Test Switch Operations, Accessories & Hot Sockets

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The Eastern Specialty Company

for MEAU Meter School 102

March 3, 2020

9:30 a.m. – 10:45 a.m.

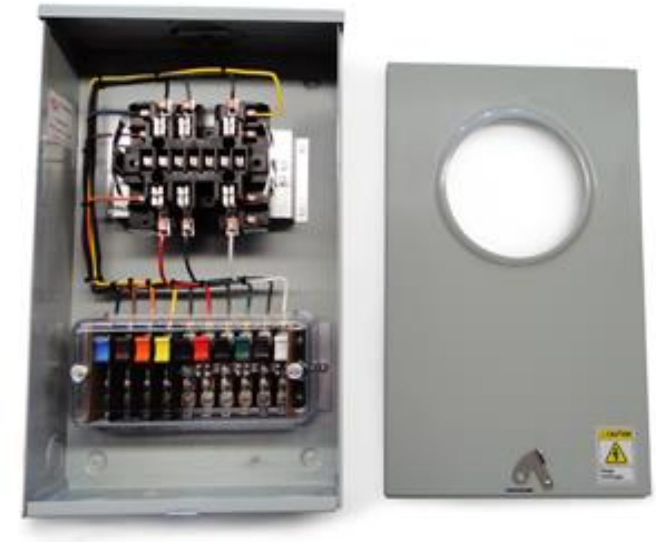
Premise

Purpose:

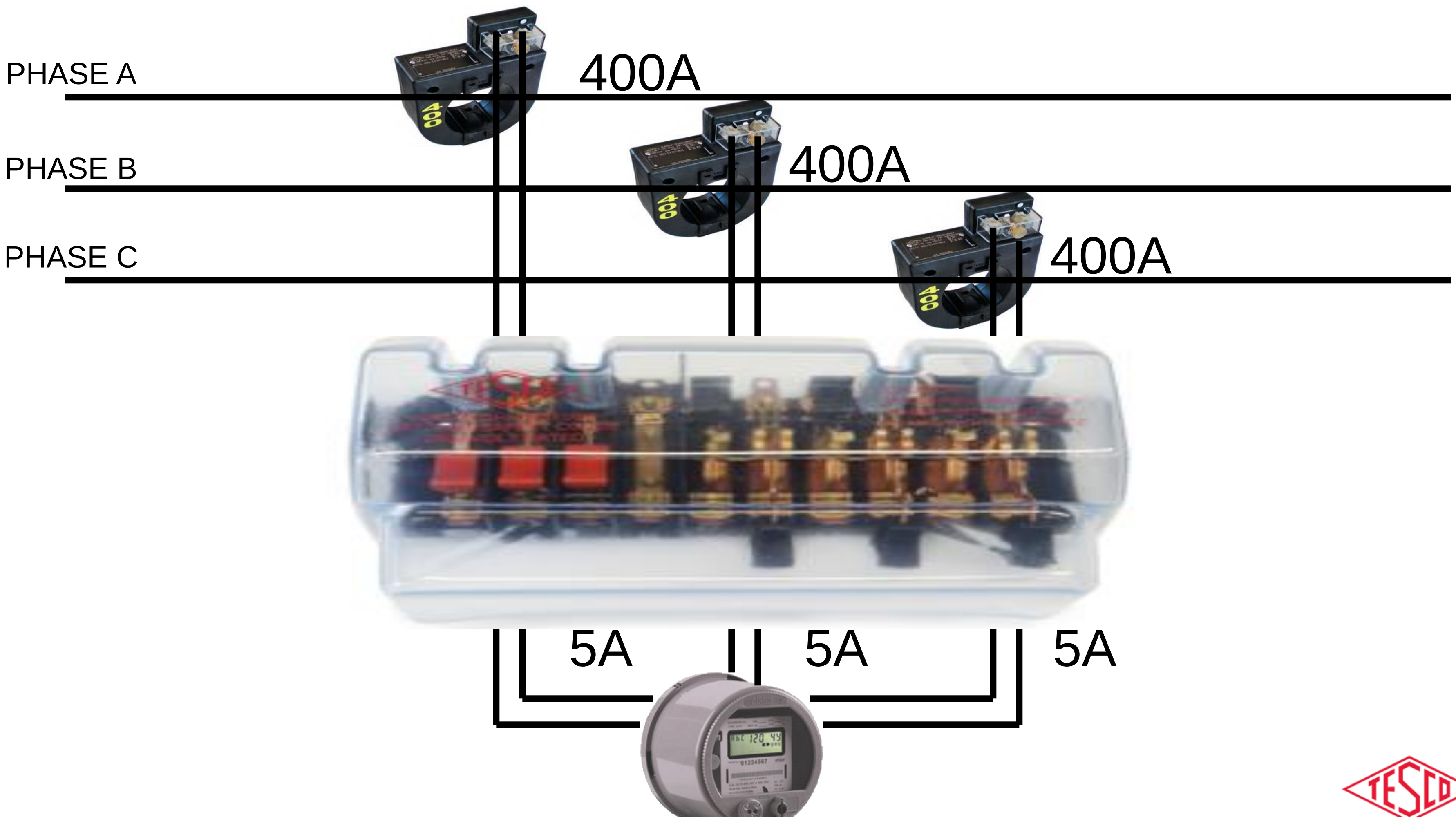
To acquaint the attendees with the use and purpose of Meter Test Switches

Course Breakdown of Topics:

- Using Test Switches
- Meter Test Switch Specifications
- Meter Test Switch Configurations
- Meter Test Switch Accessories
- Pre-Wired Transformer Rated Enclosures



Transformer Rated Service- 9S Installation with 400:5 CT's



Safety

Testing current transformers while they are in service can be a dangerous operation if certain safety procedures are not followed. The secondary loop of a current transformer must NEVER BE OPENED when service current is present in the primary. When there is current in the primary, and the secondary of a current transformer is open circuited, the voltage across the secondary can rise to hundreds and even thousands of volts, creating an extremely dangerous situation. The open CT secondary voltage magnitude varies with CT design and primary current flow. The high voltage that is present on the open secondary of an energized current transformer generates two great hazards. The first hazard is ELECTRICAL SHOCK TO TESTING PERSONNEL. The second hazard is THE BREAKDOWN OF THE CURRENT TRANSFORMER INSULATION. Both hazards can be avoided provided that the secondary of the current transformer is never opened. The safest current transformer installations for testing are those that have a Test Switch as part of the secondary loop. A Test Switch is a device that will facilitate inserting instrumentation in the current transformer secondary loop without the danger of opening the circuit.

Test Switch Specifications

- ANSI C12 Definitions
- Test Switch Materials
- Plating
- Barriers
- Wiring Connections
- What to look for
- Covers

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For Test Switches and Jacks for Transformer-Rated Meters

1 Scope

This standard is intended to encompass the dimensions and functions of meter test switches used with transformer-rated watthour meters in conjunction with instrument transformers and test plugs used in conjunction with the test switch.

2 Definitions

2.1 short-circuiting switch

A single-pole double-throw (make-before-break) transfer switch used to transfer current away from the meter.

2.2 test jack

A spring-jaw receptacle in the current element of a test switch that provides a bipolar test connection in the metering current circuit without interruption of the current circuit.

2.3 test jack switch

A single-pole single-throw disconnect switch used in conjunction with a test jack to provide a parallel current path during normal operating conditions.

2.4 test plug

A bipolar mating plug to a test jack for inserting instrumentation into the metering current circuit.

2.5 voltage switch

A single-pole single-throw switch used to open or close a voltage circuit.

3 Standard ratings

3.1 Current

The current rating shall be 20 A minimum.

3.2 Voltage

The voltage rating shall be 300 V or 600 V.

4 General requirements for test switches

4.1 Material and workmanship

The test switch and its components shall be substantially constructed of suitable material in a workmanlike manner.

4.2 Nameplates

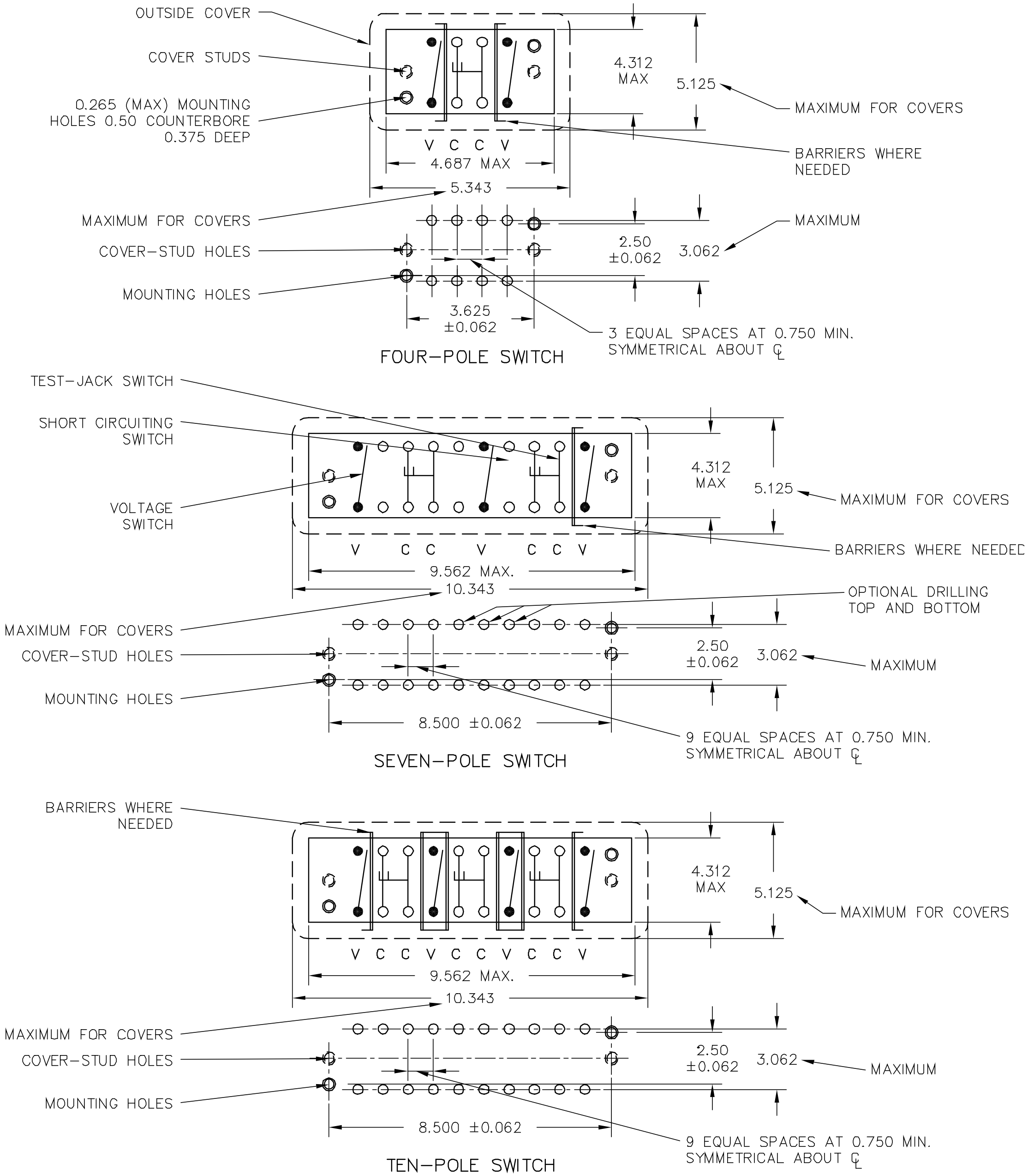
Nameplates are not required on these test switches, but a manufacturer's identifying marking (such as catalog number, trademark, etc.) shall be stamped, printed, affixed, or cast in a convenient place on each test switch. When required, a warning label indicating hidden internal jumpers should be affixed.

4.3 Movable parts

Movable conducting parts such as blade hinges shall be held in place by locknuts or pins or their equivalent, arranged so that a firm and secure connection will be maintained at any position of the switch blade.

ANSI C12.9 TEST SWITCH DEFINITIONS

ANSI C12.9 Test Switches



NOTES: (1) All dimensions are in inches.
(2) Unless otherwise specified, all tolerance shall be ± 0.015 inch.

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1.1 Insulating barriers

When a voltage switch is installed adjacent to current switch or to another voltage switch at a different potential then for safety considerations the two switches shall be separated by an insulating barrier as indicated in figures 1 through 3. Barriers may be an integral part of the base, a separate part fastened to the base, or an integral part of each individual switch section.

1.2 Wiring terminals and test clips

1.2.1 Wiring terminals

Test switches shall be provided with suitable wiring terminals for the connection of AWG No. 14 to AWG No. 8 secondary conductors.

1.2.2 Test clips

Facilities for attaching test clips shall be provided on the terminals or on the wire binding screws.

1.3 Mounting holes

Mounting holes (two minimum) shall be of the dimensions shown in figures 1 through 3.

1.4 Cover

1.4.1 General

An insulated cover shall be available for the test switches and if used shall be held in place by cover studs. The cover may be made of glass, plastic or other suitable non-conducting material, but shall not exceed the maximum dimensions shown in figures 1 through 3. When the cover is in place, all switches shall be in a closed position.

1.4.2 Cover holes

The diameter of the cover-stud holes shall be 0.281 in., located as shown in figures 1 through 3.

1.4.3 Cover studs

Removable cover studs with suitable provisions for sealing shall be available for use in each instrument-transformer-meter test switch in the positions indicated in figures 1 through 3. The diameter of these studs shall not exceed 0.25 in. Standard instrument-transformer-meter test switches shall be provided either with or without cover studs.

1.5 Acceptable spacings

The minimum acceptable spacings shall be as indicated in table 2.

Table 2 – Minimum acceptable spacings

Voltage between parts involved (V)	Minimum spacings from live parts to			
	Parts of opposite polarity*		Grounded metal**	
	Over surface (in.)	Through air (in.)	Over surface (in.)	Through air (in.)
0-300***	0.750*	0.375*	0.500	0.375
301-600	1.250*	0.750	1.000	0.500

*To be acceptable at other than wiring terminals, through-air and over-surface spacings of 0.375 in between parts of opposite polarity shall withstand a special dielectric strength test at 6 000 V, 60 Hz, for 1 min.

**To be acceptable at other than wiring terminals, through-air and over-surface spacings of 0.375 in between current-carrying parts and cast-metal enclosure or grounded metal, where indentation or deformation of the overall enclosure will not affect spacings, shall withstand a special dielectric strength test at 6 000 V, 60 Hz, for 1 min.

***300 V spacings apply to a 600 V test switch, if the phase-to-neutral voltage does not exceed 300 V for spacings: (1) from neutral to phase-voltage parts, and (2) from neutral to grounded metal.

ANSI C12.9 General Test Switch Specifications

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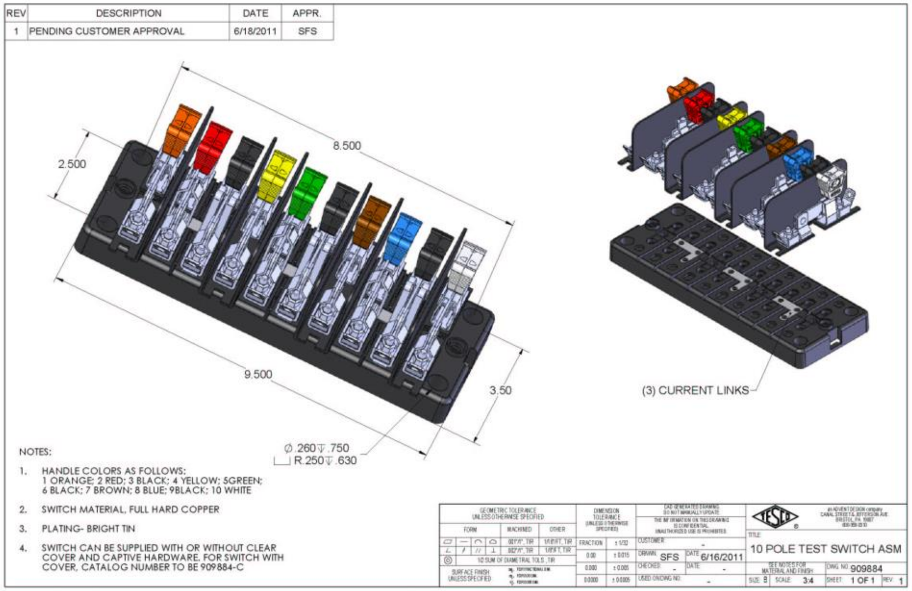
Test Switch Configurations

- Layout
- Handle Colors
- Reversed vs. Normal Potentials
- Current Links
- Base Sizing
- Barrier Locations and Removable vs Fixed



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Test Switch Accessories

- Test Plugs
- Safety Covers
- Test Switch Isolators

On installations that contain Test Switches, test leads terminated with a test switch
safety test probe (test plug) should be used for CT testing. This provides a "make-before-break" connection to prevent accidental opening of the current transformer secondary loop.

4.6 Provision for test plugs

Each double-pole short-circuiting current switch shall incorporate a test jack which is designed to permit the insertion of a test plug. The test-jack switch can be either in the left-hand or the right-hand position. In order to assure proper mating with the test plug the test jack shall conform to Figure 4.

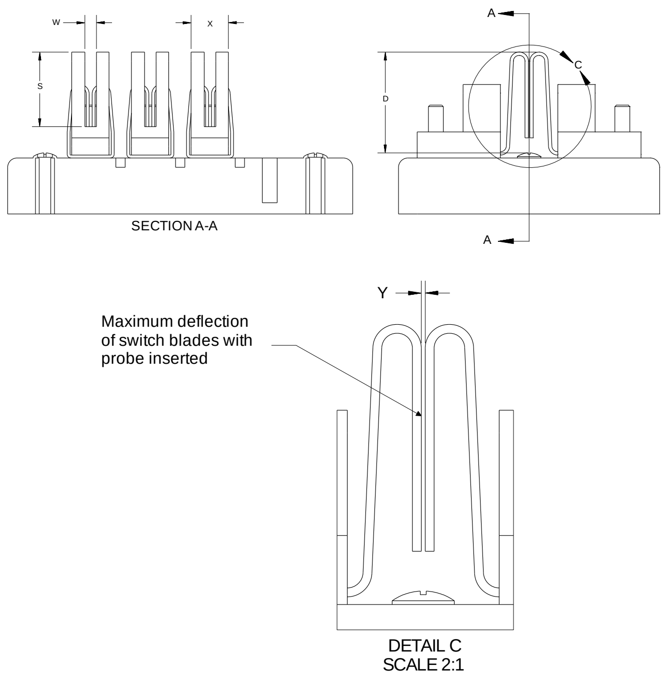


Figure 4 – Test switch typical cross section

Table 1 – Test switch dimensions

TEST SWITCH DIMENSIONS			
DIMENSION	**MINIMUM**	**PREFERRED**	**MAXIMUM**
S	**0.900**	**1.200**	**1.250**
W	**0.125**	**0.140**	**0.175**
X	**0.430**	**0.500**	**0.550**
D	**1.280**	**1.350**	**N/A**
Y			**0.188**

ANSI C12.9 Test Jack Specifications

ANSI C12.9 Test Plug Specifications

1 General requirements for test plugs

1.1 Materials and workmanship

The test plug shall be constructed with an insulated handle providing an anti-slip gripping area and a barrier to help prevent the user's gloved hand from slipping into contact with the test switch.

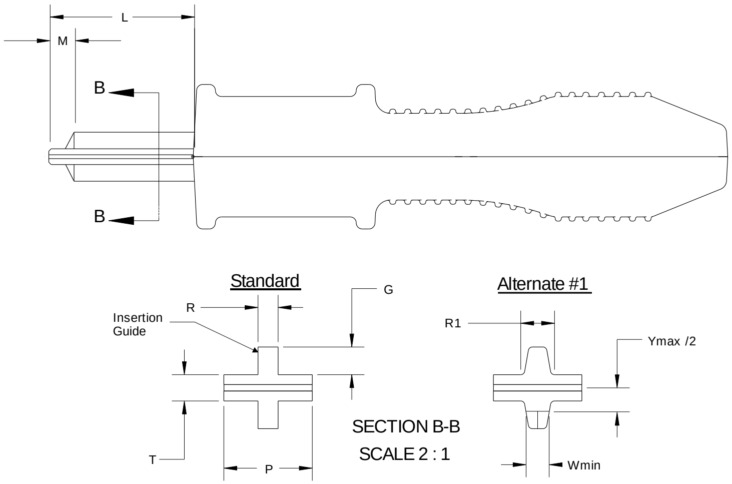


Figure 6 – Typical test plug

Notes:

(1) When the insertion guide takes the form of Section B-B Alternate #1, then for a switch with a slot width Wmin, the switch Jaws shall not be separated by more than Ymax = 0.188" when inserted.

(2) If a positive stop is provided on the probe blade to limit insertion depth of the probe to M by bottoming out against S of the switch, then L may exceed Lmax provided M < Dmin – Smax = 0.030".

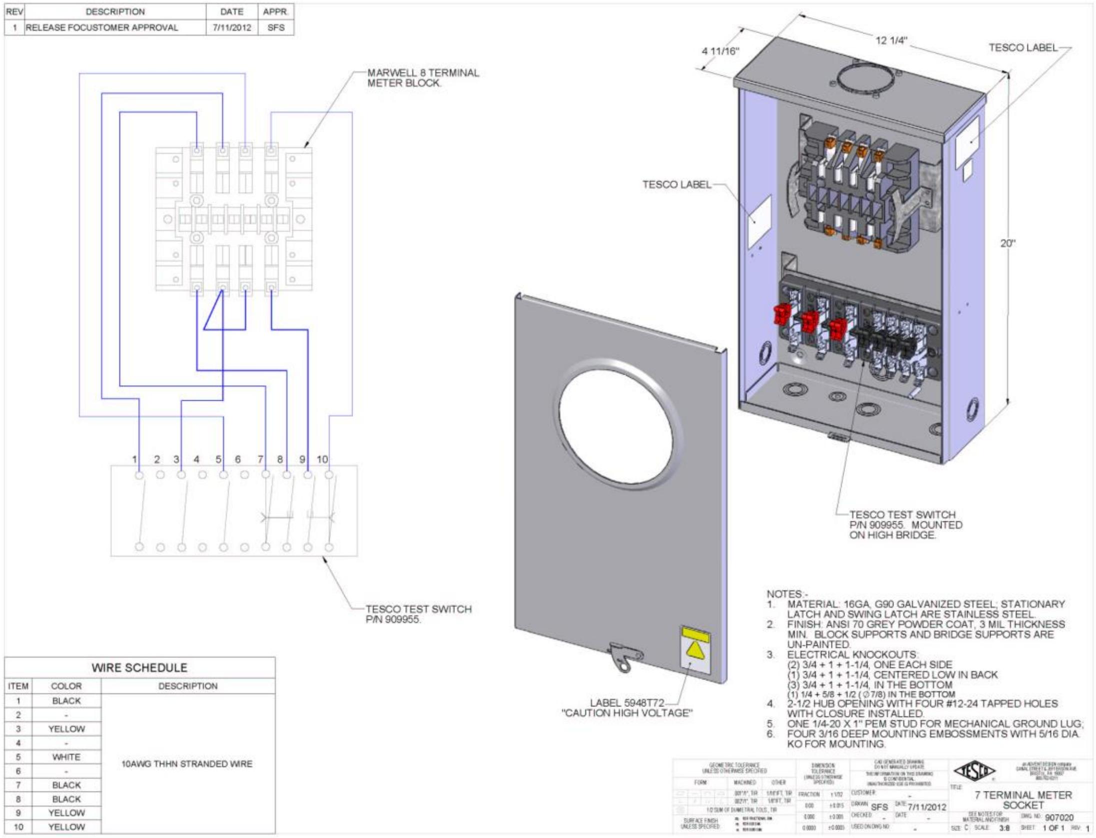
Table 3 – Test plug dimensions

TEST PLUG DIMENSIONS			
DIMENSION	**MINIMUM**	**PREFERRED**	**MAXIMUM**
L	**1.100**	**1.200**	**1.260**
M	**0**	**0.140**	**0.175**
R	**0.090**	**0.110**	**0.120**
R1	**n/a**	**n/a**	**0.156**
T	**0.100**	**0.130**	**0.156**
G	**0.040**	**0.125**	**0.175**

ALERT TO USERS: Prior to adoption of this standard there are known instances of probes and switches where interferences exist which may not allow all probes and switches to mate or which may lead to probes shorting to undesired conductors.

Pre-Wired Transformer Rated Enclosures

- Cover Types
- Wiring
- Sockets



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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?

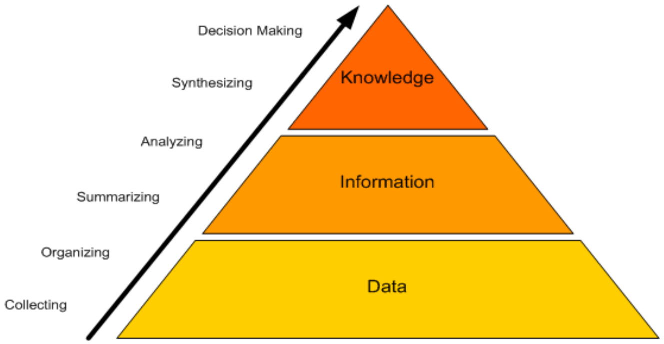
  - What are the best practices for handling potential hot sockets?

- 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.

- We will also cover new technology developed and patented by TESCO and L+G 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?

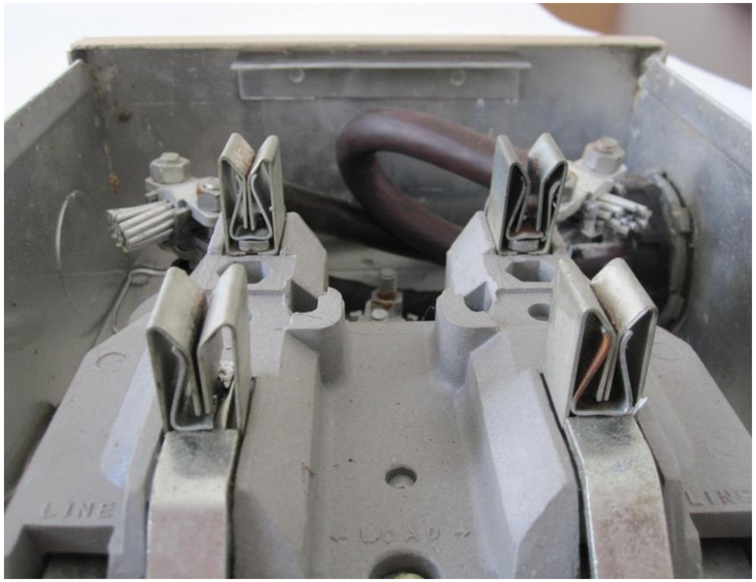
- L+G has been investigating hot sockets and how to make their meters withstand hot socket conditions for longer periods of time so the socket has a greater likelihood of being repaired prior to catastrophic failure.
- L+G has also been investigating ways to utilize AMI communication to possibly alert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



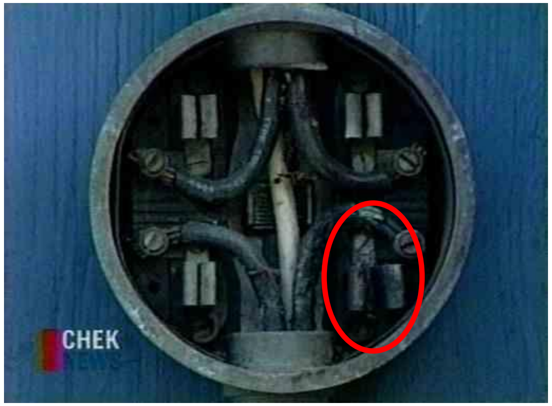
- TESCO has access to a large number of meters which have been exposed to hot sockets both before and after catastrophic failure as well as a limited number of sockets that were hot sockets and did not yet fail catastrophically.

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

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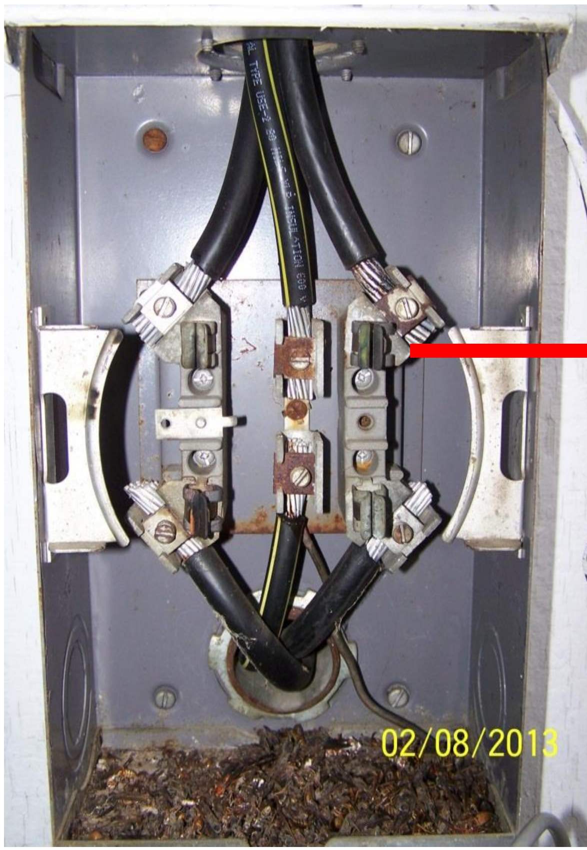
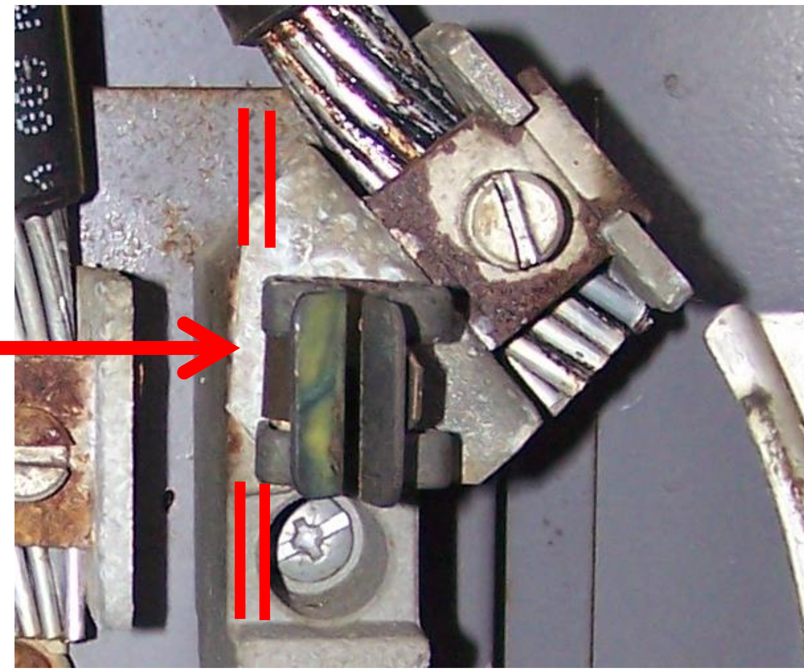
Hot Socket Causes – Sprung Jaws





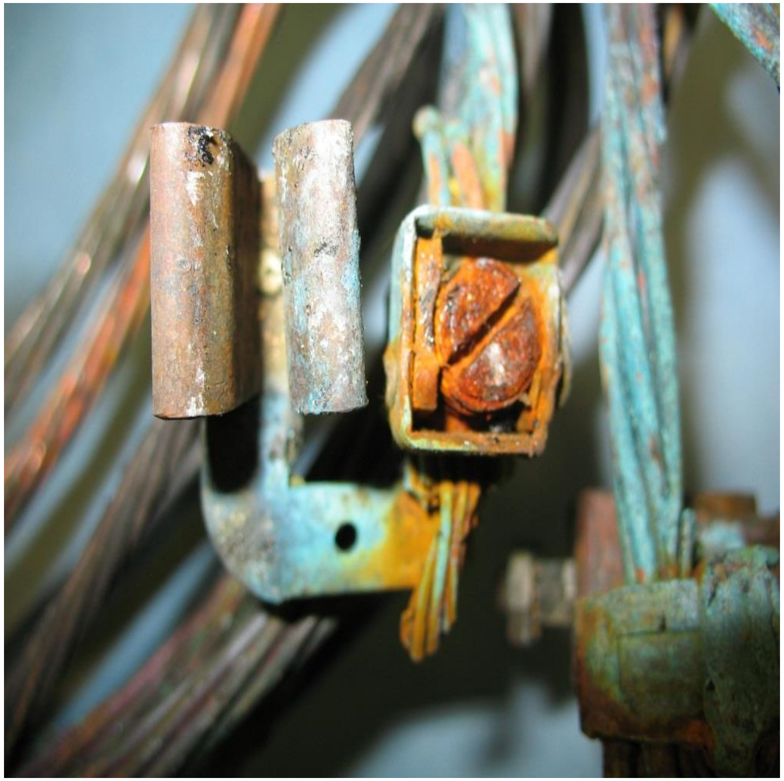
Tin plating on jaw "cooked"

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.

Hot Socket Simulation Fixture

Click to view video

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Expected & Unexpected Results

Expected:

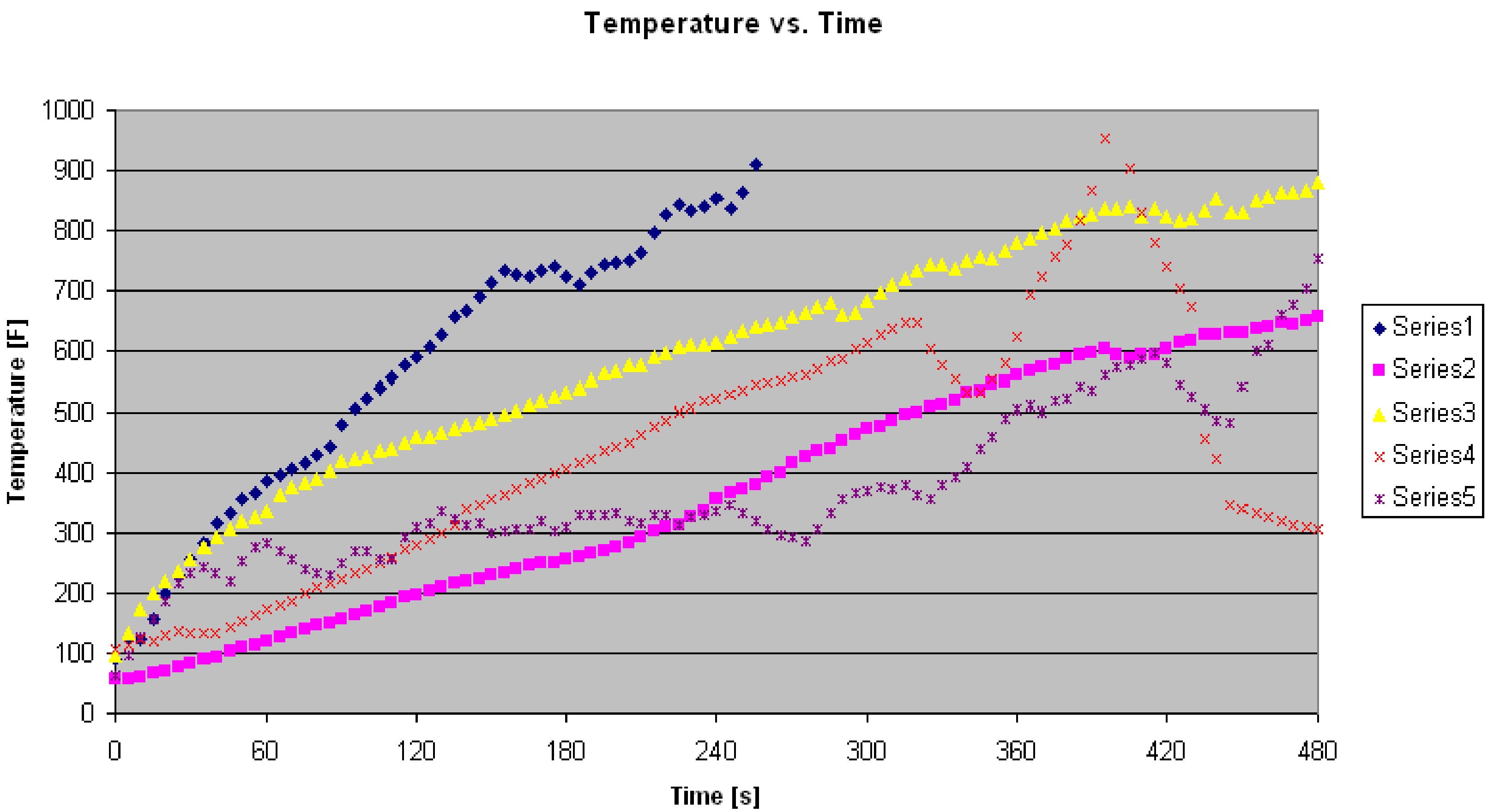
- Hot Sockets are exactly that – hot sockets. The hot sockets are the source of the problem and not hot meters.
- Electromechanical meters withstand hot sockets better than solid state meters

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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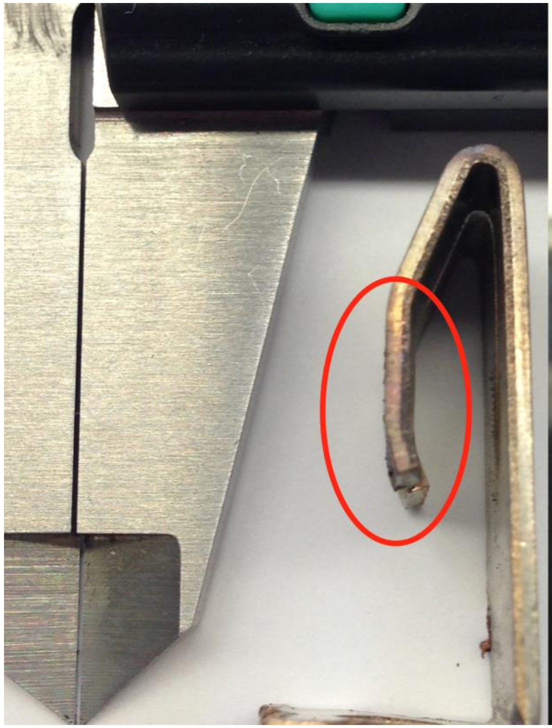
Gap Evaluation

- 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.



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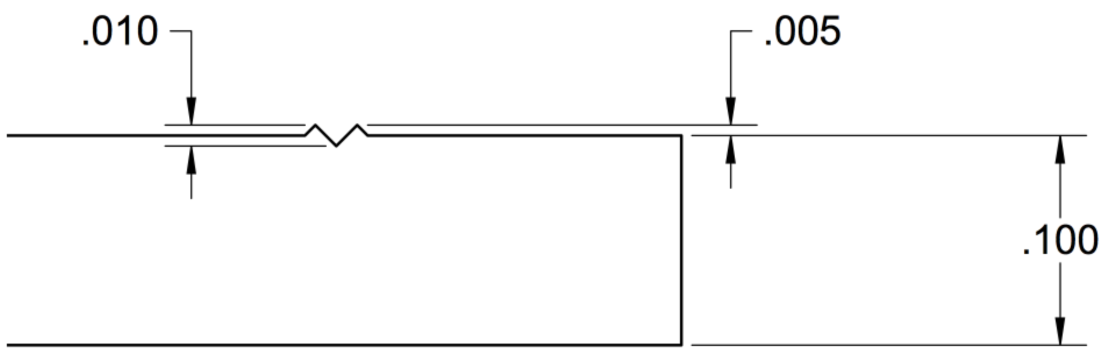
Service Degradation

- 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.



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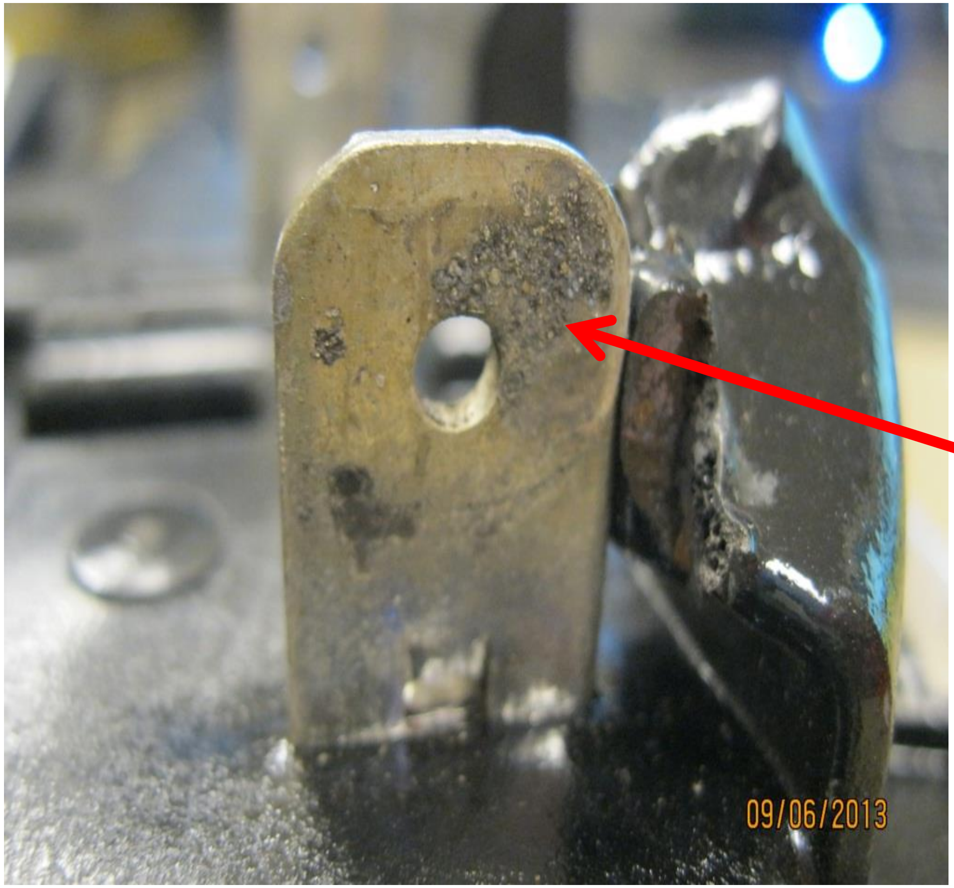
Jaw to Blade Arcing



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.

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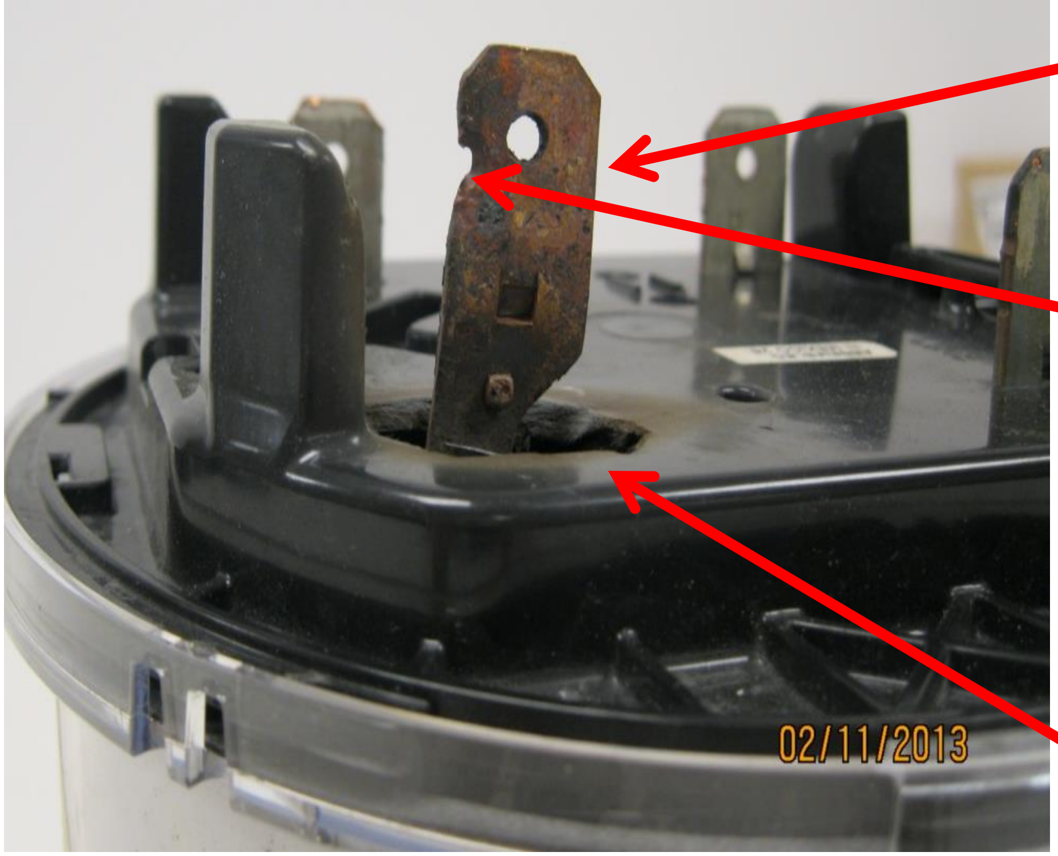
Severe Arcing Jaw to Blade



Tin burned off

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

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

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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

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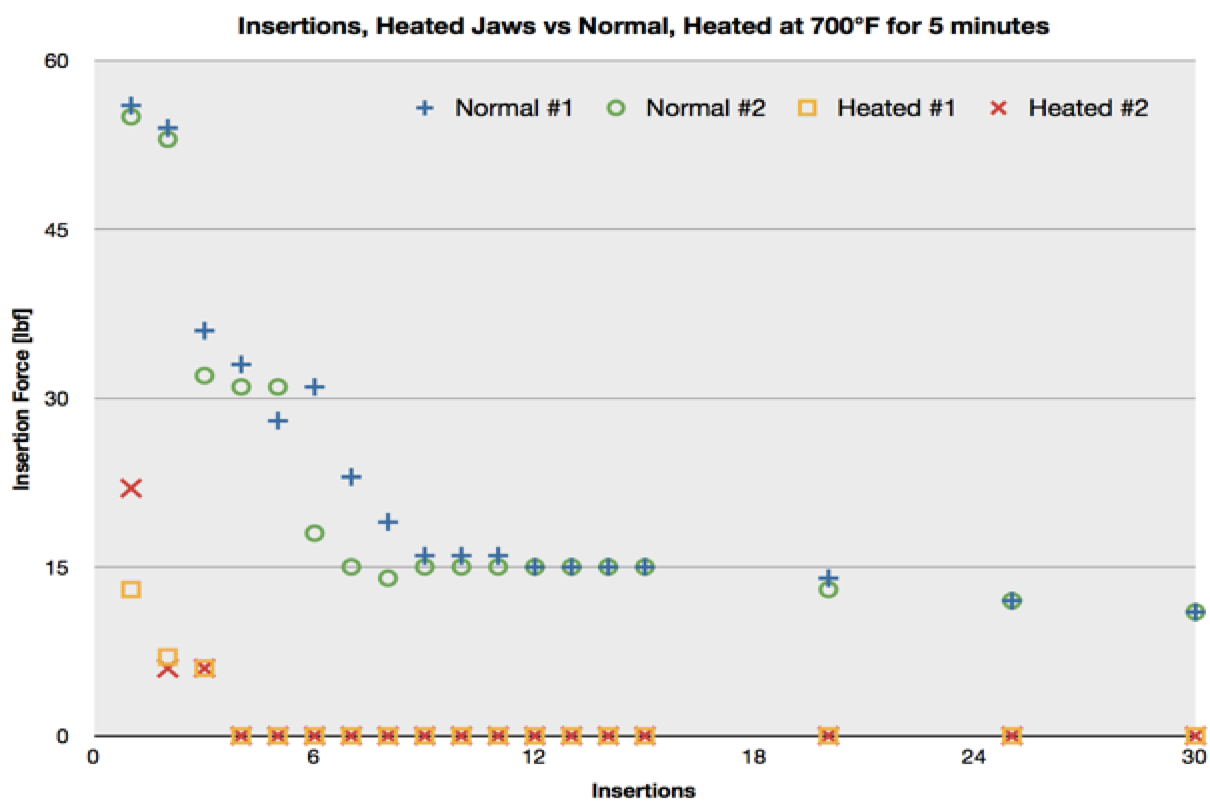
Insertions	Normal #1	Normal #2	Heated #1	Heated #2
1	56	55	13	22
2	54	53	7	6
3	36	32	6	6
4	33	31	0	0
5	28	31	0	0
6	31	18	0	0
7	23	15	0	0
8	19	14	0	0
9	16	15	0	0
10	16	15	0	0
11	16	15	0	0
12	15	15	0	0
13	15	15	0	0
14	15	15	0	0
15	15	15	0	0
20	14	13	0	0
25	12	12	0	0
30	11	11	0	0



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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.

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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**

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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 twenty four months virtually every meter manufacturer has begun to release 2S meters designed to withstand hot sockets.


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In Search of Hot Sockets

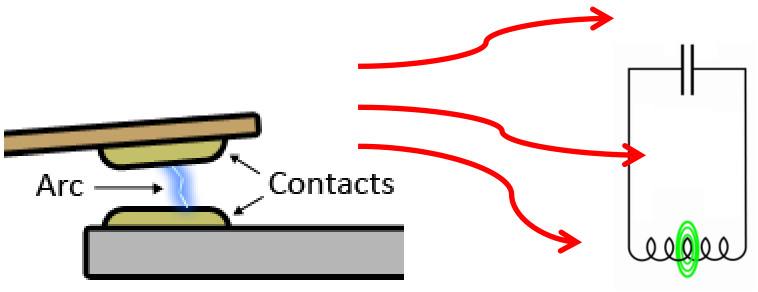
- The meter manufacturer’s and various electric utilities have also been looking at a variety of ways to better sense hot sockets.
- Utilities who have deployed are looking for a set of alarms that when taken together may give them a better idea that there is a hot socket
- Meter Manufacturers have worked 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.
- In 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.

Questions and Discussion

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