchboard. Some of these products attract rodents.*
5. Carefully inspect all devices for any visibly worn-out, cracked, or missing parts.
6. Manually open and close switches and circuit breakers several times to verify they are working properly.
7. Verify that all key interlocks and door interlocking provisions are working properly.

**CAUTION**

**HAZARD OF EQUIPMENT DAMAGE**

- Do not use an air hose to blow out the switchboard. The dust may settle inside relays and overcurrent devices, causing overheating and improper operation.
- Do not allow paint, chemicals, or petroleum-based solvents to contact plastics or insulating materials.

**Failure to follow these instructions can result in equipment damage.**



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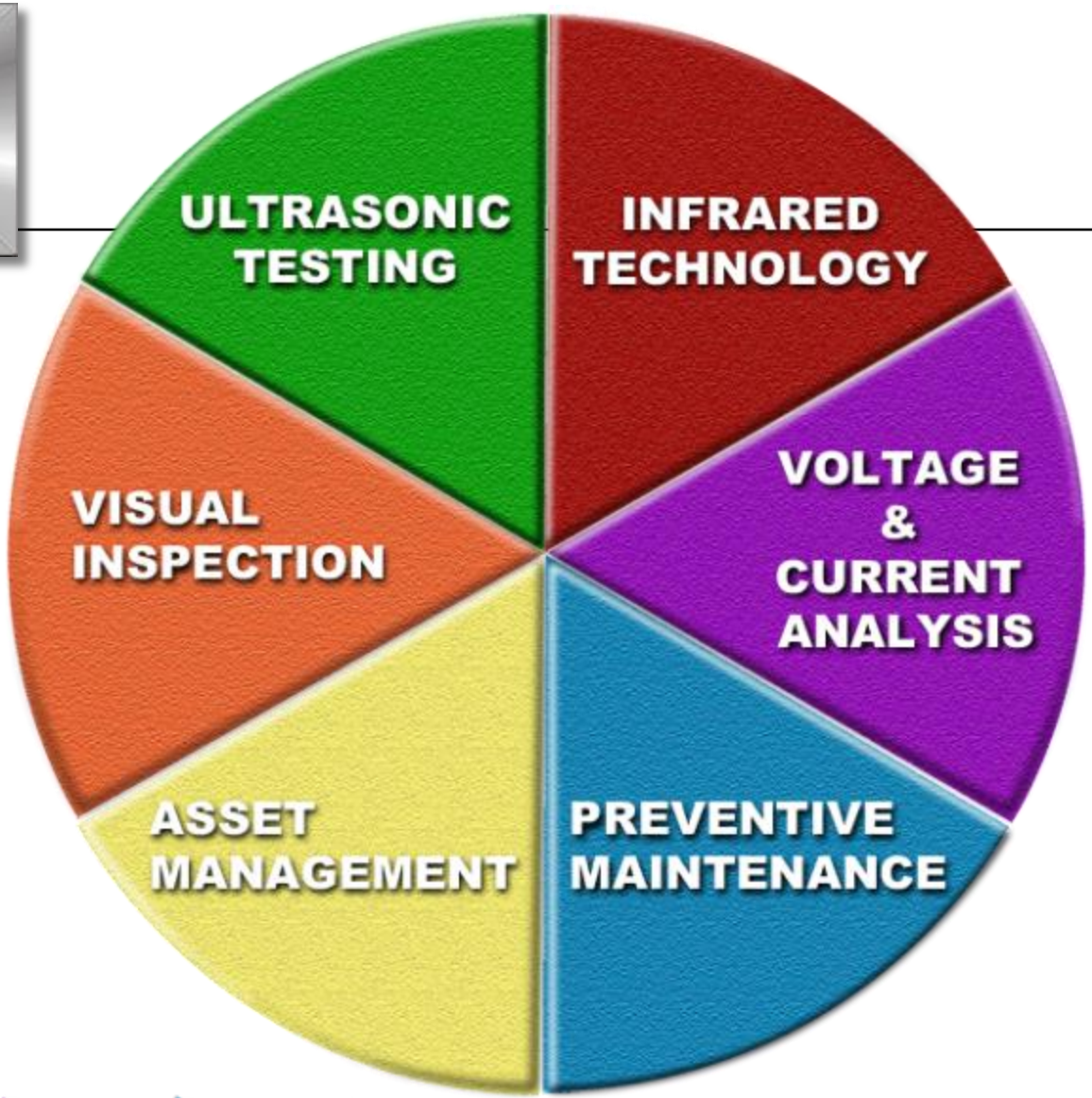
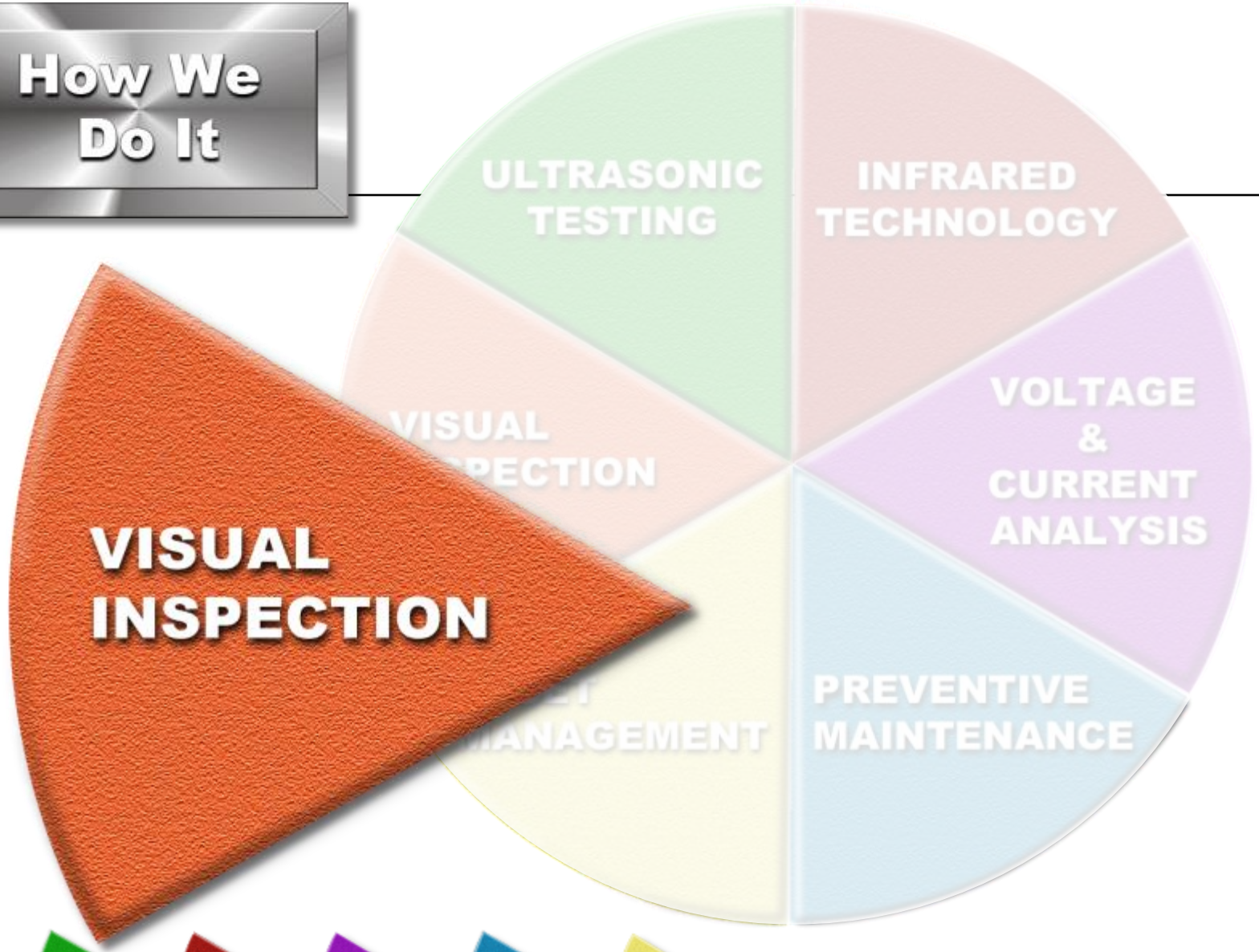
"Periodic maintenance on the switchboard includes cleaning, lubrication and exercising component parts. The interval between maintenance checks can vary depending upon the amount of usage and environmental conditions of each installation. **The maximum recommended inspection interval is one year. This definition for periodic maintenance applies throughout this manual unless otherwise noted."**

# How We Do It




VISUAL INSPECTION
ULTRASONIC TESTING
INFRARED TECHNOLOGY
VOLTAGE & CURRENT ANALYSIS
PREVENTIVE MAINTENANCE
ASSET MANAGEMENT
MAIN
How We Do It
TEGG SERVICE
Why We Do It

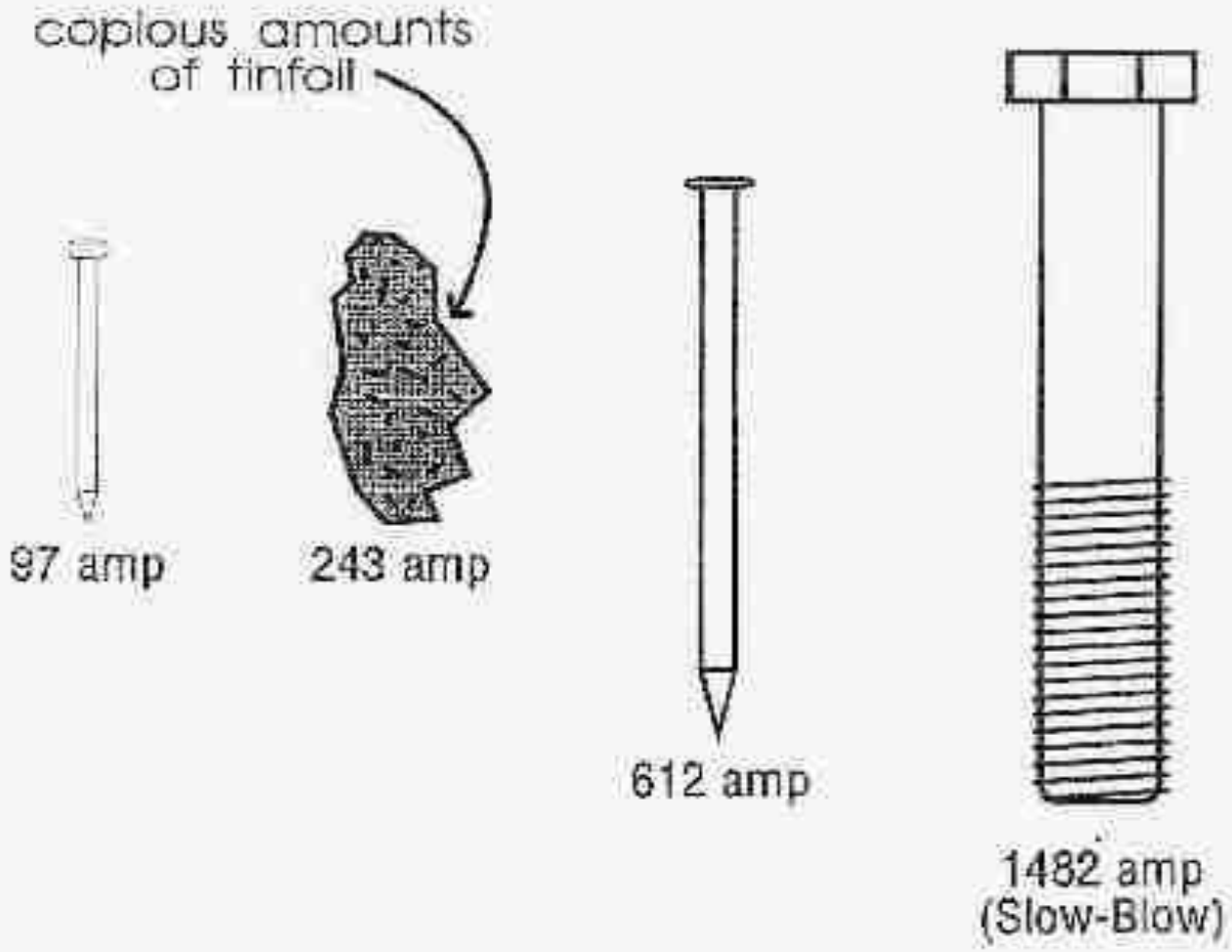
# How We Do It




VISUAL INSPECTION | ULTRASONIC TESTING | INFRARED TECHNOLOGY | VOLTAGE & CURRENT ANALYSIS | PREVENTIVE MAINTENANCE | ASSET MANAGEMENT

MAIN | How We Do It | TEGG Service | Why We Do It

# Guide to Fuse Replacement



# WARNING: Dust can be a CONDUCTOR!

**PLEASE REMEMBER:**
**What you see on the <u>OUTSIDE</u> of electrical equipment is also on the <u>INSIDE</u> of the equipment.**

***When was the last time your electrical equipment was opened and cleaned?***

# VISUAL INSPECTION

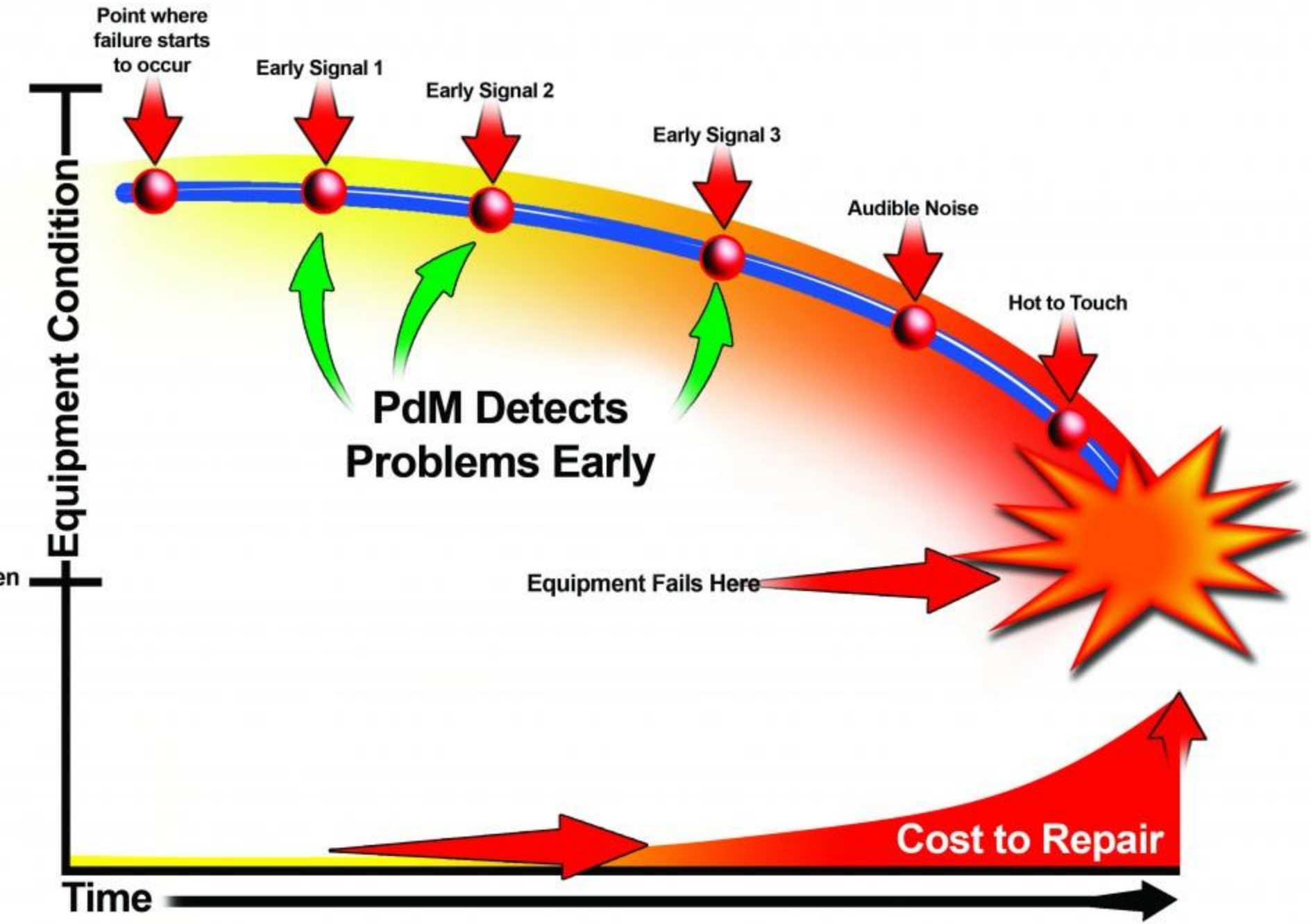
## Examples of Code Concerns

Missing bushings can cut insulation.

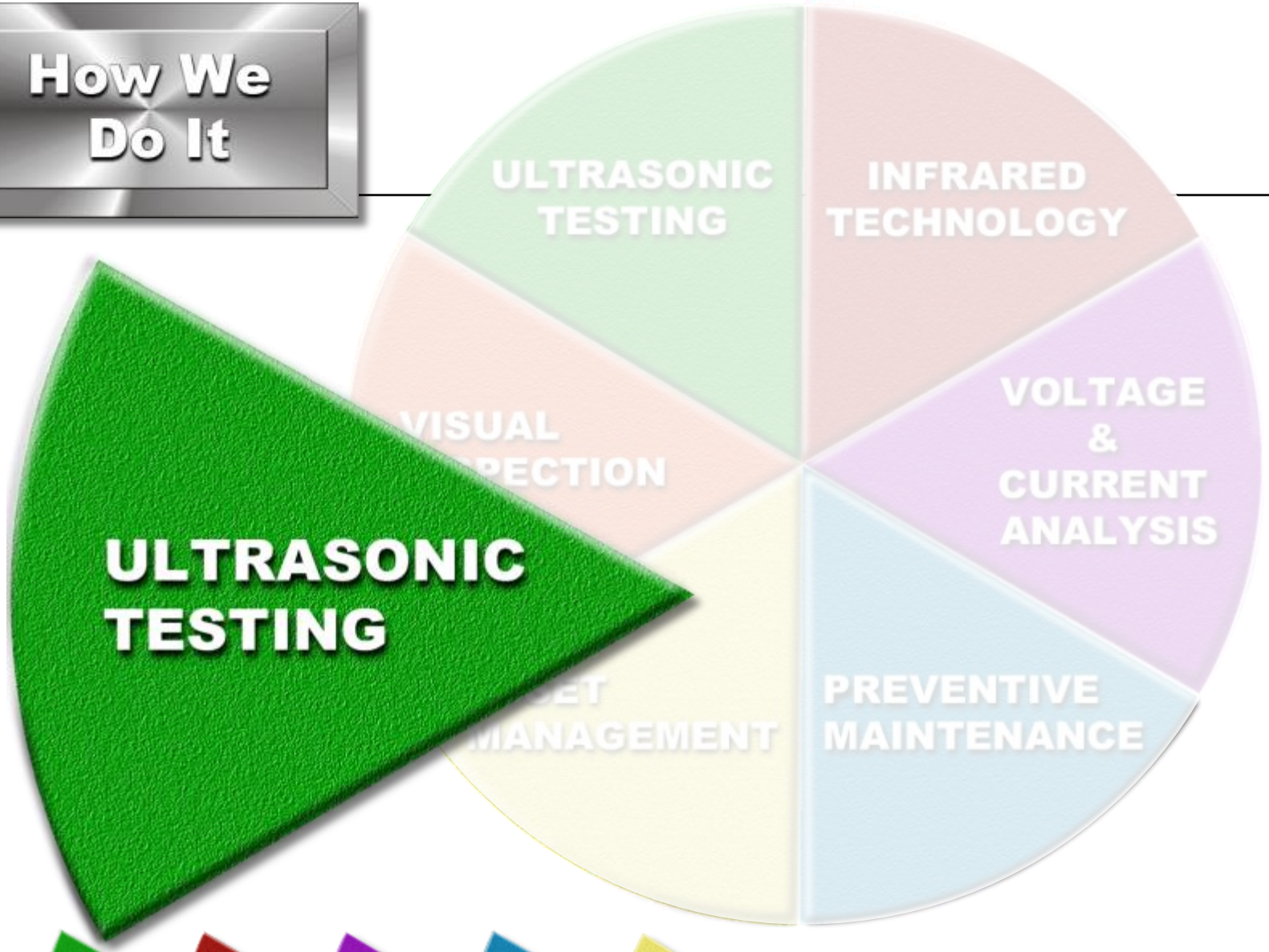
Missing knockouts and fuse storage.

Inadequate working space.

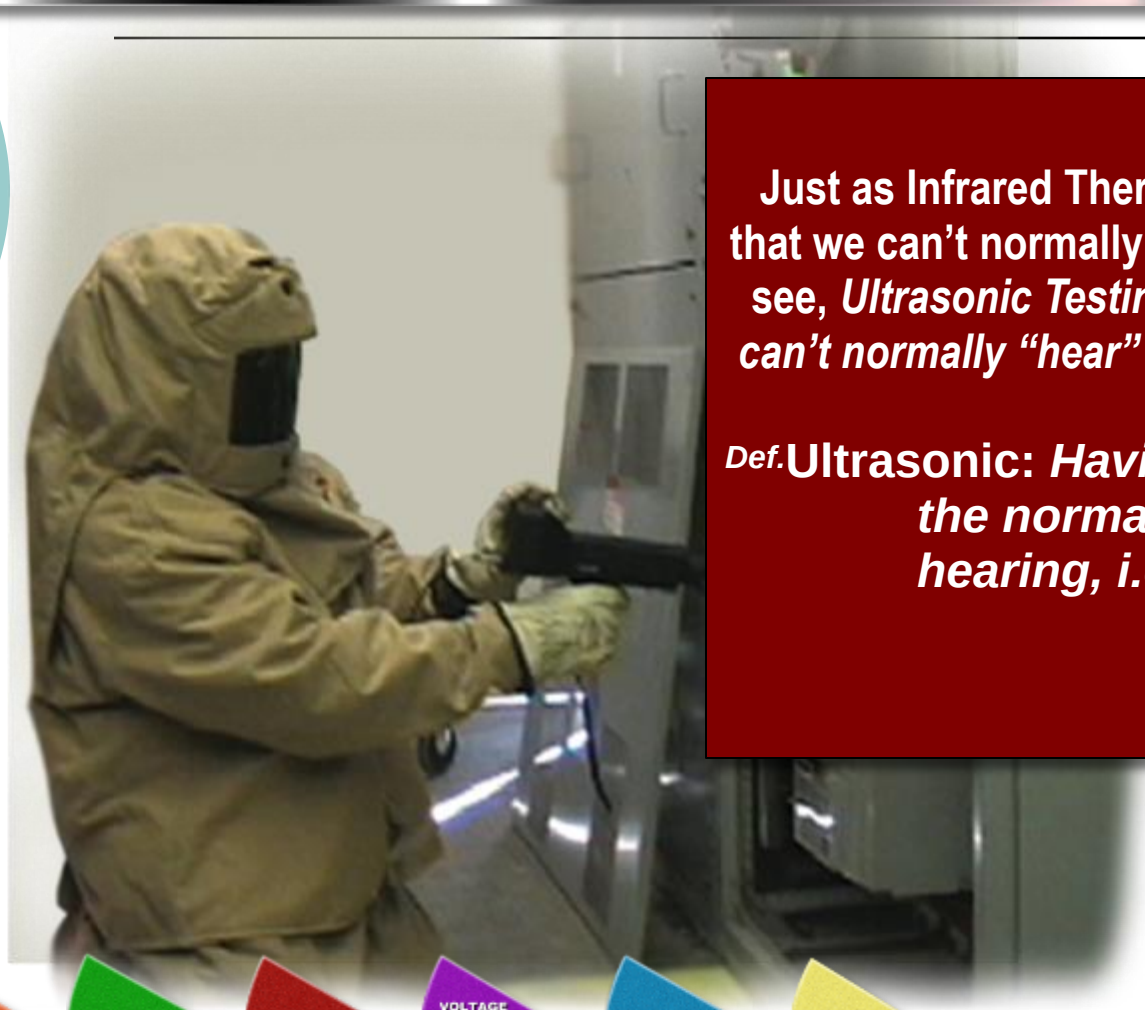
'Double Lugging'


Point where failure starts to occur
Early Signal 1
Early Signal 2
Early Signal 3
Audible Noise
Hot to Touch
PdM Detects Problems Early
Equipment Fails Here
Equipment Condition
Cost to Repair
Time

# How We Do It


ULTRASONIC TESTING
INFRARED TECHNOLOGY
VOLTAGE & CURRENT ANALYSIS
PREVENTIVE MAINTENANCE
VISUAL
PECTION
ET
MANAGEMENT
ULTRASONIC TESTING

# ULTRASONIC TESTING

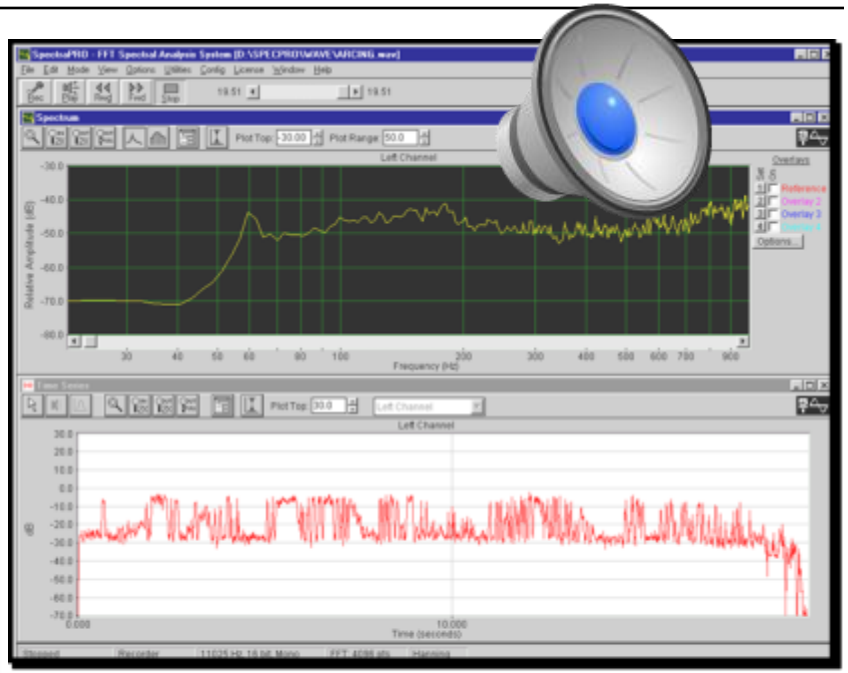


Just as Infrared Thermography converts colors that we can't normally "see" to colors that we can see, *Ultrasonic Testing converts sounds that we can't normally "hear" to sounds that we can hear.*

*Def.* Ultrasonic: *Having frequencies above the normal range of human hearing, i.e., higher than ~20kHz.*

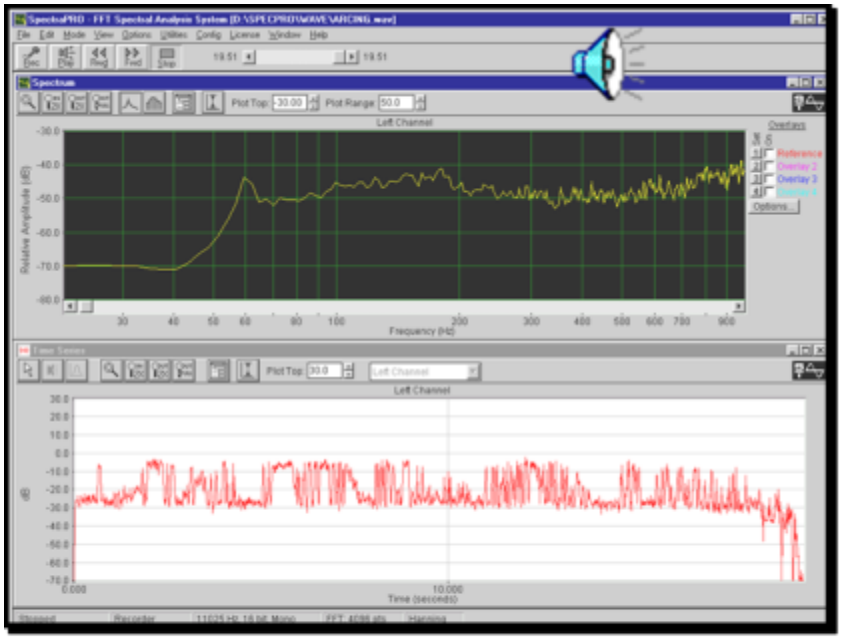
# ULTRASONIC TESTING

*"Ultrasound will hear arcing in circuit breakers, switches, contacts and relays. In most instances, a quick scan of a door seal or vent will detect the ultrasound emission."*



# ULTRASONIC TESTING

*"Destructive corona has a build up and drop-off of energy resulting in a buzzing sound accompanied by subtle popping noises."*



VISUAL INSPECTION | ULTRASONIC TESTING | INFRARED TECHNOLOGY | VOLTAGE & CURRENT ANALYSIS | PREVENTIVE MAINTENANCE | ASSET MANAGEMENT

MAIN | How We Do It | TEGG SERVICE | Why We Do It

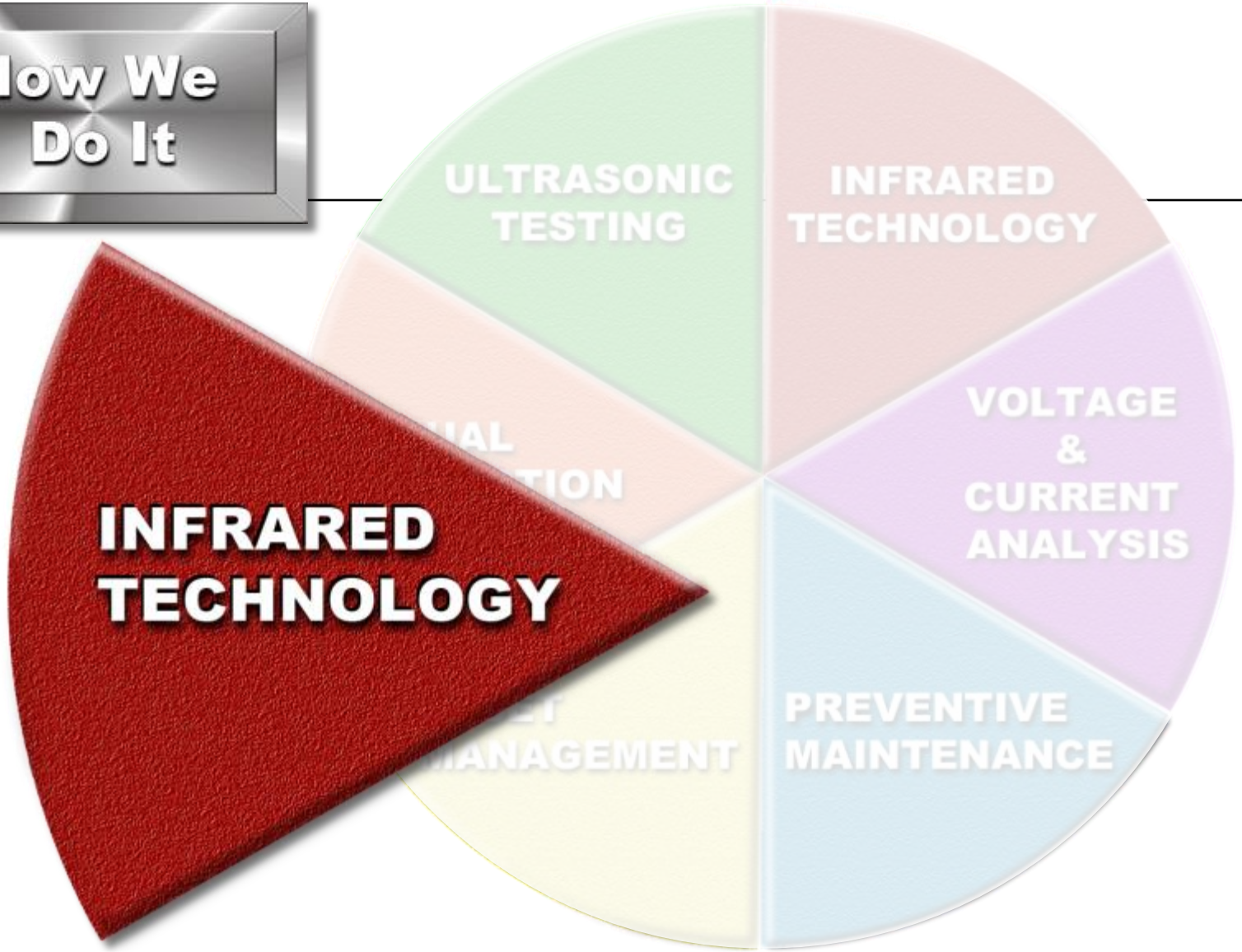
# Details on destructive corona

- UT will ‘hear’ corona, naturally occurring in transformers; UT will also ‘hear’ it when it becomes excessive & destructive
- Corona creates ozone and also ionizes nitrogen, creating nitric acid
- Ozone breaks down insulating cements resulting in internal flash-overs
- Nitric acid creates micro-arcing which in turn creates carbon tracks across insulating materials

# Why do Transformers Hum?

you know this one…

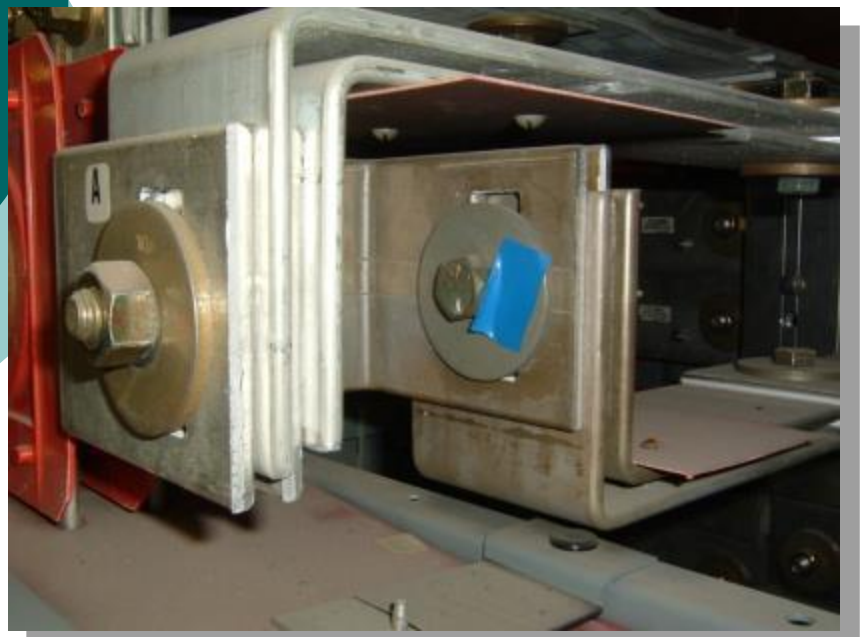
# How We Do It

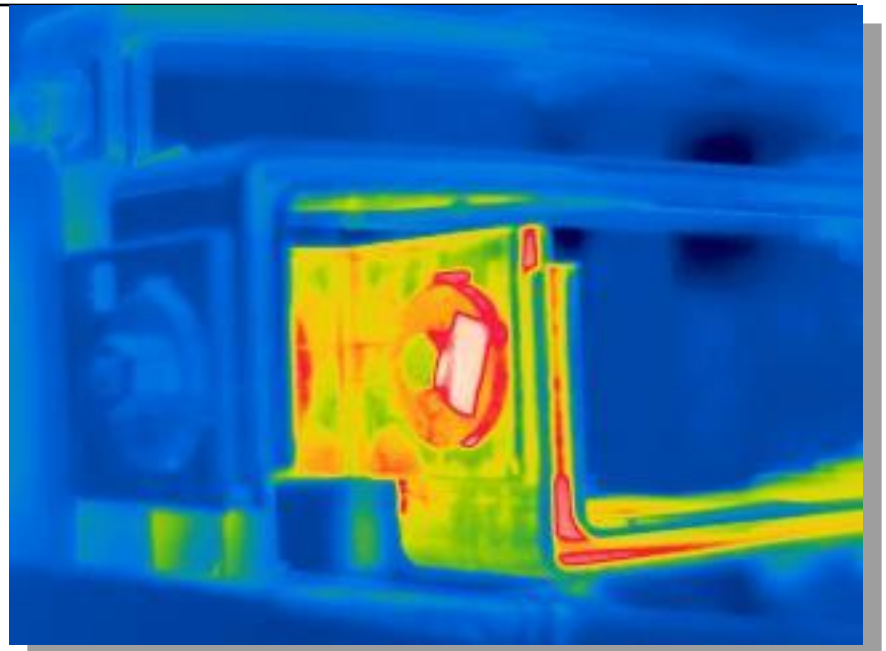



VISUAL INSPECTION | ULTRASONIC TESTING | INFRARED TECHNOLOGY | VOLTAGE & CURRENT ANALYSIS | PREVENTIVE MAINTENANCE | ASSET MANAGEMENT

MAIN | How We Do It | TEGG Service | Why We Do It

# INFRARED TECHNOLOGY

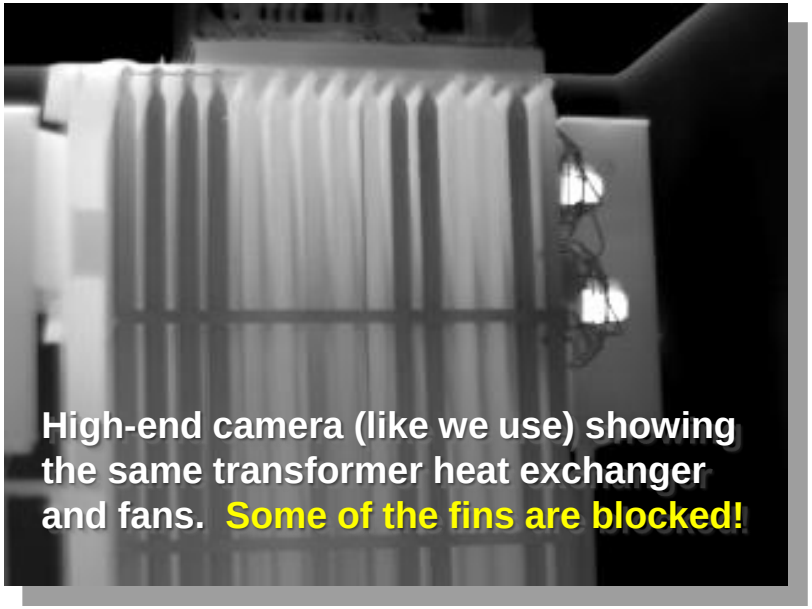




**Example of a high resistance electrical connection.**

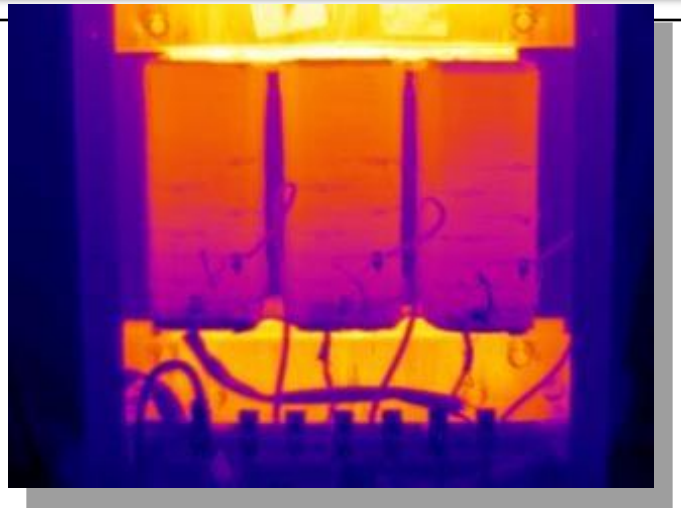
***Def.*** **Infrared:** ***Light waves just outside the visible spectrum, that is, waves slightly longer than those visible to the human eye.***

# INFRARED TECHNOLOGY




**Low-end cameras have lower resolution, which means potential costly problems are less likely to be identified!**

# INFRARED TECHNOLOGY



- ✓ Safety permitting, <u>all covers must be removed</u> to provide a direct line-of-sight to electrical connections.
- ✓ The person removing covers and 'dead fronts' <u>must be QUALIFIED</u> and familiar with the construction & hazards of the equipment.
- ✓ He/she also <u>MUST</u> wear the appropriate arc flash and shock protective equipment based on the risk associated with the task.

# ULTRASONIC TESTING

# Video Demonstration

***Payback for combining IR and UT, and not skipping the root cause analysis and documentation parts of an electrical preventive maintenance program***

Follow this link to watch the video!

http://www.twielectric.com/what-is-tegg/

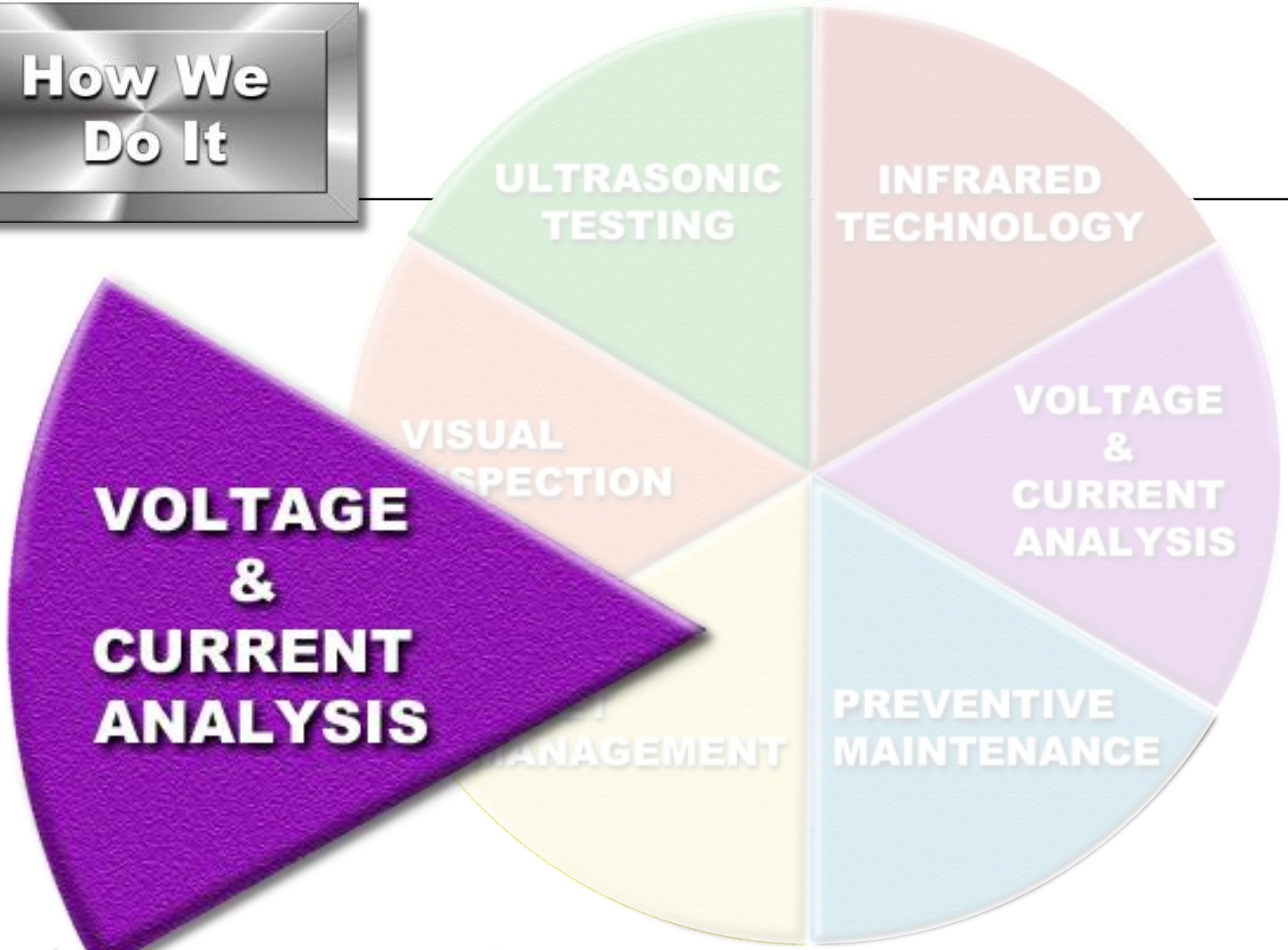
# From the previous video
# Normal Power Consumption

| | | |
|---|---|---|
| Device Current Rating | 90 | amps |
| Measured Current | 64.0 | amps |
| Percent Loaded | 71% | % |
| Max Load (80/100%) | 72.0 | amps |
| mV Drop Measured | 66 | mV |
| mV Drop at Max Load | 74 | mV |
| Contact Resistance | 1031.250 | MicroOhms |
| Pass / Fail | Pass | |
| Max Acceptable Load | 72.0 | amps |
| Wasted Power at Actual Load | 4.22 | watts |
| Wasted Power at 100% Load | 8.35 | watts |
| Price kWh | $0.10 | |
| Cost per Year | $2.69 | Actual |
| Cost per Year | $5.31 | 100% |

# From the previous video
# Excessive Power Consumption

| | | |
|---|---|---|
| Device Current Rating | 90 | amps |
| Measured Current | 64.0 | amps |
| Percent Loaded | 71% | % |
| Max Load (80/100%) | 72.0 | amps |
| mV Drop Measured | 1028 | mV |
| mV Drop at Max Load | 1157 | mV |
| Contact Resistance | 16062.500 | MicroOhms |
| Pass / Fail | Fail | |
| Max Acceptable Load | 6.2 | amps |
| Wasted Power at Actual Load | 65.79 | watts |
| Wasted Power at 100% Load | 130.11 | watts |
| Price kWh | $0.10 | |
| Cost per Year | $41.84 | Actual |
| Cost per Year | $82.75 | 100% |

# How We Do It


ULTRASONIC TESTING
INFRARED TECHNOLOGY
VISUAL INSPECTION
VOLTAGE & CURRENT ANALYSIS
ASSET MANAGEMENT
PREVENTIVE MAINTENANCE
VOLTAGE & CURRENT ANALYSIS

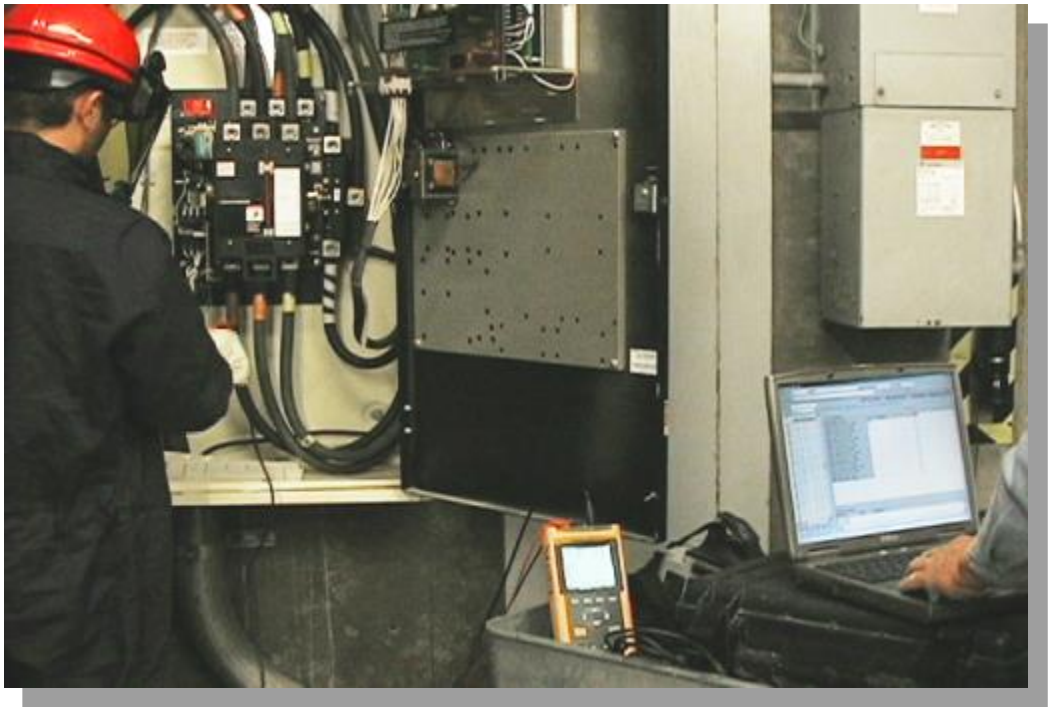
# VOLTAGE & CURRENT ANALYSIS

## MEASUREMENTS TAKEN:

- ✓ Current
- ✓ Voltage
- ✓ Harmonic Distortion

## CHECK FOR:

- ✓ Voltage Imbalance
- ✓ Current Imbalance
- ✓ Voltage Drop
- ✓ THDv>5
- ✓ Ground Conductor Currents
- ✓ Neutral to Ground Voltage
- ✓ Values compared with equipment ratings and tolerances



# VOLTAGE & CURRENT ANALYSIS

Harmonic Distortion indicates the ability of your system to adequately carry non-linear loads.

**EXAMPLES OF NON-LINEAR LOADS:**

- ✓ VFDs, DC Power Supplies, Lighting Ballasts, Computer Power Supplies

**EXAMPLES OF POWER QUALITY PROBLEMS:**

- ✓ Nuisance tripping
- ✓ Circuit board failure or data loss
- ✓ Inability to retransfer back to utility power
- ✓ Overheating Delta-Wye transformers
- ✓ Failing motor contactors

**MEASUREMENTS TAKEN:**

- ✓ Current Distortion: THDc
- ✓ Voltage Distortion: THDv

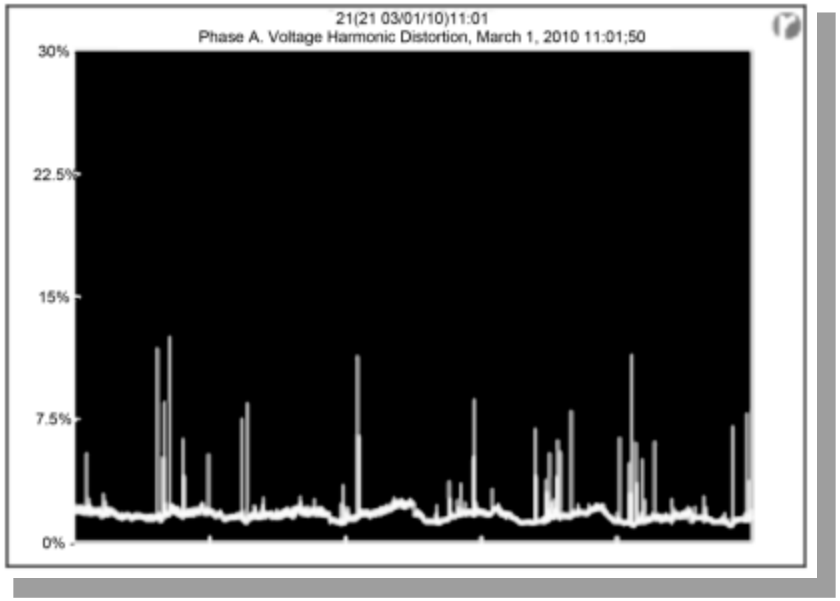
# VOLTAGE & CURRENT ANALYSIS

**WE CAN ALSO PROVIDE A COMPREHENSIVE POWER QUALITY ANALYSIS**

- ✓ Long-term monitoring of Voltage, Current, and THD
- ✓ Analysis of recorded data to identify Power Quality Problems

**POWER QUALITY PROBLEMS:**

- ✓ High voltage distortion
- ✓ Sags & swells
- ✓ Outages
- ✓ Transients
- ✓ Grounding & bonding
- ✓ Fault clearing
- ✓ Switching events
- ✓ Or some combination of the above



# *Think carefully, there's a reward involved…(SHOUT)*

True or False

Most power quality issues are generated from within a plant, caused by ground conductor currents, neutral to ground voltages, and harmonic distortion.

# B4 we get into the exciting topic of power correction capacitors…

# Power Factor Correction System (Capacitor)

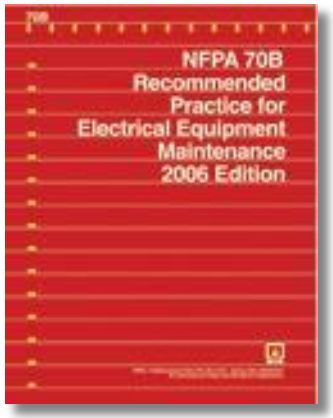
**Many electric utility companies penalize Customers for inefficient use of power by charging a "power factor penalty." Rarely are older capacitors still working as designed.**

# Power Factor Correction System (Capacitor)

- Old style: ceramic
  - Entire sections can fail and is obvious
- New style
  - Metallized polypropylene film
  - Self healing
  - Gradual decrease in capacity
- High ambient temperatures shorten life from 20 years to ?
- Simply check output v nameplate

# National Fire Protection Association

***"Without an EPM (Electrical Preventive Maintenance) program, management assumes a much greater risk of serious electrical failure and its consequences."***




**Source: National Fire Protection Association, NFPA-70B**

# THE IMPORTANCE OF SAFETY

**An arc flash is an electric current that passes through air when insulation or isolation between electrified conductors is no longer sufficient to withstand the applied voltage.**

- ✓ **Immediate flash and the results may cause severe injury.**
- ✓ **Each year, more than 2,000 people are treated in burn centers in the US with severe arc flash injuries.**

*Source: http://standards.ieee.org/announcements/pr_nfpa1584.html*

Electrical Transformer Blast.avi

Arc Flash Protection

Arc Flash SAFETY.MPG

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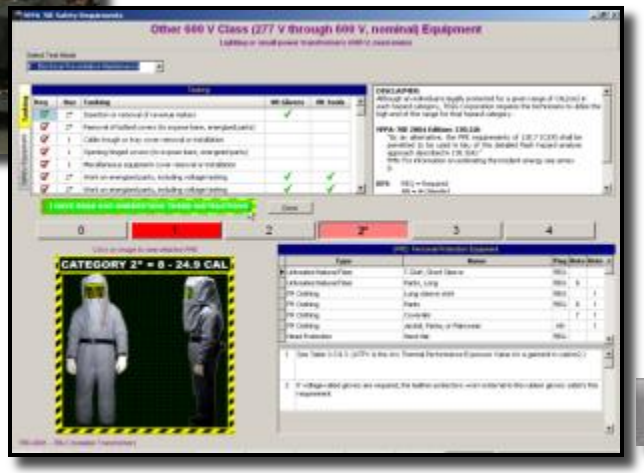
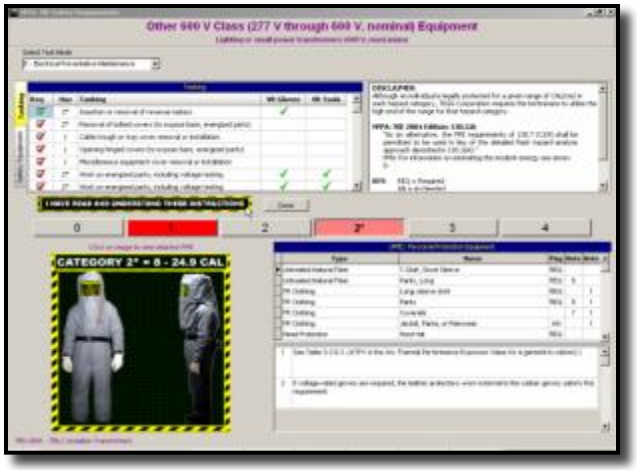
# THE IMPORTANCE OF SAFETY

**In order to protect ourselves <u>AND YOU</u> (and your liability), anyone working on energized components must be NFPA 70E QUALIFIED, follow the appropriate safety practices and wear the appropriate level of PPE.**

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# Highlights
# 2015 NFPA 70E Arc Flash Standard

- Formerly like old seat belt law
- Add insult to injury
- Federal <u>and</u> state OSHA is now being proactive with manufacturers, esp. chemical companies

# Highlights (cont.)
# 2015 NFPA 70E Arc Flash Standard

- Detailed responsibility of owners and managers
- Added emphasis on preventive maintenance
- Refined "Energized Work Permit" with clarity on Qualification Training

# Thank you….

- …..for what you do
- proud to be an associate member and supporter of SCAMPS

To ask questions or to download this maybe helpful and possibly amazing PowerPoint presentation (for the jokes if nothing else), go to www.twielectric.com