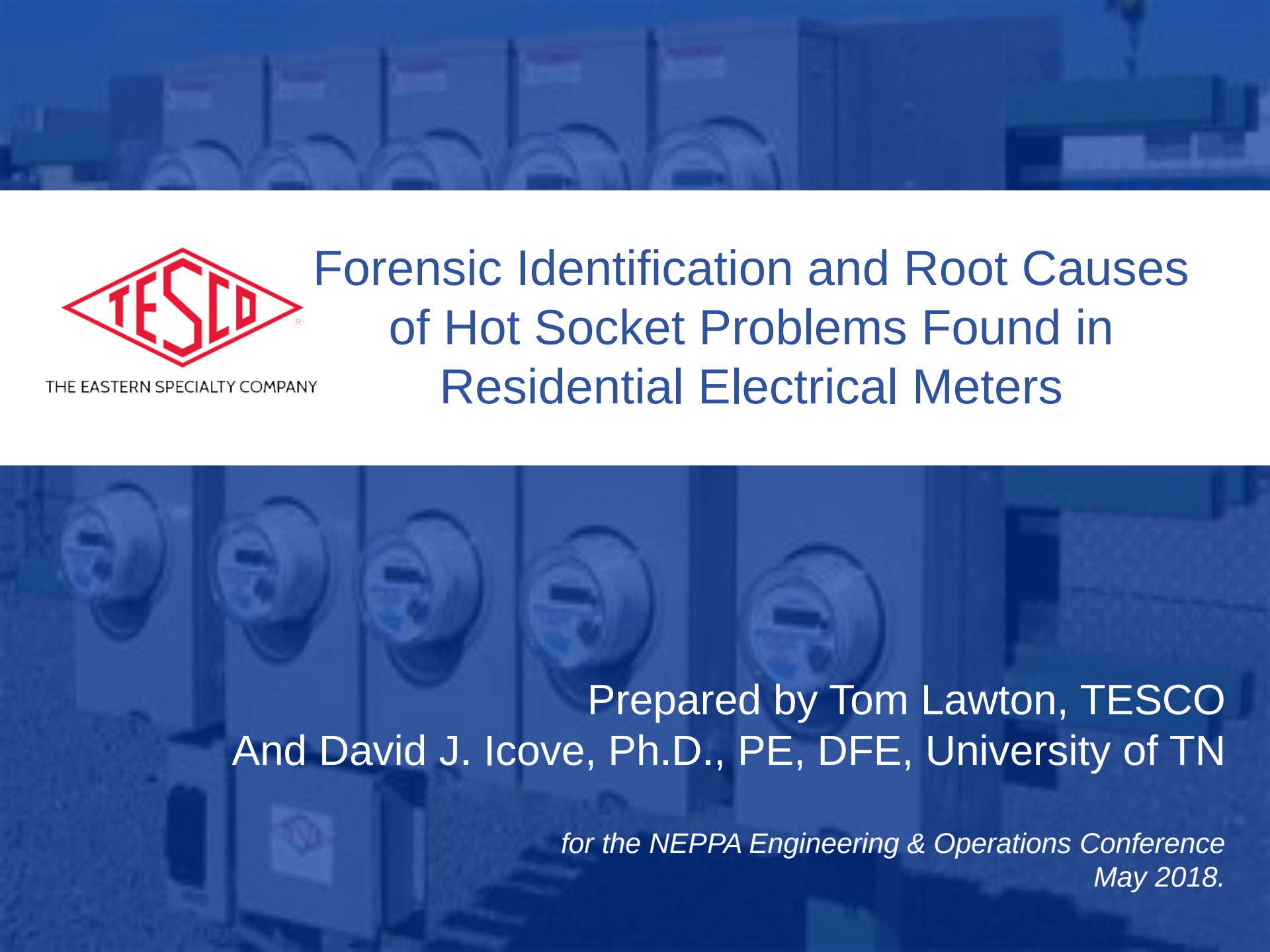

THE EASTERN SPECIALTY COMPANY

Forensic Identification and Root Causes of Hot Socket Problems Found in Residential Electrical Meters

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OBJECTIVE

Provide a basic understanding of the condition known as a “Hot Socket” and what to look for when investigating a fire in or near a meter box.

INTRODUCTION

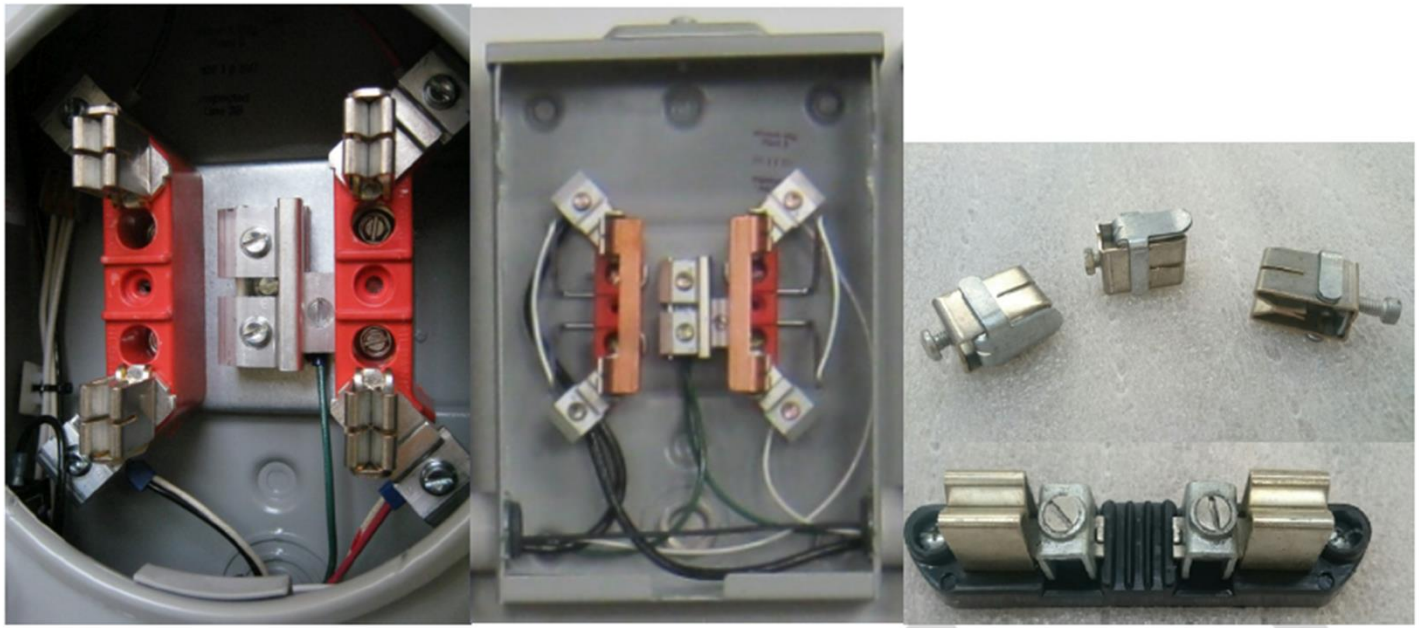
- Electric meters play a critical role in electrical utility distribution systems, particularly with residential customers
- Due to the low frequency of occurrence, forensic engineers may not be fully aware of a condition known as a “hot socket” where the blades of the electric meter fail to make sufficient electrical contact with the socket jaws
- This condition is due to spreading, corrosion, or other abnormalities resulting in high resistance contacts
- These conditions can cause excessive heating, occasional fires, and an unrealized risk of injury to individuals maintaining these meters

RESIDENTIAL METERED ELECTRIC POWER

- Within the socket adaptor, there are located four clamps where are commonly referred to as “jaws”
- On the back of the face part of the typical meter, there are located four matching prongs known as “blades”
- These jaws, which are analogous to leaf springs, must have sufficient force between the blades and the surface of the jaws to maintain and minimize contact resistance
- The greater the gripping force by the jaws, which come into contact with the meter stabs, the lower the contact resistance

NORMAL METER IMAGES

Typical meter socket base, meter socket, and jaws (left to right).



LOSS HISTORIES OF ELECTRICAL METER CENTER FIRES

- Electrically-caused fires within residential meter centers are a rare event when compared to other fire causes
- NFPA statistics show that forensic experts who conduct analyses of electrical fires may investigate very few cases in their careers based on slight numbers of fires in meters and meter cabinets
- NFPA's statistics between 2010 and 2014, 45,210 electrical fires occurred in home structures per year, with 39,670 involved electrical failures
- The NFPA statistics show that fires in meters or meter boxes average 760 per year out of 39,670 fires (1.9 percent)

THE ISSUE WITH “HOT SOCKETS”

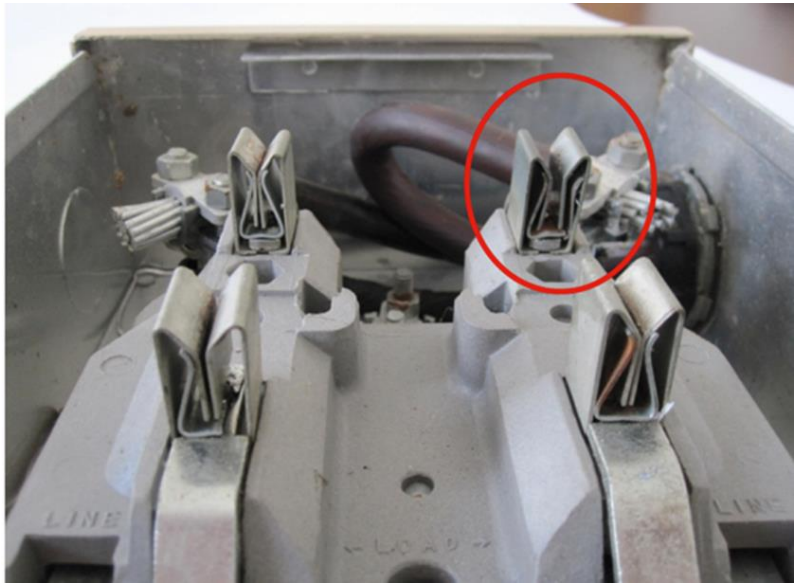
- Under normal conditions, the components of the residential meter center should last the life expectancy of the structure and should not normally be replaced

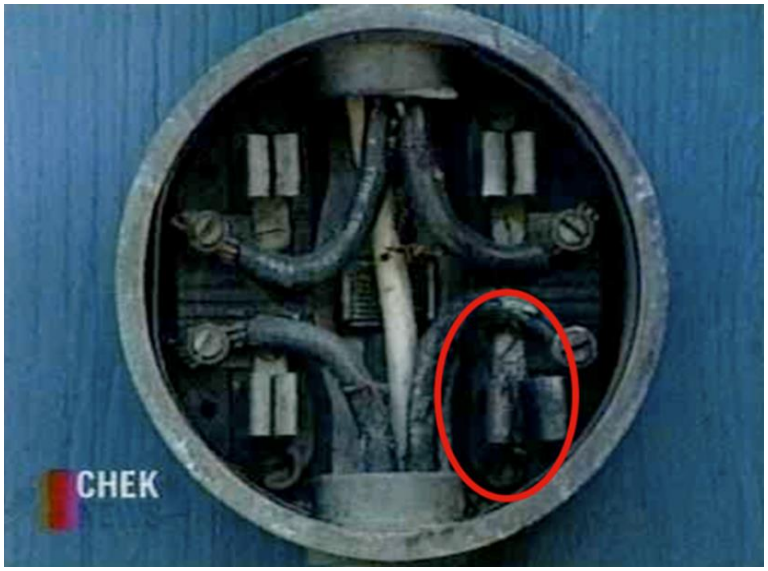
- However, there are conditions which exist that can lead to deformation of these components through accidental, natural, or intentional actions that can cause fires to occur within residential meter centers

- The mechanisms for overheating at electrical connections, such as those in meter service panels, are complex due to the number of variables

DAMAGE OF HOT SOCKETS

Damage features for Hot Socket conditions showing pitted and discolored jaw sockets.



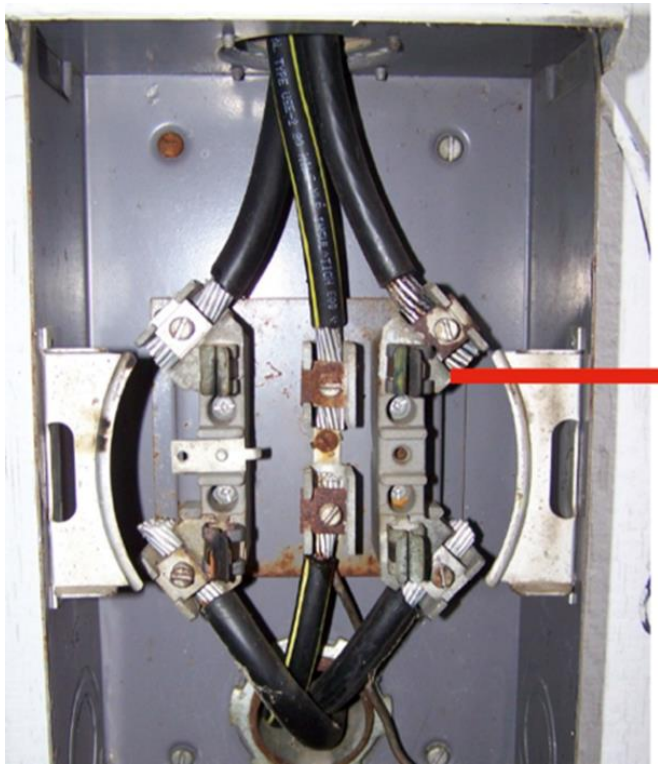


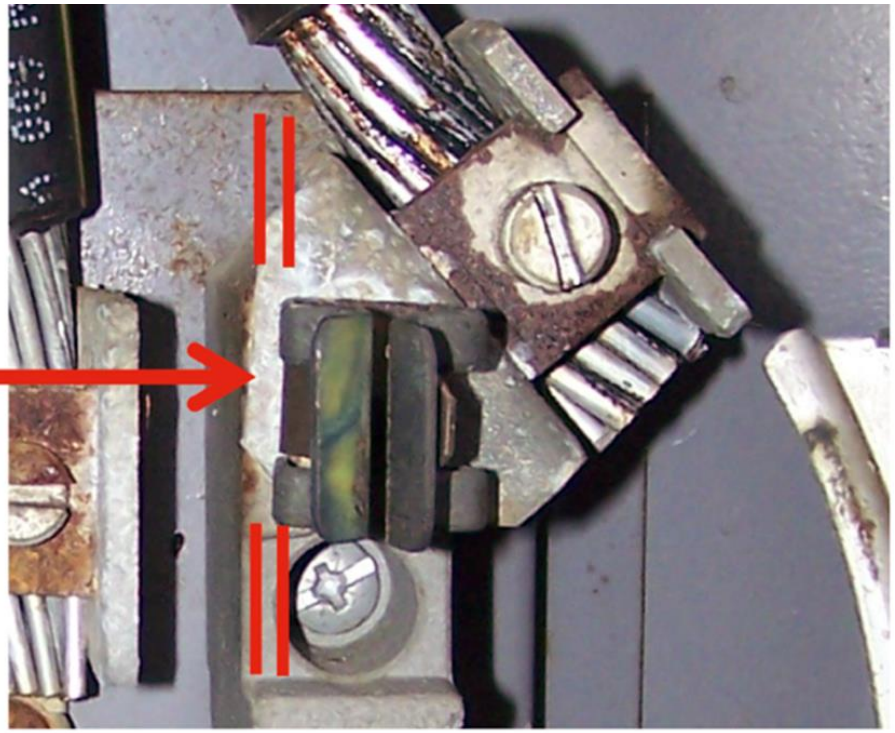
REPORTED CONDITIONS CONTRIBUTING TO HOT SOCKETS

- Failed Socket Jaw
- Vibration
- Improper insertion of meters
- Introduction of moisture into the meter enclosure
- Localized resistive heating
- Corrosion of the jaws
- Deep electrical cycling
- Unbalanced loads
- Tampering, electrical power theft
- Failure of the initial installer of the meter base enclosure to properly apply sufficient torque to the meter mount connections

DEFORMED JAW

Deformed jaw which results in evidence of localized heating and discoloration due to a poor electrical connection.



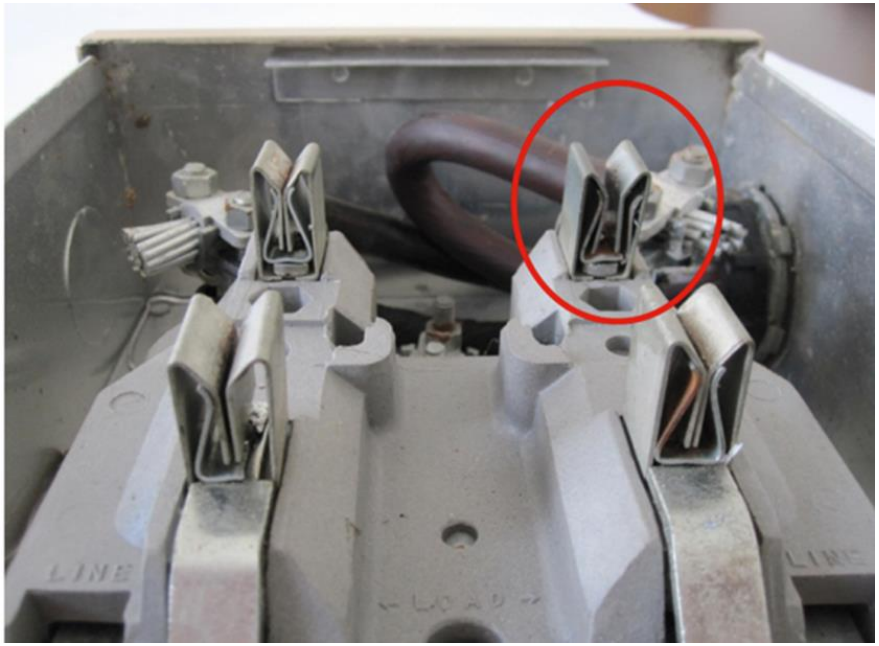


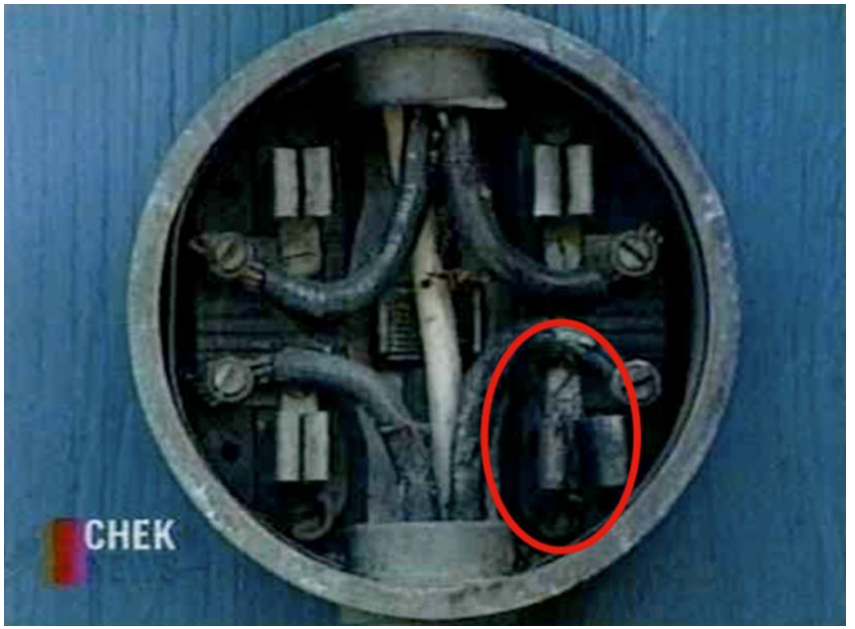
FORENSIC ENGINEERING ANALYSIS OF HOT SOCKET CASES

The following are recommended areas of inspecting electric meter centers and associated equipment, if possible, the subject electric meter:

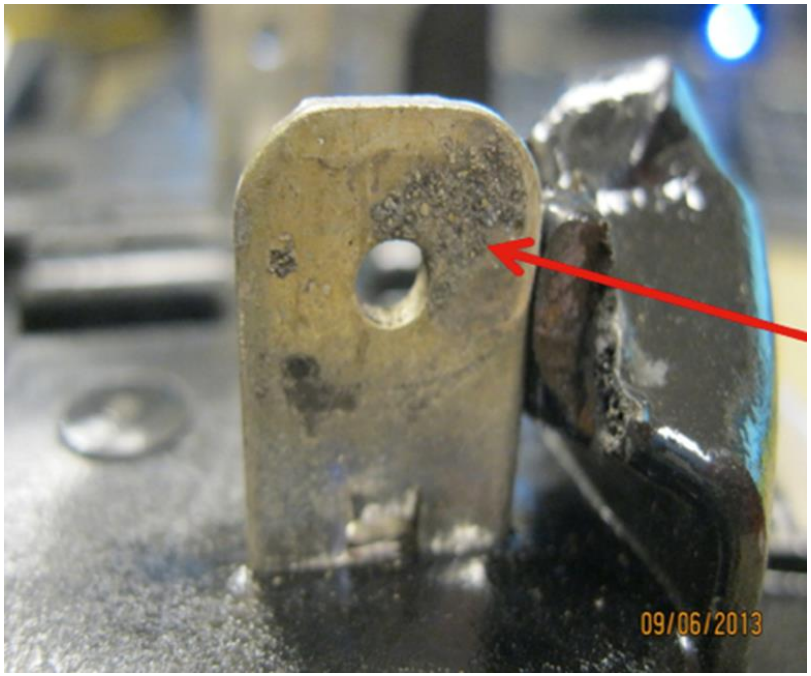
- Gaps in meter socket jaws
- Discoloration of one jaw vs. the other three
- Signs of melted or deformed plastic on meter base
- Pitting of either meter blade or socket jaw
- Loss of tension in meter socket jaws
- Condition of wire insulation and connections to meter jaws
- Overall condition of the box, socket, meter and how they attach to each other and the building.
- Signs of tampering
- Signs of water or debris inside of the meter can

PITTED AND DISCOLORED JAW SOCKETS

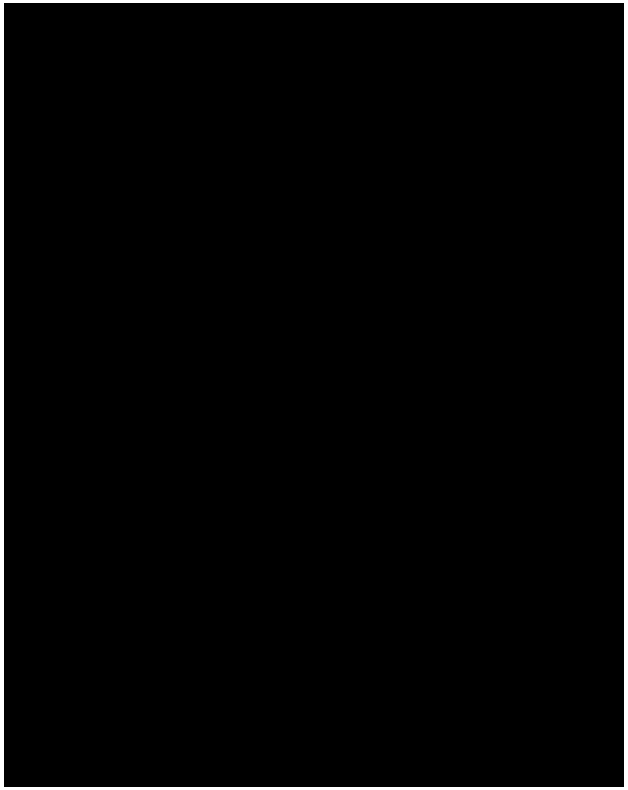




EARLY DETECTION OF SIGNS OF JAW-TO-BLADE ARCING



HOT SOCKET SIMULATION



EMERGING AREAS OF HOT SOCKETS INVOLVING SMART METERS

- Since the late 1980's, the standard baseline electromechanical meters and electronic meters are incrementally being replaced with a new generation of electronic solid state meters. Since 2007 these electronic meters are being replaced with a new generation of electronic meters known as "Smart Meters".
- Loss histories tend to suggest that the new smart meters should be designed with hot sockets detection components in mind
- Improvements include placing temperature sensors closer to the meter blades, components within the meter designed to withstand higher temperatures and dissipate heat, increased mass of plastic at the meter base
- The use of a specialized field detector embedded within the meter and using the two way communication feature of the new "Smart Meters" to send an alarm back to the Utility

ANALYTICAL TOOLS

- NFPA 921 suggests that Failure Mode and Effects Analysis (FMEA) is an appropriate technique useful in identifying the basic sources and consequences of failure within the electric meter centers
- Factors used when applying FMEA can include the component, failure mode and frequency, direct effect, potential hazard, and corrective actions
- The results of the FMEA assists in identifying:
  - The item (or action) being analyzed
  - Basic fault (failure) or error that created the hazard
  - The consequence of the failure.

RESPONSIBILITIES OF THE FORENSIC ENGINEERING EXPERT

When confronted with potential hot socket or similar cases, the forensic engineer has the responsibilities to recommend extensive non-destructive and destructive forensic testing of the preserved evidence:

- Per NFPA 921 and ASTM E860 recognize, secure, preserve essential evidence and notify interested parties
- Perform non-destructive and destructive testing of the meter, meter center, jaws, and associated equipment to document the hot socket condition as well as any signs of tampering or vandalism
- Conduct an examination to show that there is still sufficient jaw tension

RESPONSIBILITIES OF THE FORENSIC ENGINEERING EXPERT (cont.)

- Look for signs of pitting on the jaw and the blade which is usually a result of a prolonged period of meter arcing (a series of intermittent events that occurred in ever increasing durations over a prolonged period)
- Conduct scanning electron microscopy (SEM) and, where possible, x-ray computed tomography (CT), and focused ion beam (FIB) of all of the electrical equipment
- Determine the difference between arcing and melting of components
- Inspect neighboring meters and meter centers to determine if there existed similar conditions
- If potential product defects were found and after consultation with their client, notify other interested parties of their existence and file the appropriate disclosures to the U.S. Consumer Product Safety Commission.

SUMMARY AND CONCLUSIONS

- Hot sockets start with a loss of tension in at least one of the meter socket jaws
- This loss of tension can be from a variety of sources that start as early as improper installation or even “tight sockets”
- Loss of tension is one factor necessary to create the initial micro-arcing conditions
- Sockets with repeated meter exchanges observed to have higher incidence of hot socket issues and “booting” a meter may spring jaws even more

SUMMARY AND CONCLUSIONS (cont.)

- Vibration appears to be the most common catalyst to the micro-arcing that creates the initial heat in a “hot socket”
- The meter must have some power, but current is not a significant The effects of vibration and weakened jaws appear to be cumulative
- Meter manufacturers have all been working on the design of their meters to better withstand a hot socket
- Thorough visual inspections of all services when replacing a meter should include a tension inspection for all jaws
- A non-invasive check that the minimum safe holding force or greater is present in all socket jaws should be performed

Questions and Discussion

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This presentation can also be found under Meter Conferences and Schools on the TESCO web site:
www.tescometering.com