



- SAFETY TOPICS - Hot Socket Issues

Causes and Best Practices



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For the North Carolina Electric Meter School 2015

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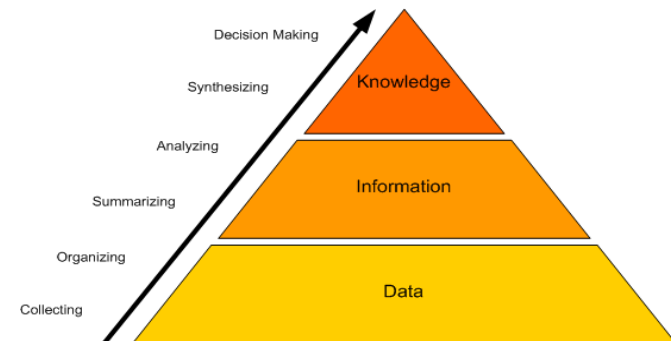
The Issue

- 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?
- This presentation 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.



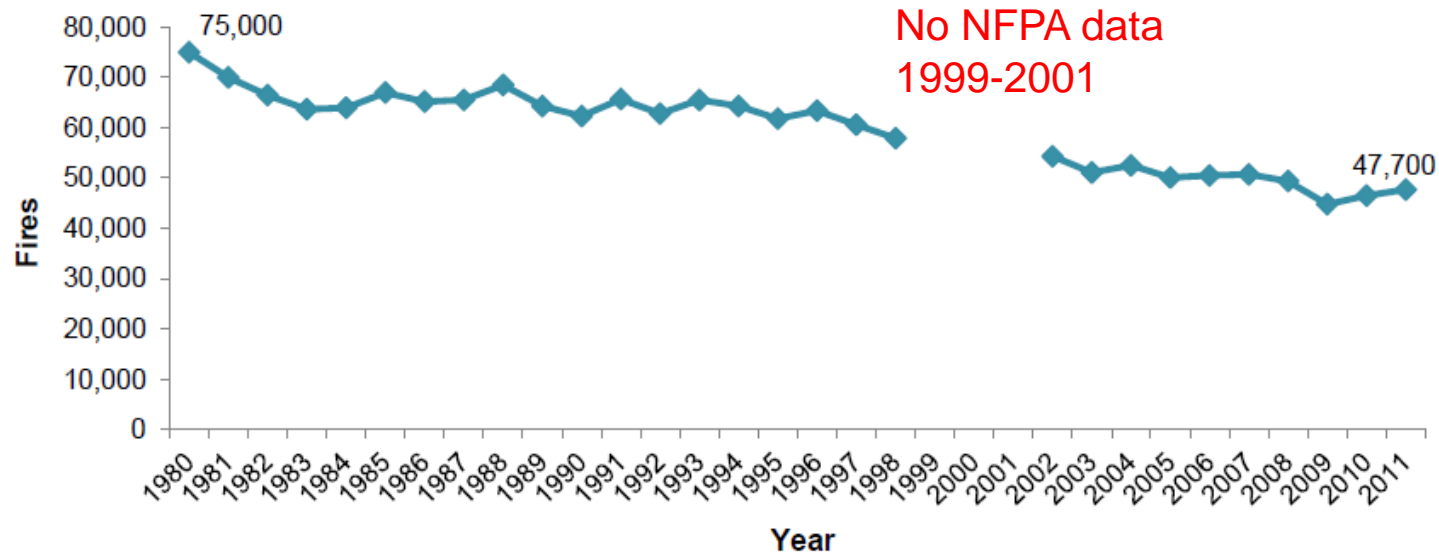
Why do we know anything about hot sockets?

- L+G has been investigating hot sockets and how to make their meters withstand hot socket conditions for longer periods of time so the socket has a greater likelihood of being repaired prior to catastrophic failure.
- L+G has also been investigating ways to utilize AMI communication to possibly alert head end systems of hot socket incidences.
- 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.



Electrical Fires Generally Decreasing

Figure 1.1. Home Fires Involving Electrical Failure or Malfunction
as Factor Contributing to Ignition, by Year
Structure Fires Reported to U.S. Fire Departments



Source: Data from NFIRS (Version 5.0 after 1998) and NFPA survey.

Note: See Note in Table 1.1.

National Fire Prevention Association (NFPA) tracks sources of home electrical fires - 2013 report.

Sources of Electrical Fires

Annualized Rate of Occurance 2007-2011

Equipment Involved in Ignition	Fires	
Electrical distribution or lighting equipment	20,700	(48%)
Unclassified wiring	6,590	(15%)
Outlet or receptacle	2,590	(6%)
Branch circuit wiring	2,200	(5%)
Fuse or circuit breaker panel	1,350	(3%)
Extension cord	1,330	(3%)
Service supply wiring from utility	690	(2%)
Meter or meter box	610	(1%)
Unclassified lamp, light fixture or sign	560	(1%)
Incandescent light fixture	560	(1%)
Wiring from meter box to circuit breaker	530	(1%)
Surge protector	480	(1%)
Unclassified cord or plug	430	(1%)
Power (utility) line	380	(1%)

610 fires/year in the vicinity of the Meter or Meter Box

Electrical Fires Near the Meter

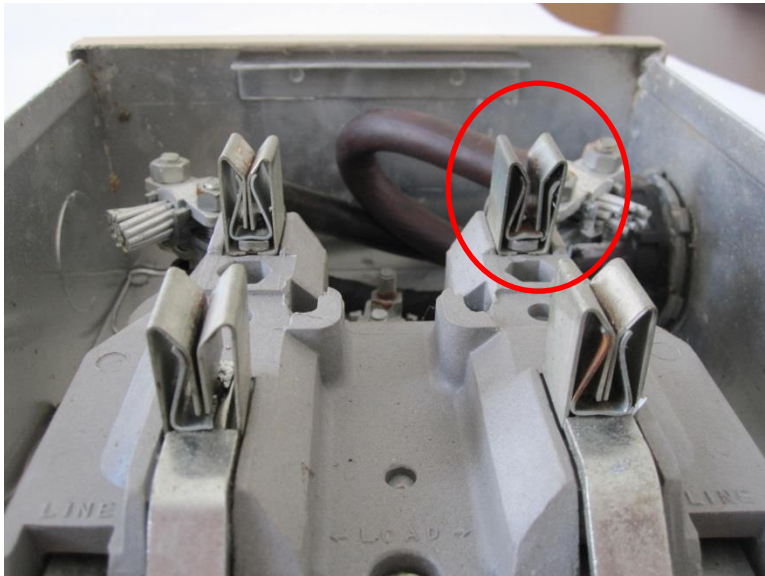
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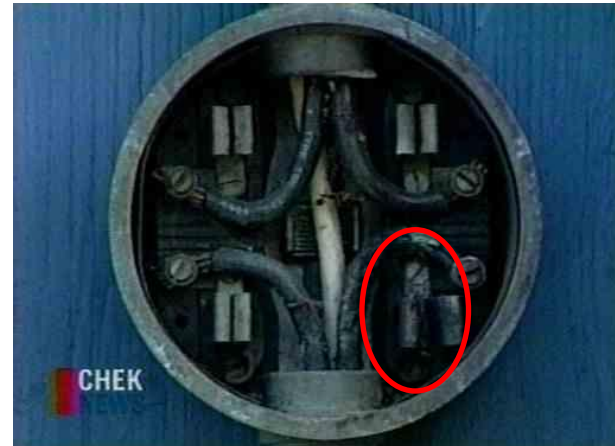
- Approximately 135 million electric meters installed in the US 610 fires/year / 135m = 4.5 per million meters per year
- Taking into account wiring into/out of socket may increase the rate: $(690+610+530)/135m = 13.5$ per million meters per year

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

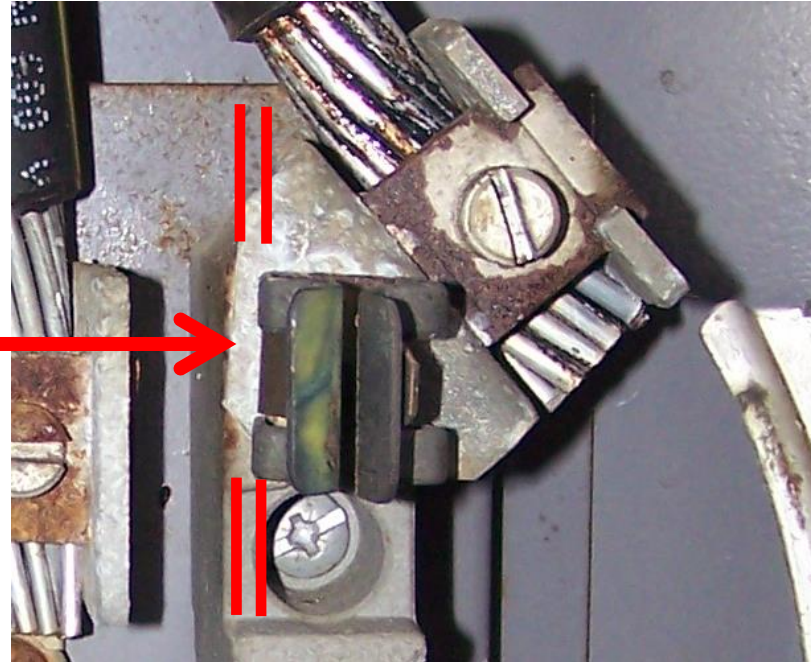
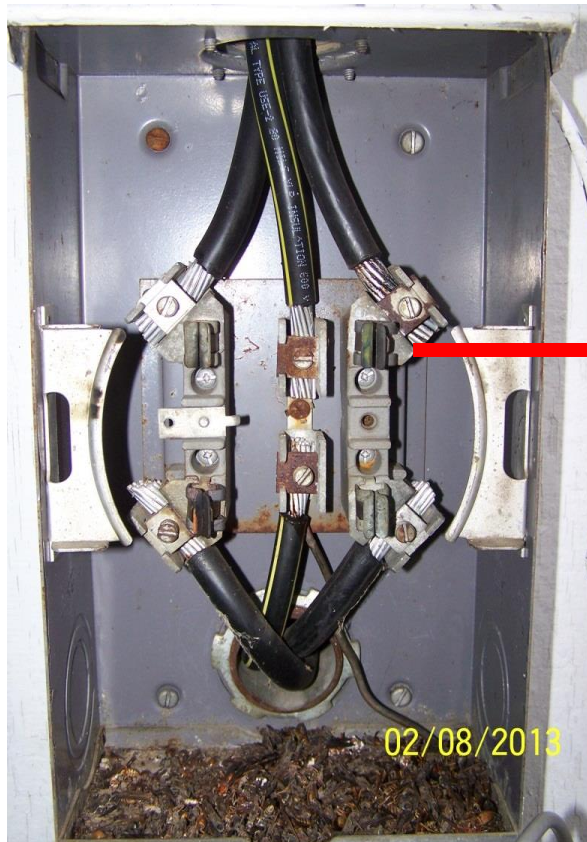


What are Likely Socket Concerns?

- 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



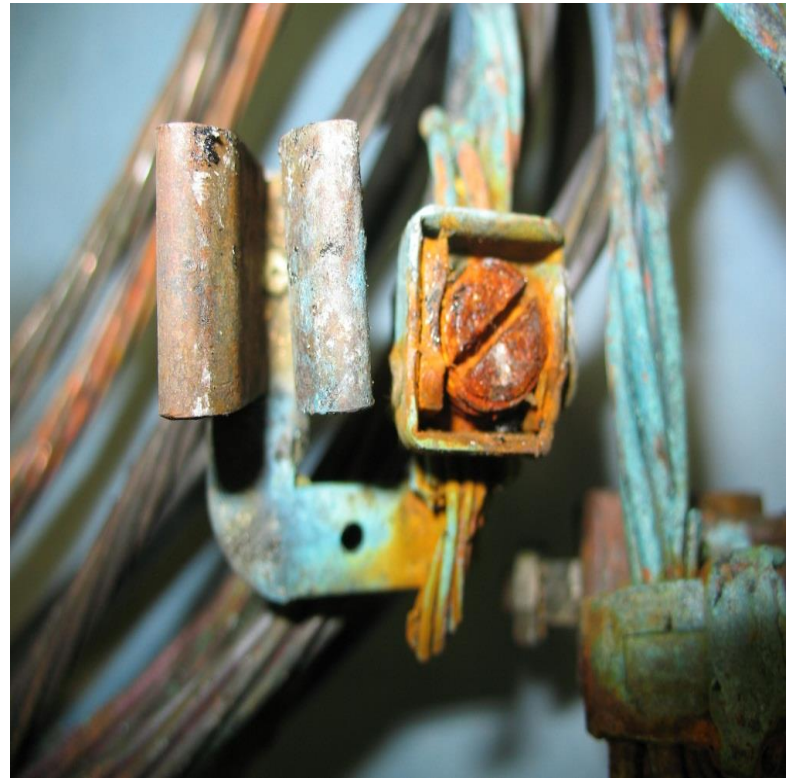
Tin plating on jaw "cooked"

Heat accelerates oxidation on lug wire

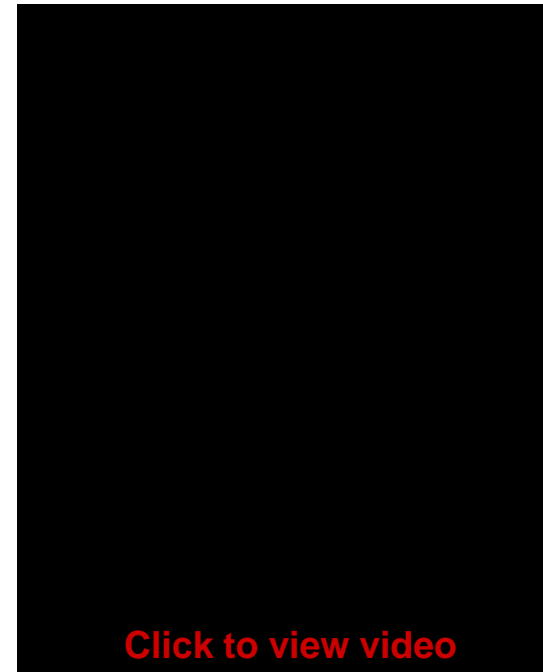
Note: Tin Melts at 232°C (450°F)

Example – “Sprung Jaw”

Jaw completely separated - large gap resulting in poor connection



Hot Socket Simulation Fixture





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

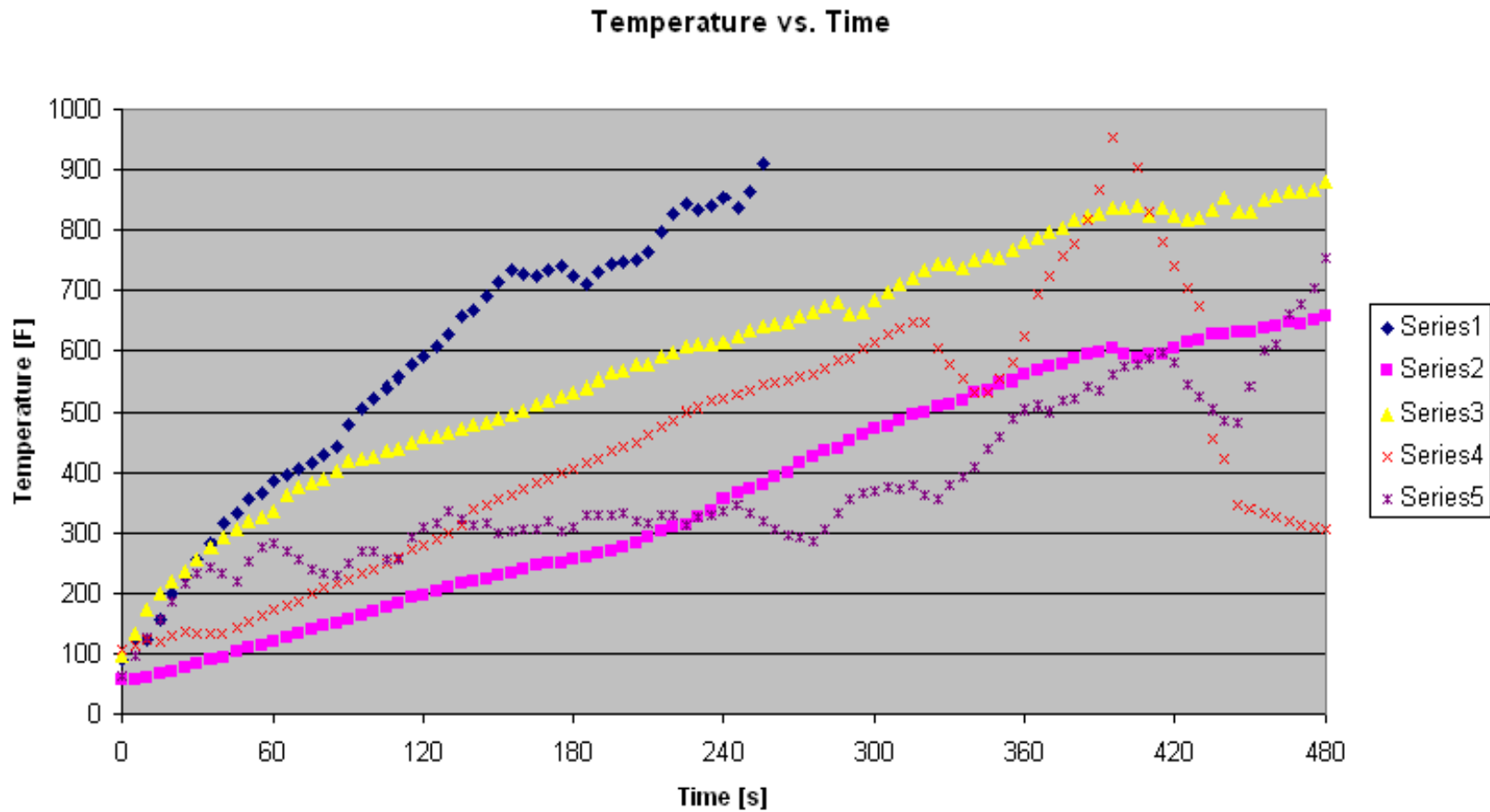
Unexpected:

- 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

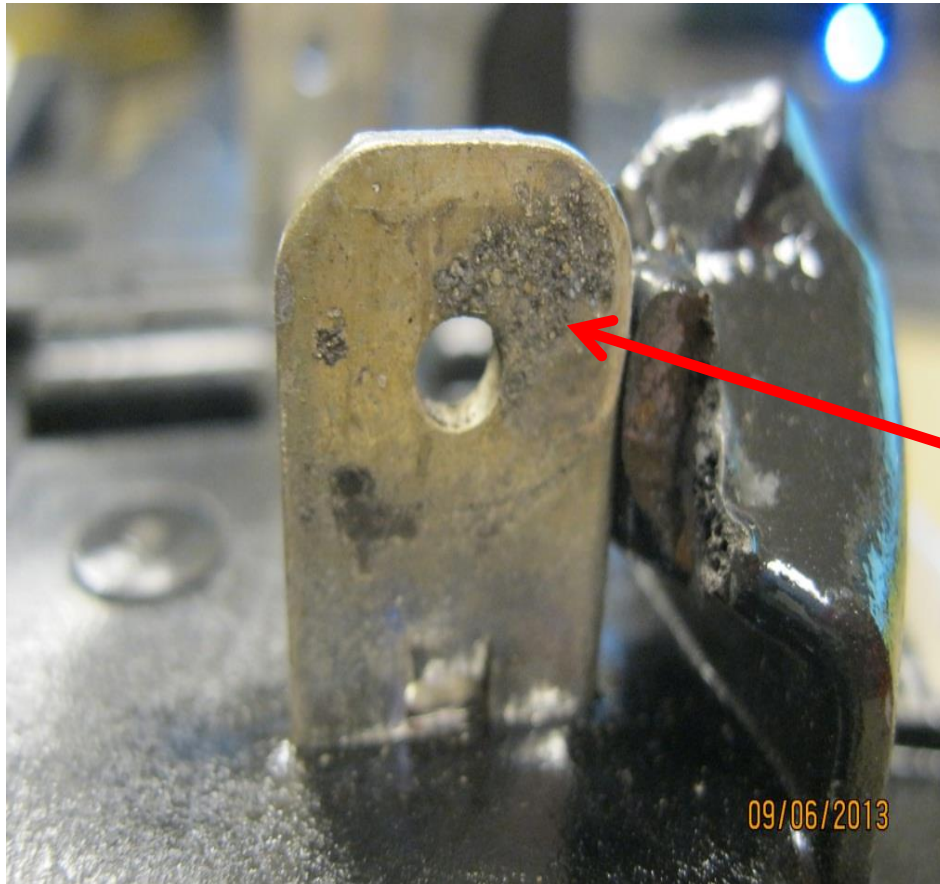


And some newer solid state meters are better than electromechanical meters.

Temperature Rise Data



Jaw to Blade Arcing

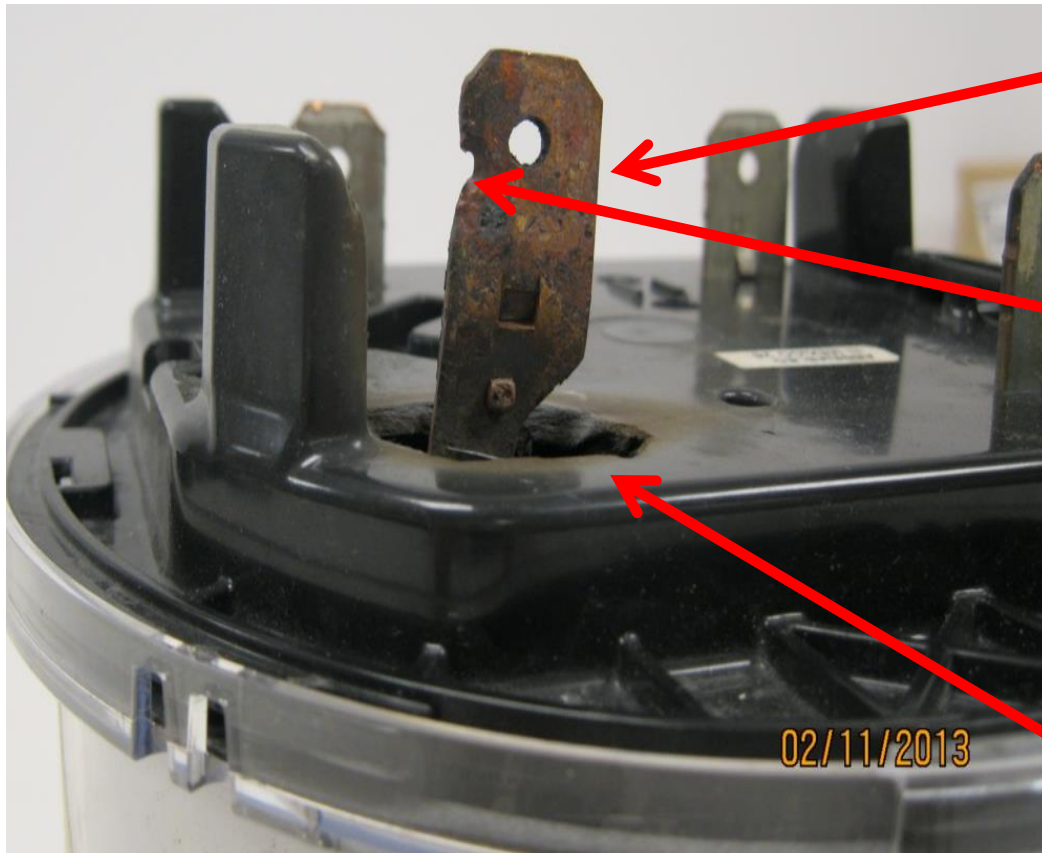


Jaws with intermittent connections will arc to the meter blade resulting in pitting on the blade.

Blade shows early signs of arcing.

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

Severe Arcing Jaw to Blade



Tin burned off

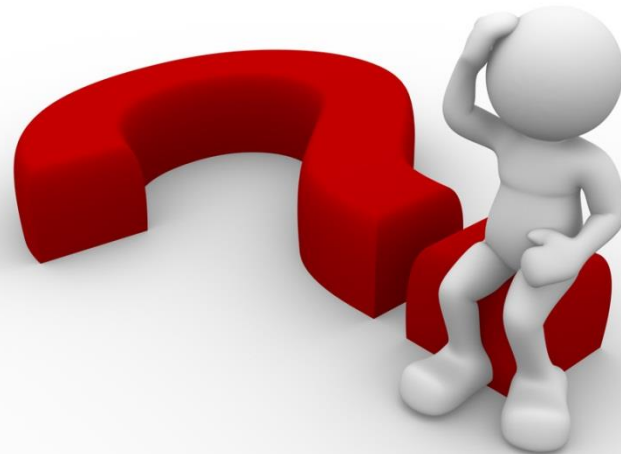
Blade hole due to arcing to jaw – Copper melts at 1040°C (1900°F)

AX-SD base thermoset plastic melts at 960°C (1760°F)

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

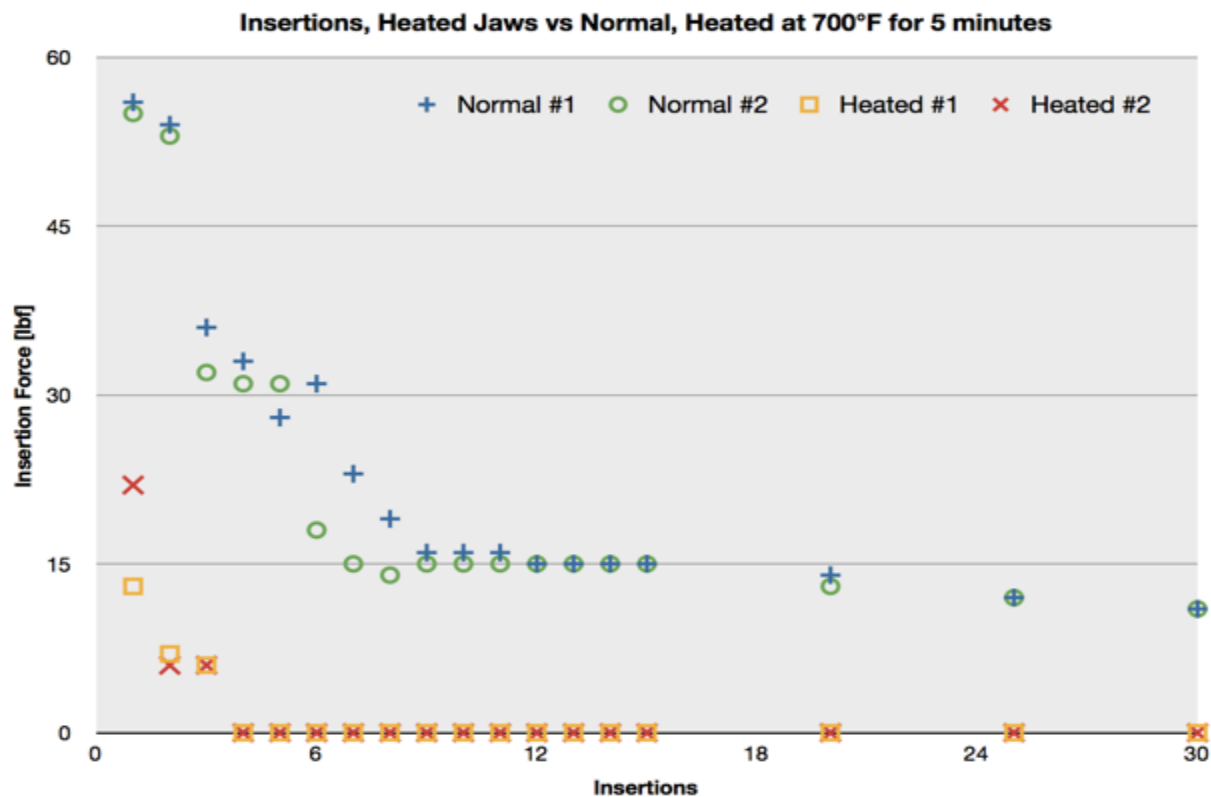


Reviewing the data and learning from the data

- 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



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



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



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. The tension in the damaged jaw will not return simply by taking a pair of pliers and closing the jaw tighter.
- Either the entire box should be replaced or the damaged jaw (assuming the wiring and other jaws are deemed safe through the rest of the inspection.)



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 twelve months some meter manufacturers have begun to release 2S meters designed to withstand hot sockets and some have even begun to put temperature sensing closer to the meter blades instead of only on the metrology boards.
- One meter vendor's service switch meter has used high temperature base plate plastic since it was launched in 2008.)



Summary

- 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
- 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.

Questions and Discussion



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