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Site Verification for Self-Contained

Issues Commonly Seen and Hot Socket Detection

Tuesday, March 8, 2022

3:00 PM – 4:30 PM

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PREMISE

- Over much of the 20th century, utilities, regulators and customers each relied upon lab and field meter testing efforts which were primarily focused upon the accuracy of the watt-hour meter and demand register.

- This focus is now changing with overwhelming deployment of electronic meters and significant deployment of AMR and AMI meters throughout the installed base in North America.

- Meter Failure modes are changing. More meters are rejected for functional test failures than accuracy tests

- One of the benefits of AMI is that utilities can spend less time on residential metering and focus their meter techs on their more complex metering operations. More time can and should be spent inspecting and testing the Transformer rated installations in each utilities service territory.

Topics We Will Cover

Purpose:

To acquaint the attendees with the concept of Site verification and not just meter testing

Course Breakdown of Topics:

- The importance of Site Verification
- Safety issues regarding Site inspection
- Hot Sockets
  - What they are
  - Who they effect
  - How to find them
- How to use these concepts for Transformer Rated Services

Common Features and Common Sources of Concern

Electro Mechanical meters were subject to registration errors caused by mechanical issues with moving parts resulting in either the loss of revenue to the utility or over billing for the customer. Some of the more common problems were:

- Friction wear
- Gear mesh misalignment
- Retarding magnet failure
- Timing motors

ELECTRONIC METERS – NEW FAILURE MODES REQUIRE NEW TESTING AND INSPECTION METHODS

Electronic meters fail as do electro mechanical meters but differently

- Their overall life expectancy is not nearly the same
- Failure modes include drift and creep (unexpected)
- Failure modes with zero registration failures (expected)
- Failure modes include non-catastrophic but significant measurement error modes (unexpected)
- Failure modes can include non-measurement issues which render the meter ineffective or inaccurate for billing purposes.

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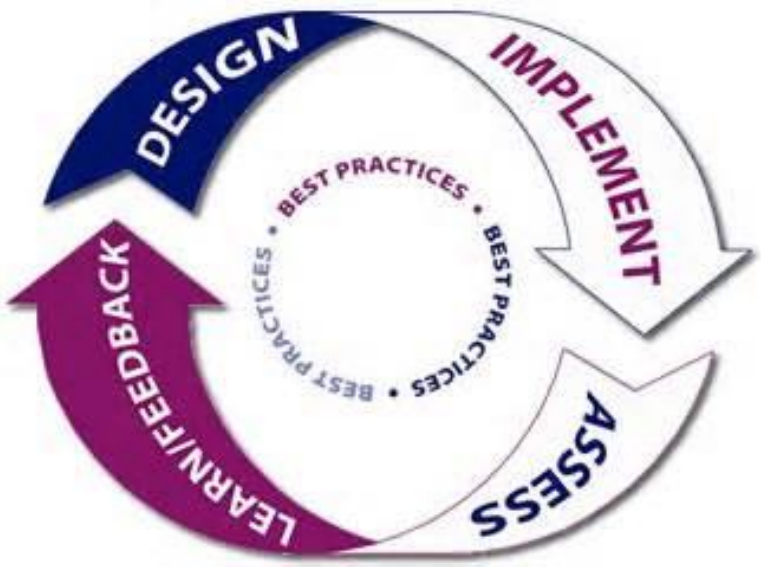
BEST PRACTICES

- Residential vs Commercial
- Self-Contained vs Transformer Rated
- Follow the money and be as proactive as possible



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Potential Site Check List

- Double check the meter number, the location the test result and the meter record.
- Double check the serial number of any attached device (e.g. communication module, disconnect device.
- Perform a visual safety inspection of the site. This includes utility and customer equipment. Things to look for include intact down ground on pole, properly attached enclosure, unwanted voltage on enclosure, proper trimming and site tidiness (absence of discarded seals, etc.)
- Visually inspect for energy diversions (intentional and not). This includes broken or missing wires, jumpers, open test switch, unconnected wires and foreign objects on meters or other metering equipment. Broken or missing wires can seriously cause the under measurement of energy. A simple broken wire on a CT or VT can cause the loss of 1/3 to 1/2 of the registration on either 3 element or 2 element metering, respectively.
- Visually check lightening arrestors and transformers for damage or leaks.
- Check for proper grounding and bonding of metering equipment. Poor grounding and bonding practices may result in inaccurate measurements that go undetected for long periods of time. Implementing a single point ground policy and practice can reduce or eliminate this type of issue.

Field Inspection of Sockets Best Practices

- Example field check list
  - 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
  - Check condition of wire insulation and connections to meter jaws
  - Check the overall condition of the box, socket, meter and how they attach to each other and the building.
  - Look for signs of tampering
  - Look for signs of water or debris inside of the meter can

The Issue

- Hot Sockets are not a new phenomenon. Virtually every meter man has pulled a meter with a portion of the meter base around a blade melted and virtually every utility has been called to assist in the investigation of a fire at a meter box.

- AMI deployments because of the volume of meters involved put a spot light on this issue.

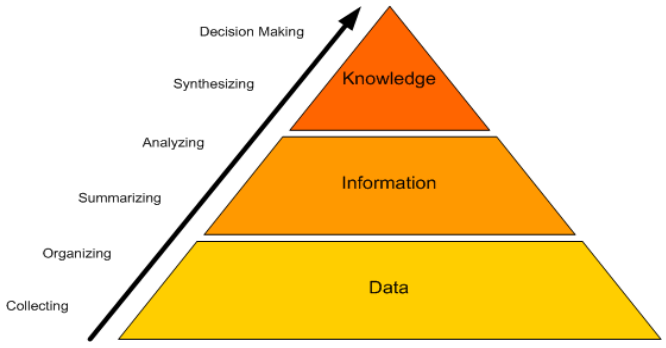
  - What causes a hot socket?
  - Are the meters ever the cause of a meter box failure?
  - What are the things to look for when inspecting an existing meter installation?
  - What are the best practices for handling potential hot sockets?

- We will cover the results of our lab investigation into the sources for hot sockets, the development of a fixture to simulate hot sockets, the tests and data gleaned from hot sockets, and a discussion of “best practices” regarding hot sockets.

- We will also cover new technology developed and patented by TESCO to use the meter to sense a hot socket and forward an alarm in near real time to the head end system.

Why Do We Know Anything About Hot Sockets?

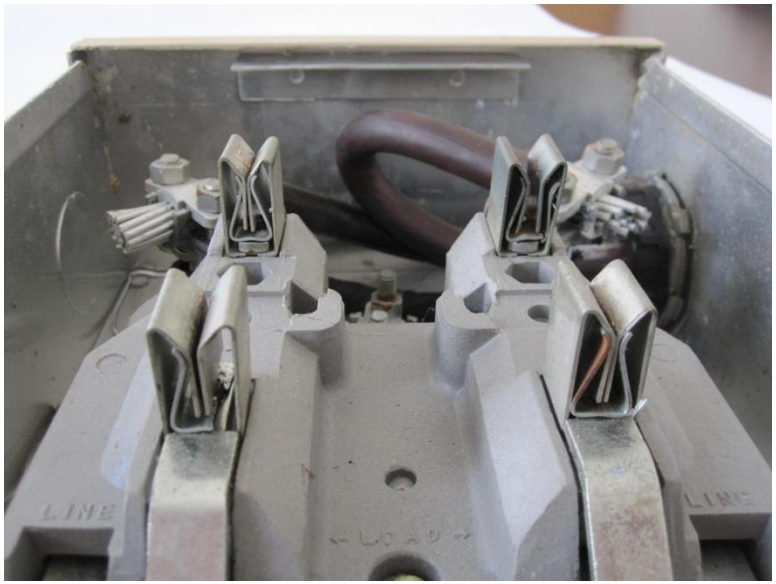
- TESCO has been fortunate enough to be involved in several meter deployments where we supplied full time and part time meter engineers and project managers to our customer's AMI deployment teams. In this capacity we have been involved in evaluating hot socket issues and helping to determine an appropriate response to actual or potential hot sockets.
- TESCO's meter lab was contracted to develop a laboratory fixture that would simulate the various features common to most hot sockets found in the field. TESCO was also contracted to develop test protocols, gather data and benchmark various conditions and meters.



- TESCO has access to a large number of meters which have been exposed to hot sockets both before and after catastrophic failure as well as a limited number of sockets that were hot sockets and did not yet fail catastrophically.

Searching for Hot Socket Sources

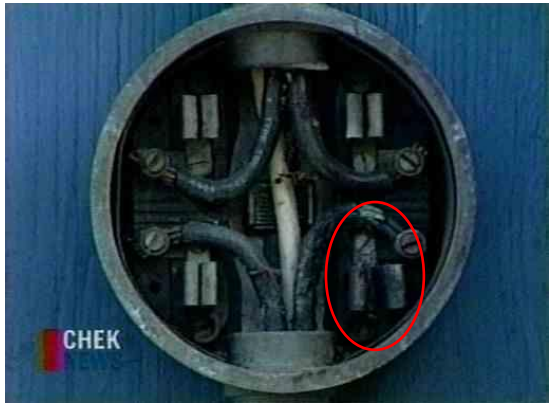
Common Features and Common Sources of Concern



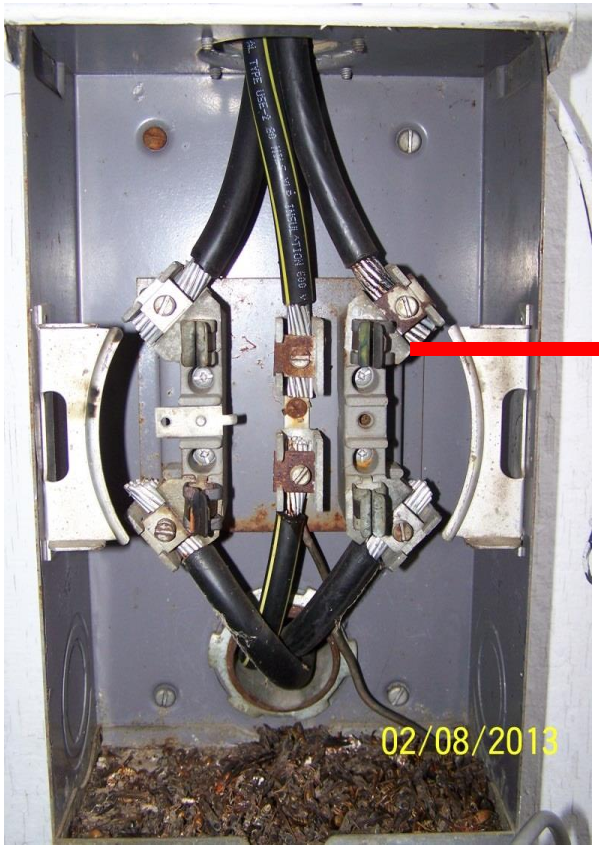
- Pitted and discolored meter blades
- Melted plastic around one or more of the meter stabs (typically the plastic around one stab is where the deformation starts)
- Pitted and discolored socket jaws
- Loss of spring tension in the socket jaws

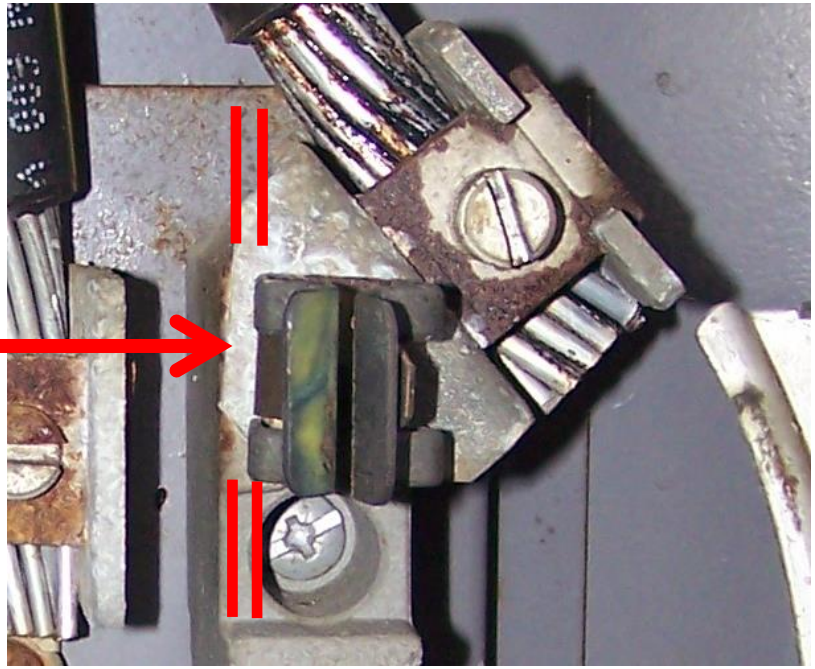
What Are Likely Concerns?

- Sprung/damaged jaw
- Loose wire termination at line or load side jaw
- Meter blade beside and not into socket jaw
- Worn line/load wire insulation arcing over to grounded mounting box
- Total load exceeding socket capacity – lots of older 100 amp services in the field



Hot Socket Causes – Sprung Jaws





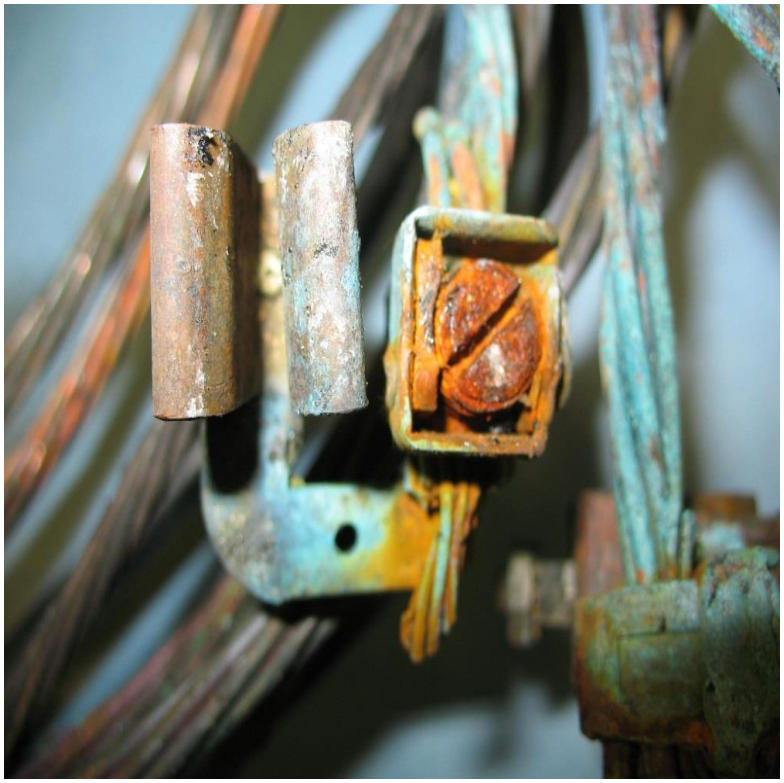
Tin plating on jaw “cooked”

Heat accelerates oxidation on lug wire

Note: Tin Melts at 232ºC (450ºF)

EXAMPLE – "SPRUNG JAW"

Jaw completely separated - large gap resulting in poor connection



AMI Deployments and Hot Sockets

- Replacing a meter in an existing meter socket will weaken the socket and if performed enough times this action will create a hazardous condition. **AMI deployments** will increase the incidence of hot sockets and meter fires unless precautionary steps are taken as part of the meter deployment.

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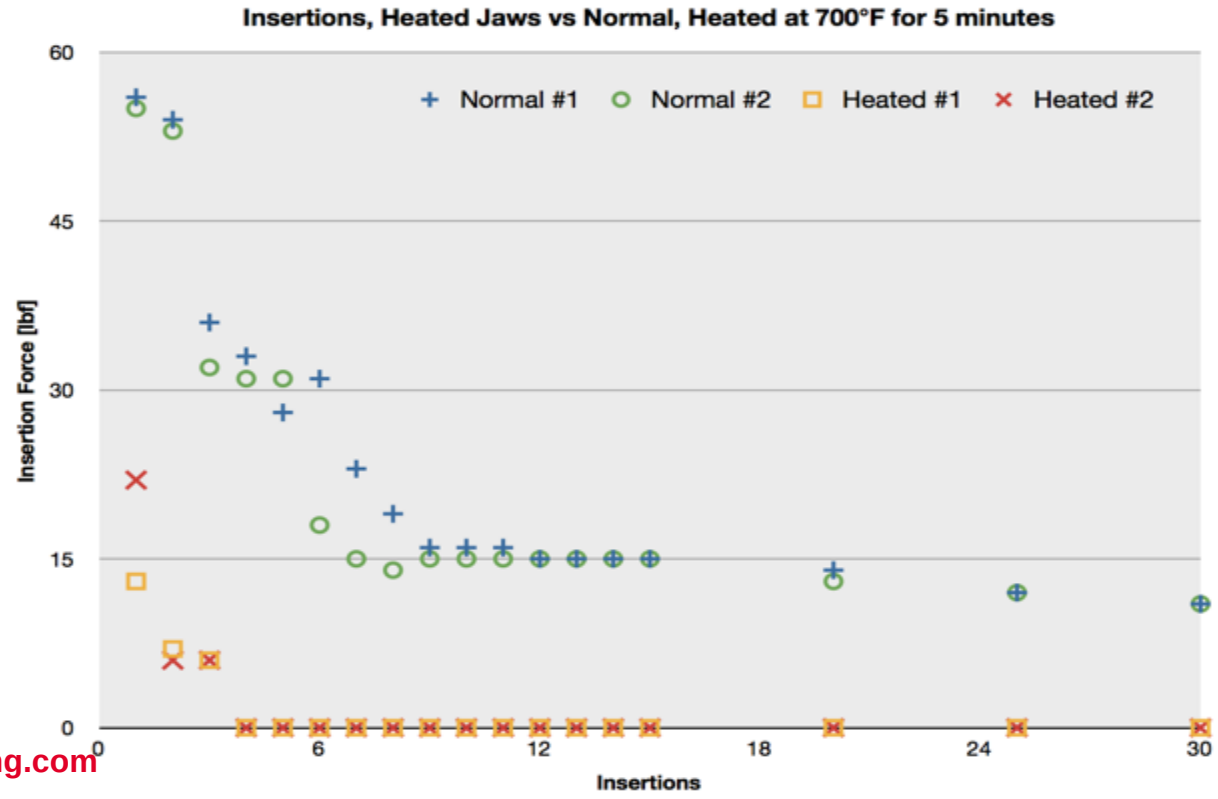
Insertions	Normal #1	Normal #2	Heated #1	Heated #2
1	56	55	13	22
2	54	53	7	6
3	36	32	6	6
4	33	31	0	0
5	28	31	0	0
6	31	18	0	0
7	23	15	0	0
8	19	14	0	0
9	16	15	0	0
10	16	15	0	0
11	16	15	0	0
12	15	15	0	0
13	15	15	0	0
14	15	15	0	0
15	15	15	0	0
20	14	13	0	0
25	12	12	0	0
30	11	11	0	0



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HOT SOCKET SIMULATION FIXTURE

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HOT SOCKET

Expected & Unexpected Results

Expected:

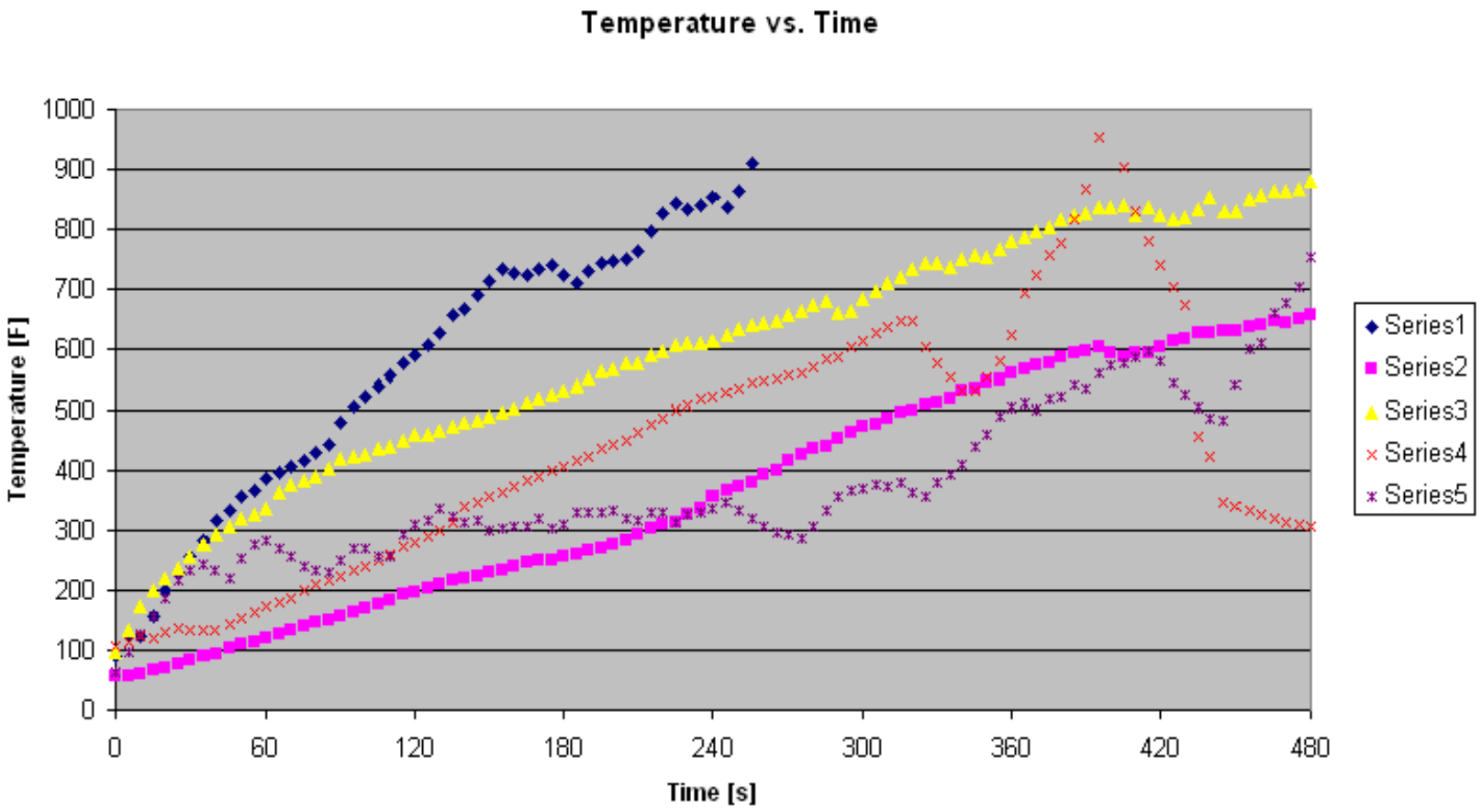
- Hot Sockets are exactly that – hot sockets. The hot sockets are the source of the problem and not hot meters.
- Electromechanical meters withstand hot sockets better than solid state meters

Unexpected:

- Current plays only a small role in how quickly a meter will burn up. Meters were burned up nearly as quickly at 3 amps, 30 amps, and 130 amps.
- Relatively small amounts of vibration can be the catalyst in the beginning and eventual catastrophic failure of a hot socket. Note: Other catalysts include but are not limited to power surges, debris, humidity, salt water.
- Contact resistance plays no role in creating a hot socket

And some newer solid state meters are better than electromechanical meters.

TEMPERATURE RISE DATA



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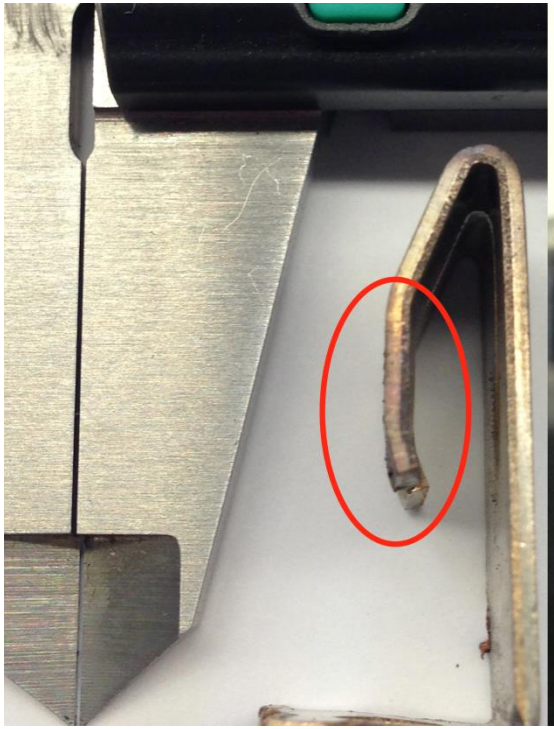
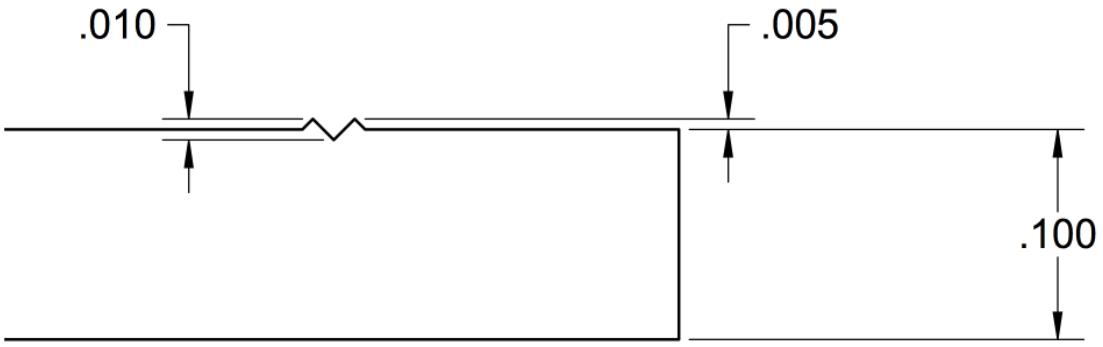
GAP EVALUATION

- Calipers show a .01” gap, with that size gap between jaws and stabs we were able to heat meter stabs over 1000 degrees Fahrenheit in a few minutes.
- The rough spots you see on the post-test jaw next to the calipers are over .005” high. This surface degradation appears on the stab as well.
- Between the two surfaces you can have large gaps, along with insulating by-product of the arcing, that can sustain heavy arcing in a solid state.

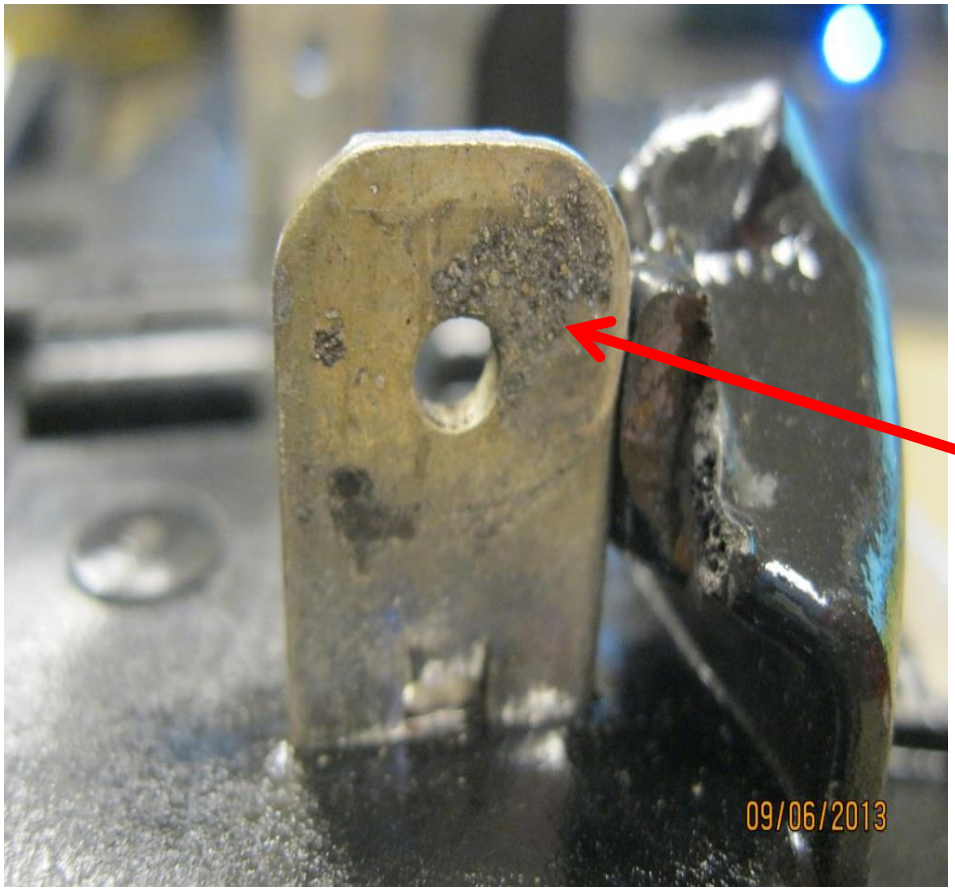


SERVICE DEGRADATION

- In a representative side view of a .1” thick standard meter stab, you can see how small these distortions appear relative to the thickness of the stab, while creating an air gap large enough for significant arcing.



Jaw to Blade Arcing

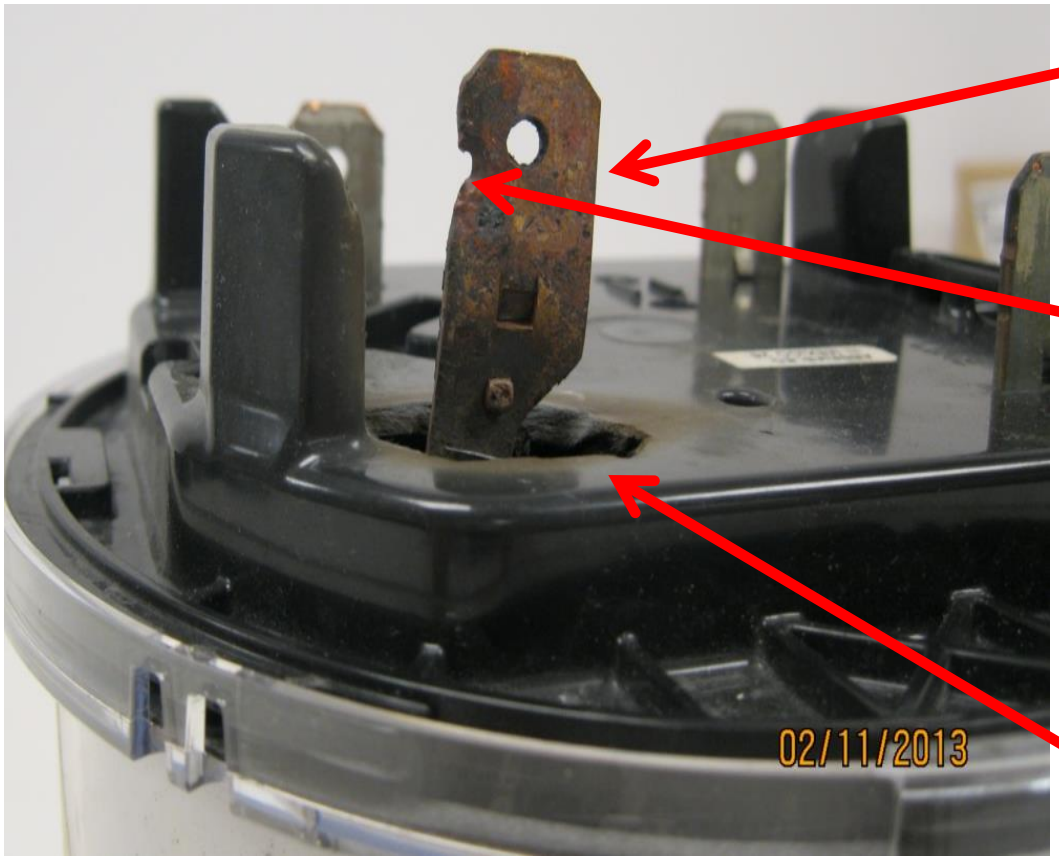


Jaws with intermittent connections will arc to the meter blade resulting in pitting on the blade.

Blade shows early signs of arcing.

Tin Melts at 232ºC which is lower than the 350ºC base plate plastic.

Severe Arcing Jaw to Blade



Tin burned off

Blade hole due to arcing to jaw – Copper melts at 1040ºC (1984ºF)

AX-SD base thermoset plastic melts at 960ºC (1760ºF)

What Are the Necessary Ingredients for a Hot Socket?

There are three necessary ingredients to create a hot socket (Note: We are not suggesting that we have simulated or even understand all causes for all hot sockets and meter related fires, but rather that we have simulated and understand the causes behind most hot sockets and meter related fires):

- Loss of jaw tension in at least one of the socket jaws.
- Vibration (or other catalyst to initiate arcing)
- Minimal load present

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Reviewing the Data and Learning From the Data

- Repeated meter insertions degrades the tension in the socket jaws (see graph), but not to dangerous levels
- Exposure to elevated temperatures rapidly degrades the socket jaw tension to dangerous levels (see graph)
- Visual inspection will catch some but not all dangerous socket jaws
- Arcing creates the heat
- Exposure to elevated temperatures has a cumulative effect on the meter socket jaw
- Relatively small vibration can initiate arcing

WHO SEES HOT SOCKETS?

- Most AMI deployments utilize third party contractors to handle residential and some self contained non-2S services.
- After to or prior to AMI deployments, Utility personnel typically see these sockets
- Transformer rated meters typically handled by the meter service department of the utility.
- Hot socket concerns with lever by-pass sockets used on 3-phase meters are extremely rare.

What Can Be Done Once a Hot Socket Is Identified?

- Easiest resolution is to replace the damaged jaw.
- **Never** try and repair a damaged jaw by simply “squeezing” the damaged jaw with a pair of pliers or other tool. The metallurgical properties of the jaw will not magically return and the jaws will simply spread again as soon as a meter is put into the socket.
- If the other jaws are deemed to be in good repair, the box and wiring are in good condition and appropriate Socket Blocks are available to effect a repair, then replacing the damaged socket block with a new one is the most expedient and cost effective solution. If any of these conditions do not exist then replacing the box is the best solution.

HOT SOCKET EQUIPMENT

Top: **Cat. 300 Hot Socket Gap Indicator**; Right: **Hot Socket Repair Kit** (Cat. 304-Basic; Cat. 305-Pro); Below, left: Cat. 301 **Socket Safety Clip**; Below, right: Cat. 302 **Hot Socket Gap Indicator Calibration Fixture**

Base Line Data Electro Mechanical Meters vs Solid State vs the Latest Generation of Meters Designed with Hot Sockets in Mind

- At the start of our laboratory investigation the oldest electro mechanical meters withstood hot sockets the best
- The latest vintage solid state meters withstood hot sockets the least.
- Over the course of the past several years every meter manufacturer has released 2S meters designed to withstand hot sockets.

In Search of Hot Sockets

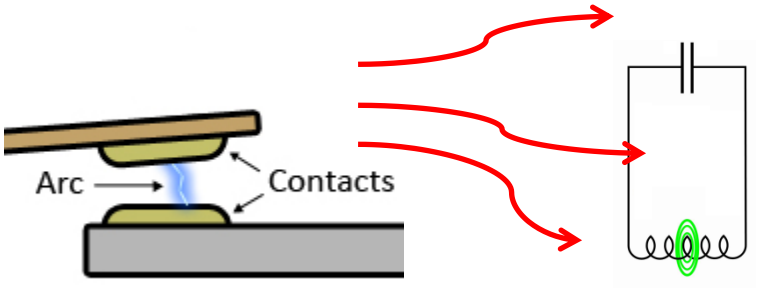
- The meter manufacturer's and various electric utilities have also been looking at a variety of ways to better sense hot sockets.
- Utilities who have deployed are looking for a set of alarms that when taken together may give them a better idea that there is a hot socket
- Meter Manufacturers have worked on evaluating a variety of temperature levels to send an alarm, disconnecting the meter if there are sustained elevated temperatures, using increased impedance to signify a hot socket, improving the temperature sensors and putting additional temperature sensors on the blades of the meters.

Finding a Hot Socket with a Meter – What is Known and Keys to These New Technologies

1. Temperature Sensing – sensing the temperature at the metrology board and at the meter stab(s).

2. Impedance Sensing – detecting a change in impedance in the meter circuit.

3. Detecting the RF signature of a micro Arc with a near field sensor - Arcing emits broadband energy in the form of radio waves. Launching radio waves requires a disturbance in the electric and magnetic fields near where the arc occurs (the near-field space).



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SUMMARY OF THE PROBLEM

- 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 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.
- 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 factor in how quickly or dramatically a hot socket occurs
- The effects of vibration and weakened jaw are cumulative

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SUMMARY OF THE POTENTIAL SOLUTIONS

- Meter Manufacturers have all been working on the design of their meters to better withstand a hot socket. These new meters have better baseline performance than even the older electro mechanical meters, but a hot socket will eventually burn up even the most robust meter.
- Thorough visual inspections of all services when replacing a meter whether for AMI or not
- Hot Socket Indicator inspection for all jaws. This is a non-invasive way to check that the minimum safe holding force or greater is present in all socket jaws.
- Hot Socket clips. Allows for the meter tech to leave the service as safe or safer than when the problem jaw has been identified.
- Hot Socket detection circuit incorporated into the Meter circuit for near real time detection and alarm to the head end allows the utility to identify compromised jaws before they damage the meter and before they become dangerous to the rate payer or tenant. This feature is just now becoming available and can be specified when requesting meters.

Fundamental Site Check List – for all sites Commercial or Residential

- Double check the meter number, the location the test result and the meter record.
- Double check the serial number of any attached device (e.g. communication module, disconnect device.
- Perform a visual safety inspection of the site. This includes utility and customer equipment. Things to look for include intact down ground on pole, properly attached enclosure, unwanted voltage on enclosure, proper trimming and site tidiness (absence of discarded seals, etc.)
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Field Inspection of Self Contained Sockets Best Practices

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  - Gaps in meter socket jaws
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  - Signs of melted or deformed plastic on meter base
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Questions and Discussion

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