**BEFORE THE STATE CORPORATION COMMISSION
OF THE STATE OF KANSAS**

In the Matter of the Consolidated Complaints filed Against Kansas City Power & Light and Westar Energy Regarding the Required Use of Advanced Metering Infrastructure Digital Electric Meters.	)))))	Docket No. 15-WSEE-211-COM Docket No. 15-KCPE-265-COM Docket No. 15-KCPE-474-COM Docket No. 16-WSEE-066-COM
In the Matter of the Complaint Against Westar Energy by Richard J. Hesse and Monika R. Hesse.	)))	Docket No. 16-WSEE-365-COM
In the Matter of the Complaint Against Westar Energy by Alan & Susan Peterson.	))	Docket No. 16-WSEE-392-COM
In the Matter of the Complaint Against Westar Energy by Barbara R. Brooks.	))	Docket No. 16-WSEE-396-COM
In the Matter of the Complaint Against Westar Energy by Eric L. and Ramona E. Ryker.	)))	Docket No. 16-WSEE-397-COM
In the Matter of the Complaint Against Westar Energy by Austin Lowry.	))	Docket No. 16-WSEE-404-COM

**NOTICE OF FILING OF STAFF'S
REPORT AND RECOMMENDATION**

COMES NOW, the Staff of the State Corporation Commission of the State of Kansas (Staff and Commission, respectively), and hereby files its Report and Recommendation in the above consolidated complaints regarding the required use of Advanced Metering Infrastructure (AMI) Digital Electric Meters. Staff conducted additional inquiry regarding claims raised by the five most recent Complainants (Joining Complainants). This inquiry primarily centered on: (1) supervised installation of AMI meters, (2) causal links between AMI meters and structural fires, and (3) cyber-security threats related to remote disconnection of electricity to customers.

Staff's attached Report and Recommendation supplements and adds to its previous recommendations. Staff recommends that Westar Energy, Inc. (Westar) and Kansas City Power & Light Company (KCP&L) provide an annual report to Staff of any structure fires involving AMI meters. These reports should include a failure analysis regarding fires that are thought to have been caused by utility equipment. Additionally, Staff recommends that all AMI meters installed after the date of the Commission's Order in this docket be equipped with temperature sensors. Finally, Staff recommends that Westar and KCP&L immediately include the use of a go/no go tool to test the quality of meter bases during routine meter testing, in the event a temperature alert is triggered (e.g. temperature exceeds 185^{o}F) and during meter change out programs.

WHEREFORE, Staff submits its Report and Recommendation for Commission review and consideration, and for any other relief the Commission deems appropriate.

Respectfully submitted,

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REPORT AND RECOMMENDATION
UTILITIES DIVISION

TO: Chairman Jay Scott Emler
Commissioner Shari Feist Albrecht
Commissioner Pat Apple

FROM: Casey Gile, Energy Engineer
Leo Haynos, Chief of Utility Operations & Pipeline Safety
Jeff McClanahan, Director of Utilities

DATE: September 15, 2016

SUBJECT: 15-WSEE-211-COM; 15-KCPE-265-COM; 15-KCPE-474-COM; 16-WSEE-066-COM; 16-WSEE-365-COM; 16-WSEE-392-COM; 16-WSEE-396-COM; 16-WSEE-397-COM; 16-WSEE-404-COM: In the Matter of the Consolidated Complaints filed Against Kansas City Power & Light and Westar Energy Regarding the Required Use of Advanced Metering Infrastructure Digital Electric Meters

EXECUTIVE SUMMARY:

The Commission has received multiple Formal Complaints from residential customers of Westar Energy (Westar) and Kansas City Power & Light (KCP&L) (or collectively referred to as the Utilities) regarding the installation of Automated Infrastructure Metering devices ("AMI" or "Smart Meters"). Staff filed a Report and Recommendation (R&R) on January 15, 2016, in this Docket that addressed issues raised by four Complainants that were consolidated in the Docket at that time. The issues previously addressed include: radio frequency and electromagnetic fields emitted from the meters causing health problems; security of Complainants' Personally Identifiable Information (PII); and the desire to opt-out of the installation of the AMI meters. After the initial R&R was issued, additional customer complaints were received by the Commission, which were consolidated into the previous Docket. The most recent complaints raise the same issues as those addressed in Staff's previous R&R and they raise new concerns related to AMI meters that Staff has not addressed. After reviewing the most recent complaints, Staff wishes to supplement its R&R to address the following allegations and concerns raised in the most recent complaints:

- The installation of the AMI meters are not supervised directly by the Utilities and are not inspected once installed by city code inspectors;

- AMI meters are the cause of structural fires; and
- The possibility of a cyber-security threat related to remote disconnection of electricity to customers.

After conducting additional discovery pertaining specifically to these new complaints, Staff believes there is no state or local regulatory requirement for the inspection of the AMI installation. AMI meters are installed by the Utilities or their contractors that historically have exhibited the necessary expertise to perform this function. Staff agrees with the Complainants that electric meters are one of the many electrical components that may be involved in house fires. However, Kansas data indicates this tendency applies to analog meters as much as it applies to the digital AMI meters with radio transmitters. Because AMI meters are a relatively newer technology, Staff recommends the Commission request the Utilities to report any fires to Staff where an AMI meter is considered to be involved in a fire or is considered to be a point of ignition. If a trend in AMI meter related fires develops, Staff will recommend further investigation in to the matter at that time. Staff's research indicates a probable cause of fires associated with electric meters is a loose connection between the meter and the customer's meter base plate. Therefore, Staff also recommends the Utilities perform a test of the meter socket gap whenever a meter is pulled by the Utilities. Regarding the concern posed by unauthorized access to a customer's meter, many of the Utilities' AMI meters provide the option for the Utilities to remotely disconnect a specific customer's service. With this ability to single one customer out of many, the possibility of PII exposure seems inherent. Staff believes its original recommendation to require the Utilities to modify their tariffs to include the Utilities' obligations to protect its customers' PII adequately addresses this issue.

ANALYSIS

Installation and Inspection of Installation of AMI meters: In general, the Utilities are responsible for installing and operating metering equipment and the adequacy of all utility operations are subject to review by the Commission.[1] Historically, the Commission has not required the Utilities to provide company personnel to directly observe the actions of their contractors. Staff has no evidence that would suggest the use of professional contractors to install AMI meters has resulted in unsafe or poor quality installations. Previous analog meter installations required no such inspections or oversight. As part of this Docket, Staff has reviewed the Utilities' training procedures for AMI meter installations (see Appendix A). Staff believes the summary of the training procedures in Appendix A demonstrates the Utilities have a solid training program for their contractors and employees regarding meter installation. We note, however, the training programs and meter replacement procedures only require a visual inspection of the meter base plate. While such an inspection will determine any visually detectable wear or arc burns to the meter socket, it does not test the spring tension of the meter socket.

[1] *See* K.S.A. 66-101h.

AMI Meters Causing Structural Fires: There have been reports posted on the internet of utilities replacing large quantities of AMI meters due to customer concerns about the meters' involvement in structure fires. Landis+Gyr and Sensus[2] are some of the major manufacturers of AMI meters that have come under scrutiny for providing metering equipment that allegedly have been involved in fires.[3] Both of these companies seem to have done their due diligence in ensuring a safe product is being supplied. Landis+Gyr partnered with TESCO, an industry leader in electric meter testing and products, and performed a series of tests to demonstrate other maintenance issues are often what lead to fires in meter boxes.[4] Due to incidents where AMI meters manufactured by Sensus were reported to have started fires, Saskpower, a public utility in Canada, recalled over 100,000 AMI meters to further investigate the quality of the meters. Further testing found the meters passed the Underwriters Laboratory (UL) testing standard and the UL test confirmed that the Sensus meters were not the cause for the fires.[5] Other electric utilities have seen both success and failure in the deployment of AMI devices in the subtext of meter fires. Successes have been attributed to proper training of installers and performing the necessary maintenance on meter boxes at the time of installation.[6] Staff notes all Westar AMI meters are equipped with temperature sensors that provide alarm capability through the third party contractor then back to the meter data management system, if the meter's temperature exceeds a set point of 185 degrees Fahrenheit. After the alert has been issued to Westar, a brief investigation is conducted on the history of the particular meter and, if no known issues are seen, a ticket is produced for an inspection of the meter. To date, none of the Westar AMI meters have indicated an abnormal operating temperature.[7] KCP&L has temperature sensors on approximately 15% of the smart meters that they have installed.[8]

Occurrence of Electrical Meter Fires in Kansas: A recent report has been published by a local Kansas City area news channel that smart meters could be the source of fires in the Kansas City area.[9] The news report notes that KCPL has had 6 "problems" with smart meters that have been installed and that the wiring to the meters is often the issue. To understand the significance of electric meter related fires, Staff reviewed Kansas data from 2012 to 2016 from the National Fire Incident Reporting Service (NFIRS). NFIRS is a national database that collects data from individual fire departments as to the cause of fires. For that time period, NIFRS reports there were 32 incidents in the Utilities' operating areas where the meter or the meter box was considered to be the cause of structure fires. Notwithstanding the following discussion, Staff believes it is important to note there have been very few meter fires (analog or AMI meters) in relation to the

[2] https://takebackyourpower.net/smart-meter-fire-risk-liability-is-undeniable-and-unprecedented/

[3] http://www.cbc.ca/news/canada/saskatchewan/saskpower-to-remove-105-000-smart-meters-following-fires-1.2723046.

[4] Response to Staff Data Request to Westar No. 15C.

[5] http://www.greentechmedia.com/articles/read/sensus-smart-meters-pass-ul-safety-tests-but-fire-concerns-remain.

[6] *See* Staff Report to the Commission re: ComEd Smart Meter Fires, Illinois Corporation Commission, p. 12 (Aug 28, 2013).

[7] Response to Staff Data Request to Westar No. 20.

[8] Response to Staff Data Request to KCPL No. 16.

[9] http://www.kshb.com/news/local-news/investigations/kcmo-smart-meter-fire-sparks-investigation.

Comparison of NFIRS Data on Meter Fires to Utility Data (only AMI meters)				
NFIRS Date of Fire	**NFIRS Reported Cause**	**Type of AMI meter**	**Westar Reported Cause**	**KCPL Reported Cause**
1/31/2015	Meter box wiring	Landis+Gyr	--	Not related to meter.*
1/9/2015	Wiring from Meter Box to Circuit Breaker	Landis+Gyr	--	Not related to meter.*
7/22/2014	Wiring from Meter Box to Circuit Breaker	Landis+Gyr	Meter not energized on date of fire.	--
11/27/2014	Meter/Meter Box	Elster	Breaker box caught fire.	--
7/27/2015	Meter/Meter Box	Elster	Not related to meter.*	--
3/3/2015	Wiring from Meter Box to Circuit Breaker	Elster	Meter removed after fire; no record of cause of fire.	--
8/15/2015	Meter/Meter Box	Elster	Meter removed after fire; no record of cause of fire.	--
*Meter still in operation after date of fire.				

number of customers served by the Utilities. For the 32 addresses in the NFIRS report, Staff asked the Utilities to review their respective records in order to determine the type of meter installed at the date of the fire and determine if the Utilities agreed with the fire departments' investigative results. For AMI meters, that comparison is as follows:

In addition to the AMI meter reports noted above, Staff also reviewed all NFIRS reports for electric meter fires. Staff's analysis of the NFIRS data indicates electric meters (analog or AMI) or the electric meter bases are at times involved in fires caused by some type of electrical fault. But, there is no direct correlation to indicate fires associated with AMI meters are more prevalent than other types of electrical fires. What is noticeable to Staff in the Utilities' data is the lack of a failure analysis associated with electrical fires involving utility equipment. For 2012 to 2016, NFIRS reported 26 Westar meters as involved in structure fires that were thought to be caused by an electric distribution system. Westar was notified of and responded to 19 of the NFIRS reported fires. In some cases, Westar's notes state that Westar facilities were not involved. In the remaining cases, there is no indication as to the cause of the fire. There is one case in which Westar's notes state, "arcing meter can-house fire cut wire at house" for an address served with an analog meter, but there is no analysis of the cause of the fire. Westar confirmed that five of the meters (19% of the total) installed at the date of the NFIRS-reported fire were AMI meters. Of those five meters, Westar records indicate only two may have been involved in a fire. Again, for those two meters, the records do not state the cause of the fire.

For KCP&L, NFIRS reported two fires associated with addresses where an AMI meter was installed. In both cases, KCP&L records indicate the meter was not involved in a fire. For all of the NFIRS-reported fires in KCP&L's operating area, KCP&L has records of responding to either fire department requests or customer service requests for the six listed addresses, but there is no analysis in KCP&L records as to the cause of the fire. Staff notes one KCP&L record states there was a "fire in the meter can" for an electronic non-AMI meter, but the record does not provide an analysis as to the meter being the cause of the fire.

<u>Maintenance of Meter Bases:</u> While the AMI meters that are being installed in the Utilities' territories are all new, customer-owned meter bases in which the meters are connected are typically original equipment installed when the house was built. These meter bases can vary in age and size depending on the vintage of construction. In other words, a meter and meter base could have been joined for the past thirty to forty years and now they are being separated with a new meter installed into the old meter base. Even with the training and installation procedures that are in place, the Utilities are likely to encounter unforeseen circumstances that may result in slight modifications to their installation procedures. Maintenance of the meter bases has been found to be a common problem associated with meter fires. Staff's research into this matter raises the possibility that fires associated with electrical meters could be the result of micro-arcing between the meter stabs and the meter socket of the base plate. A detailed study of this phenomenon is attached as Appendix B to this R&R. This study is provided by TESCO, an electrical supply company that specializes in meter testing and products. The study states, "AMI deployments have made hot sockets a front page issue, as removing a meter from an old socket and forcing a new one in can actually create a problem. However, the deployments are also an opportunity to observe and flag sockets that are potentially dangerous."[10] TESCO has developed a tool to evaluate the condition of the meter socket jaw. Based on the evidence presented in the TESCO study, Staff believes the use of a go/no-go tool[11] to determine if a particular meter socket jaw is compromised would result in a more reliable examination of a meter base plate than the visual inspection currently performed by the Utilities. Because the use of this tool is a relatively simple test of the condition of the customer's meter base plate, Staff recommends the Commission order the Utilities to perform this test as part of their routine meter testing or meter change out programs. For any AMI meters equipped with a temperature sensor, Staff recommends such a test if the Utilities receive an alarm indicating the meter temperature has exceeded 185^{o}F. Furthermore, Staff recommends that all future AMI meters be equipped with temperature sensors to provide a temperature condition report on the meter's operation.

<u>Security of Complainant's PII:</u> As noted in Staff's previous R&R, we believe cybersecurity is of the utmost concern to the Utilities and they demand similar efforts in their contracts with their third party providers. We recommended the Utilities institute formal procedures to test on a regular basis the security of the third party providers to assure they are meeting their contractual obligations to the Utility, and we recommended the Utilities modify the general terms and conditions of their respective tariffs to codify the obligation to protect customers' PII. In one of the recent complaints, an additional concern was raised about the risk of an outside party getting through the Utilities' security system to cause widespread disconnections of customers' electric service. As noted in our previous Report, AMI meters have the capability of remotely disconnecting customers when necessary. When this situation arises there is one command given from

[10] *See* Appendix B.
[11] http://www.tesco-advent.com/equipment-300-hot-socket-gap-indicator.html.

the Utility to the third party service provider to disconnect the one specific customer. At that point, the service provider sends the necessary signal to the meter to disconnect service. There is no customer PII sent to the third party service provider to accomplish the isolated disconnection.

If a cyber hacker was able to send the appropriate code to disconnect a customer, it is unlikely such an approach could be used to cause a mass denial of electric service because such an unusual approach would be recognized by the service provider and verified with the Utility. As noted in our previous R&R, Staff recommends the Utilities institute formal procedures to test on a regular basis the security of the third party providers to assure they are meeting their contractual obligations to the Utility to protect against unauthorized cyber access.

CONCLUSIONS

In conclusion, the Complainants expressed concern with the proper installation of the AMI meter and inspection of that installation. Staff believes that through the appropriate training procedure, the Utilities have laid the foundation for competent installers of the AMI meters. Additional inspection of a meter installation has never been required in the past and Staff sees no need to change that precedence.

The Complainants also raised a concern regarding AMI meters being the cause of structure fires. Given the discrepancies between the NFIRS data and the Utilities' records, and the lack of analysis on the part of the Utilities as to the cause of a fire that involves utility equipment, Staff believes there is insufficient data from both fire investigators and the Utilities to determine the definite source of the NFIRS-reported meter related fires. Owing to the unclear data that is present, Staff recommends that Utilities perform a root cause analysis on any fire of which they are notified that is thought to involve Utility facilities. Furthermore, Staff recommends the Utilities file an annual report with Commission Staff that provides an analysis of fires associated with electric facilities. Over time, this approach will provide the Commission the information necessary to evaluate whether there is a risk of fires caused by AMI meter installations in Kansas. This approach, combined with remote monitoring of the AMI meters' operating temperature and the use of a tool to evaluate the meter socket jaws, will develop a sufficient operating history of this technology and minimize any threats from meter related fires.

Lastly, the Complainants raised a concern regarding the threat of a cyber hacker causing widespread electrical outages by remotely disconnecting customers' electric service. Staff believes our original recommendation to require the Utilities to institute formal procedures to test on a regular basis the security of the third party providers to assure they are meeting their contractual obligations to the Utility regarding cyber security will adequately address this concern.

RECOMMENDATION:

In Staff's Report and Recommendation filed on January 15, 2016, in the Consolidated Docket, Staff listed three recommendations for the Commission's consideration. At this time, Staff wishes add the following recommendations:

- Annually, the Utilities should provide a report to Staff of any structure fires involving AMI meters.
- The report should include a failure analysis from the Utility as to the cause of a fire that is thought to be caused by the Utilities' equipment.
- All AMI meters installed after the date of the Commission's Order in this Docket should be equipped with temperature sensors.
- The Utilities should immediately include the use of a go/no go tool to test the quality of the meter base during routine meter testing, whenever a temperature alert is triggered showing the meter to be over 185^{o}F and during meter change out programs.

A. HD SUPPLY METER INSTALLATION PROCESS

VERIFY LOCATION
• Verify the address using the hard copy route sheet
• Match the location with the record on Handheld Data Collector to avoid "swapped" account billing problems

PREPLANNING AND SPECIAL INSTRUCTIONS
• Check route work orders for any special instructions (aggressive dogs, a possible medical situation, knock before accessing, etc.)
• Plan a route out on the map
• Load vehicles and complete the daily inventory reconciliation

PPE SAFETY CHECK
• Perform PPE check and verify inventory for all required PPE
• Perform daily vehicle check

AWARENESS OF HAZARDS
• When approaching a residence, for safety, check the house/business and yard for signs of animals and/or damage to the meter.

NOTIFY THE CUSTOMER
• Perform the customer instruction process

- Knock on the door, wait a minimum of 30 seconds, taking notice of the surrounds. i.e. if there is a wheel ramp, handicap sign, etc wait a little longer at the door before proceeding.
- Use GPES provided “AMI meter” script.

• Notify the customer that there will be a short interruption of electric service
• Inquire if appliances/electronics are in use and ask the customer to turn them off
• If there is no one home, and there is access to meter, proceed with changing meter out

VERIFY METER TYPE AND ID
• Enter the existing meter serial number in the handheld device
• Verify that the existing meter serial number and form matches the existing meter serial number and size in the database
• If the existing meter serial number does not match, verify the address
• If serial number still does not match, call the Supervisor for further instruction
• Perform visual inspection

  • Prior to project start date HDS and GPES will determine agreed upon parameters in which HDS is not to perform a meter exchange. (service damage, diversion, etc)

  - Note of the existing seal color. If it is a white medical seal don’t exchange the meter and send to GPES as a skip. GPES to provide the standards document on the seal colors

• Perform a technical review of the meter, the service, and the meter box before commencing with the exchange
• Look over the meter and service for signs of arcing
• Record appropriate condition into handheld device
• Contact your Supervisor for support
• If there is evidence of diversion (illegal modification of the meter that allows un-metered electricity to the facility), call supervisor immediately for guidance

REMOVAL OF THE OLD METER
•Enter the meter read in the handheld
Using handheld, take an image of old meter in service
• Using the proper procedures and PPE equipment, remove the old meter. (one at a time)

INSTALLATION OF THE NEW METER
• Using the proper procedures and PPE equipment, install the new meter. (one at a time)
• Install meter ring and seal, seal the meter with the same color seal that was found
• Using handheld, take an image of the new meter in service

VERIFY THE METER OPERATION
• Verify that the meter powers up, passes self check, and displays correctly

PERFORM DATA COLLECTION
• Record meter installation data including meter and transmitter serial
number, old meter out read, and other data into the handheld Data Collector
• Record locations that have any predefined problems with the proper trouble code

- Record the GPS coordinates

CHECK THE SITE

- Ensure tools and any debris are removed
- Close any doors or gates upon leaving

LESSON PLAN

CURRICULUM: Electric Serviceperson	CODE:	2Q020L
TOPIC: Single Phase and Polyphase Meter Socket Testers	PAGE NUMBER:	1 of 7
PREPARED/REVISED BY: J. Drassen	REVIEWED DATE:	07-08-05
	REVISED DATE:	03-23-11

OBJECTIVES:

At the conclusion of this lesson, the employee will understand:

SAFE WORK PRACTICES FOR CHECKING METER SOCKETS

APPLICATION FOR "TYPE S-120" METER SOCKET TESTER.

TESTING PROCEDURES FOR "TYPE S-120" METER SOCKET TESTER.

APPLICATION FOR "TYPE P-277" METER SOCKET TESTER.

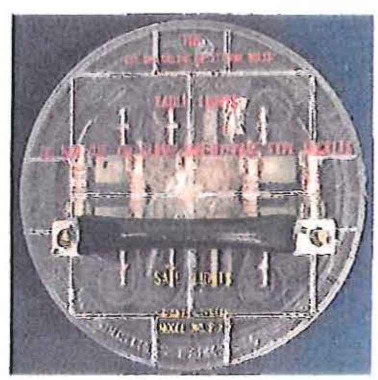
TESTING PROCEDURES FOR "TYPE P-277" METER SOCKET TESTER.

PROCEDURES FOR CHECKING FUSES IN THE METER SOCKET TESTER.

TRAINING AIDS:

Ekstrom Type "S-120"
Single Phase Meter Socket Tester

Ekstrom Type "P-277"
Polyphase Meter Socket Tester



INTRODUCTION:

This lesson will provide instructions which shall cover the application, testing procedures and principles of operation for the Ekstrom Type "S-120" and "P-277" Meter Socket Testers.

SAFE WORK PRACTICES FOR CHECKING METER SOCKETS

All tools, leads, jumpers, and test equipment shall be frequently inspected. No defective tools or equipment shall be used. Safety Rule 2301.0.3

A visual check shall be made of the meter (including nameplate and meter base) and enclosure to ensure that the proper meter is being used and the equipment is in good working condition before installing a meter in a new or previously vacated meter socket. Safety Rule 2301.0.5

Before installing a meter on all reconnects and new services, visual inspection shall be made of the meter base and tests shall be made for back feed, proper phasing and voltage, and short circuited conductors, including phase to phase and phase to ground. Safety Rule 2301.0.6

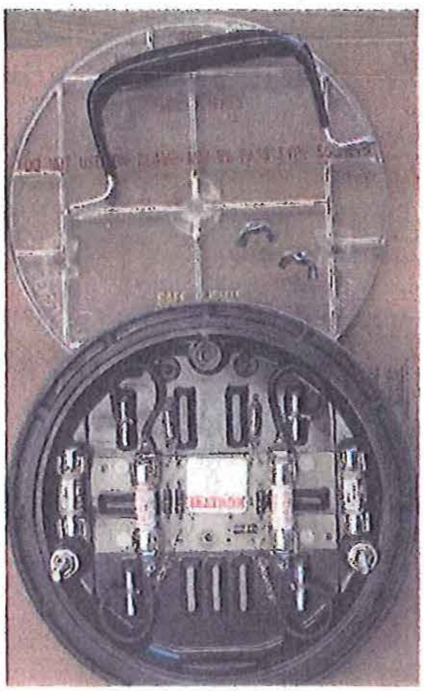
Extreme caution shall used when working on or near a 480 volt meter installation. On all 480v 3-wire, 3-phase meter installations, the service shall be de-energized before removing or installing meters. Safety Rule 2301.0.10

Customer loads shall be turned OFF before installing or removing self contained meters, where practical. Safety Rule 2301.0.13

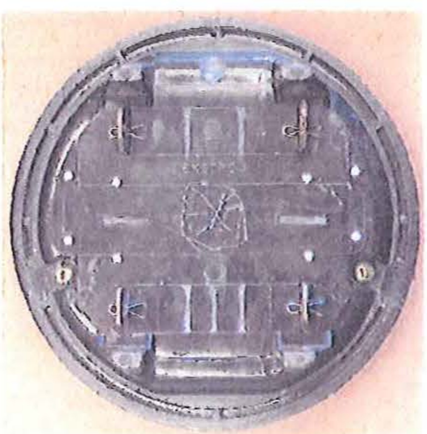
APPLICATION FOR "TYPE S-120" METER SOCKET TESTER.

This tester shall be used by meter installers to check meter socket bases for short circuits, grounds, and wiring errors PRIOR to setting the meter. This tester can be used to check 120/240 volt 3-wire and 120 volt 2-wire self contained socket installations. It can also be used to check 120/208 volt network meters and 240 volt 3-wire 3-phase services in 5-jaw meter sockets.

Note: The S-120 Meter Socket Tester is not intended as a replacement for normal socket check procedures. Although it has the capability of detecting backfeed, the manufacturer states "It will not detect backfeed in all situations". Therefore, do not rely on or expect this device to check for backfeed. Backfeed checks must be performed with a voltmeter.



This is a front view of the S-120 with the cover removed. The front cover is made of clear polycarbonate and is attached to the base and handle with two wing nuts. The front cover and handle must be attached to the base before using the tester. Notice there are 4 fuses mounted inside the base of the socket tester. The inner 2 fuses are connected between the line and load blades on the socket tester. The outer 2 fuses are spares. Before removing the front cover to access the fuses, the socket tester must be removed from the meter socket.



This is a back view of the S-120 socket tester. Notice there are 4 blades on the back of the socket tester.

TESTING PROCEDURES FOR "TYPE S-120" METER SOCKET TESTER.

The customer's main switch should be open for this test. If this cannot be done, it is possible that the customer's load will cause the fuses in the Socket Tester to blow (load more than 30 amps) and cause the fault lamps to glow. The service person should be aware of this possibility so they can proceed accordingly.

Check the fuses in the socket tester to be good before using it. Refer to the instructions on page 6 of this lesson for information on how to check the fuses.

Insert the socket tester into the socket base.

If both "safe lights" glow, set the meter.

If only one "safe light" or any "fault lights" glow, DO NOT set the meter. After the trouble is corrected, refuse the Socket Tester and repeat the testing procedure. Two spare fuses should be located inside of the socket tester. Make sure to use class "G", type "SC" (time delay, current limiting) 30 amp or equivalent type fuses.

CAUTION: Set the meter only if <u>BOTH "safe lights" glow AND NO "fault lights" glow!</u>

Situations that would cause one or both of the "fault lights" to glow or only one of the "safe lights" to glow.

<u>Grounds</u>

Indication: One or both "fault lights" glow. If a ground exists on a phase wire, the respective fuse will blow and allow its fault lamp to glow.

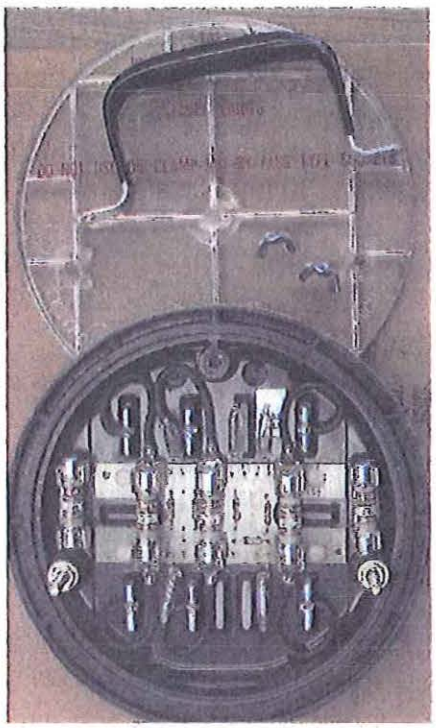
<u>Short Circuit</u>

Indication: Both "fault lights" glow. If a phase to phase short circuit exists, one or both fuses will blow, and one or both fault lamps will glow.

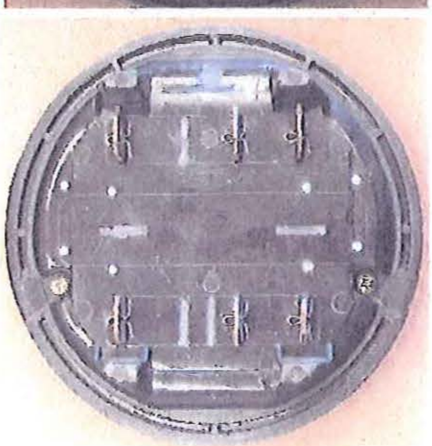
APPLICATION FOR "TYPE P-277" METER SOCKET TESTER

This tester shall be used by meter installers to check meter socket bases for short circuits, grounds, and wiring errors PRIOR to setting the meter on 120/240 volt 3-wire 240/480 volt 3-wire and 120 volt 2-wire single-phase, and on all 7-terminal polyphase self contained meter socket installations. It can also be used to check 120/208 volt network meters and 240 volt 3-wire 3-phase services in 5-jaw meter sockets.

Note: The P-277 Meter Socket Tester is not intended as a replacement for normal socket check procedures. Although it has the capability of detecting backfeed, the manufacturer states "It will not detect backfeed in all situations". Therefore, do not rely on or expect this device to check for backfeed. Backfeed checks must be performed with a voltmeter.



This is a front view of the P-277 with the cover removed. The front cover is made of clear polycarbonate and is attached to the base and handle with two wing nuts. The front cover and handle must be attached to the base before using the tester. Notice there are 5 fuses mounted inside the base of the socket tester. The inner 3 fuses are connected between the line and load blades on the socket tester. The outer 2 fuses are spares. Before removing the front cover to access the fuses, the socket tester must be removed from the meter socket.



This is a back view of the P-277 socket tester. Notice there are 6 blades on the back of the socket tester.

TESTING PROCEDURES FOR "TYPE P-277" METER SOCKET TESTER.

The customer's main switch should be open for this test. If this cannot be done, it is possible that the customer's load will cause the fuses in the Socket Tester to blow (load more than 30 amps) and cause the fault lamps to glow. The service person should be aware of this possibility so they can proceed accordingly.

Check the fuses in the socket tester to be good before using it. Refer to the instructions below for information on how to check the fuses.

Plug the tester into the socket and read the 3 "Fault Lights" on the top and the 2 "Safe Lights" on the bottom. Both "Safe Lights" will glow and no "Fault Lights" will glow if the installation is correct.

On 4 or 5 terminal sockets (single phase, network 120/208, or 240 volt 3-wire 3-phase installations) only the left "Safe Light" will glow and no "Fault Light" will glow if the installation is correct.

On 7 terminal sockets (4-wire wye and 4-wire delta installations) both "Safe Lights" will glow and no "Fault Lights" will glow if the installation is correct.

One or more "Fault Lights" will glow if the socket is not properly wired. Each light will indicate the respective conductor with the problem.

The "Safe Light" will glow if the customer's load wires are clear of shorts and grounds. The lower left safe lamp glows for single phase and both lamps will glow for three phase.

Make sure to use type "KTK" (fast acting) 30 amp or equivalent type fuses.

PROCEDURES FOR CHECKING FUSES IN THE METER SOCKET TESTER.

In order to check the fuses, the meter socket tester must be unplugged from any type of meter socket. Either an ohm meter or a continutiy tester may be used to check the fuses. Because the fuses in the tester are paralleled with a high resistance (68,000 ohm resister in series with a neon lamp), the fuses can be checked without removing them from the device. Place the test leads either directly across the fuse barrel ends (requires removing the front cover) or across the respective blades on the back of the tester (allows the front cover to remain in place) that attach to each of the fuse ends.

SUMMARY

The proper use of a meter socket tester is an essential part of working with electric meters. By following these instructions, employees can understand the application, testing procedures and principles of operation for the Ekstrom Type "S-120" and "P-277" Meter Socket Testers. Always remember to treat any instrument with care and in a delicate manner.

REFERENCE

Testing Instructions for Using "Type S-120" Meter Socket Tester., Ekstrom Industries, Inc.

Testing Instructions for Using "Type P-277" Meter Socket Tester., Ekstrom Industries, Inc.

LESSON PLAN

CURRICULUM: Electric Serviceperson	CODE:	2Q012L
TOPIC: Electric Meter Problems for Field Personnel	PAGE NUMBER:	1 of 7
PREPARED/REVISED BY: J. McGovern/J. Heilman & D. Heinetz/A. Harris & D. Kirmer	REVIEWED DATE:	06/19/01
	REVISED DATE:	02/16/04

OBJECTIVES:

At the conclusion of this lesson, the employee will be able to do the following:

I RECOGNIZE POSSIBLE METER PROBLEMS.

II KNOW VARIOUS METER PROBLEMS, POSSIBLE RESULTS OF THE PROBLEMS, AND WHAT TO DO ABOUT THE PROBLEM.

TRAINING AIDS:

- Meter Reading Training Film
- Report of Suspected Meter Tampering, Form 147-1
- Service Investigation Order
- Slides

INTRODUCTION:

Not only must field personnel read meters, connect and disconnect service, and perform various other tasks, they must be alert to identifying possible meter problems. Prompt reporting and/or attention to a meter problem can save time, money, and effort.

There is a high degree of accountability for field personnel to report situations which may result in erroneous billing to the customer that resulted from a meter problem which the Company could have prevented or corrected in a more timely manner. Meters must be installed correctly and any suspected problems must be reported at the earliest opportunity. Employees must always be especially attentive to the Company's meter sealing devices. It is the first clue as to whether an account needs to be referred for further investigation.

PRESENTATION:

I Recognizing Meter Problems.

A. Some meter problems are obvious and can even be seen from a distance.

1. Meter cover broken.

2. Meter enclosure or socket base is pulled away from the house.

3. Meter is upside down.

4. Meter is missing.

B. Many more meter problems can be detected by either inspecting the meter or by closer observation.

1. Jumpers inside the meter base.

2. Magnet inside or outside meter.

3. Tampered or missing seal(s).

4. Objects inserted inside the meter to slow the disk.

5. Hole drilled in meter base or meter cover.

C. Meter problems can be caused by nature.

1. When backfill around a foundation of a house settles, the conduit will, on occasion separate from the meter enclosure or socket base.

2. The weather can cause condensation to form inside on the meter glass.

D. Meter problems can be caused by individuals who have tampered with the meter for reasons of theft and/or diversion. These situations can also cause a potential hazard for the customer and Company personnel.

1. Meter upside down.

2. Objects inserted into the meter to slow down disk.

3. Holes in meter glass.

4. Jumpers inside the meter enclosure or socket base.

II Various meter problems, possible results of the problems, what to do about the problem.

A. Meter problems should be reported to your supervisor using the Service Investigation Order (S.I.O.) Meter readers will report visible problems by entering the appropriate codes in the Itron Hand Held Data Cap. A hard copy will be generated for the appropriate departments.

1. Demand reset device is bent.

   a. Makes it difficult to reset demand, **and/or**
   b. Prevents proper resetting of the demand.
   c. Can result in delay to account billing.

2. Conduit separated from the meter enclosure or socket base.

   a. Exposed wires could be a hazardous situation.
   b. Can result in water getting into the meter enclosure or socket base on an overhead installation.
   c. Could pull meter enclosure or socket base off the building.

3. Meter cover broken.

   a. Could be the result of:
      i. Storm damage.
      ii. Vandals.
      iii. Attempted unauthorized turn-on.
      iv. Contractor.
   b. Could stop meter from registering accurately if a small piece of glass were to obstruct the disk or jam the gears of the meter register dials.
   c. Could damage the internal workings of the meter.

4. Smoked meter cover.

   a. Could be the result of:
      i. Fire.
      ii. Short in meter or wiring.
      iii. Loose connection inside meter enclosure or socket base.
      iv. Damage by lightning.
   b. The cause of the smoked cover can result in inaccurate meter registration.
   c. Indicates a very probable hazard.

5. Condensation inside on the meter glass or on other areas inside the cover.

    a. Could be the result of:
        i. A bad gasket.
        ii. Hole or crack in the meter cover.

    b. Could result in inaccurate meter registration.

6. Meter enclosure or socket base pulled away from the house.

    a. Could be the result of:
        i. Screws coming loose.
        ii. Home improvement or maintenance project.
        iii. Possibly electrician loosened while performing work for owner.
        iv. Ground settling.
    b. May prevent meter from registering accurately if disk is not in correct vertical position.
    c. Depending on how far it is pulled away from house:
        i. Would cause interruption of service if connections broken.
        ii. Exposed wires could create safety problem.

7. Non-registering meter.

    a. Meter has stopped registering usage yet service is still on.
    b. Could be a result of:
        i. Meter malfunction.
        ii. Tampering.
        iii. An object obstructing the meter disk.
        iv. Open potential coil.
        v. Vacant building.

8. Demand reset broken.

    a. Prevents resetting of the demand.
    b. Could result in:
        i. Delayed account billing and/or
        ii. Additional billing work (ex: estimating demand).
        iii. Inaccurate registration of demand.

9. Meter dial pointers out of alignment -- the kWh meter dial pointers are either a little ahead or behind of where they actually should be.

a. Could be the result of:
   i. Loose gearing inside register.
   ii. Loose meter dial pointers.
b. Will result in:
   i. Incorrect registration, and
   ii. Incorrect billing.

10. Meter sealing device (s) broken or missing.
   a. Could indicate vandalism.
   b. May have resulted from electrician doing some type of work.
   c. If the seal is open or missing reseal the meter with a yellow seal and report as unsealed on the ITRON unit.

11. Holes in meter cover. They could be the result of:

   a. Someone drilling into cover for the purpose of inserting an object to stop or slow down disk.
   b. Vandalism.
   c. Storm Damage.

12. Magnet inside or outside meter.

   a. Could result in inaccurate meter registration.
   b. Indicates tampering and probable theft of service.

13. Objects lodged to slow disk (toothpicks, bugs, matchbooks, etc.)

   a. Whenever anything touches the meter disk, it can result in inaccurate registration.
   b. Probable causes:
      i. Tampering.
      ii. Vandalism.

14. Stolen Meter.

   a. Meter is not at location Company records indicate and meter enclosure or socket base is open.
      i. Indicates probable theft of meter.
      ii. Possible use of stolen meter is to install it at another location to restore service.

b. Meter found at a location other than where our records indicate.
   i. Possible indication of theft of meter for restoration of service at address that should be off for non-pay.
   ii. Possible company meter removal from a prior address and installed at a new address. Company records do not yet reflect the meter change.

15. Jumpers inside meter enclosure or socket base.

   a. Indicating probable theft
   b. Possibly installed by electrician restoring service for customer with service problem, and awaiting our completion of some type of Company work.

16. Meter is upside down in the socket base.

   a. A meter installed upside down in the socket base will run backwards. The meter dial pointers turn in the opposite direction, which subtracts kWhs from the register.
   b. Is a probable indication of theft.
   c. Could have resulted from Company employee or electrician installing incorrectly.

17. Open Potential Link

   a. Indicates possible tampering.
   b. Could have been left open by Company Employee.
   c. Results in no registration.

18. Excessive wear or discoloration of the meter blades.

   a. Could indicate possible tampering.
   b. Could be result of meter being frequently removed or reinstalled.

19. Excessive scratches on meter enclosure or socket base.

   a. Could indicate possible tampering.
   b. Inspect the situation and if there is not apparent tampering, leave it as is.

20. Solid blanking plate.

   a. A solid blanking plate is one which cannot be seen through.
   b. All solid blanking plates are being replaced with clear blanking plates.
   c. This allows us to see any possible tampering behind the blanking plate without having to remove it.

21. Meter Reader reads meter and read is less than the previous read. Possible causes:

   a. Overread or overestimated on previous reading.
   b. Underread on current reading.
   c. Meter change not yet reflected in Company records.
   d. Someone could have turned meter upside down to make it run backwards and then turned it upright again.

B. Any open meter base or one which is missing a cover, blanking plate, and/or meter should be reported as soon as possible, by phone or radio, directly to your supervisor.

1. Supervision will contact the appropriate personnel to correct the situation.

2. An open meter base is a hazardous condition and it is always a priority to correct. After notifying supervision of the situation, immediately return to and remain at the scene until the problem has been corrected.

C. If any problems encountered in the field appear to be the results of tampering or attempted diversion, follow the procedures as outlined in "Electric Diversions."

SUMMARY:

The majority of the meters in the field never have a problem. They are extremely accurate, reliable, and very durable. However, we must always be observant and report any possible problems. The appropriate action can then be taken to investigate the situation or fix the problem. Meter Readers visit almost every metering installation each month. This makes their role in the detection of possible metering problems extremely important, both for proper billing and for public safety.

LESSON PLAN

CURRICULUM: Electric Service Person		*CODE:*	2E016L
TOPIC: Damaged Meters or Enclosures		*PAGE NUMBER:*	1 of 3
PREPARED/REVISED BY: J. Drassen		*REVIEWED DATE:*	10/07/08
		REVISED DATE:	10/07/08

OBJECTIVES:

At the conclusion of this lesson, the employee will be able to explain:

HAZARDS OF PULLING A DAMAGED METER

ASSESSMENT OF A DAMAGED METER OR ENCLOSURE

PROCEDURES FOR REMOVAL OF METER THAT HAS A BROKEN OR CRACKED COVER, USING A "METER PULLER" DEVICE

INTRODUCTION:

The installation and removal of meters involves working around a variety of hazards. It's important that employees know these hazards, know how to identify these hazards, and know without question how to safely deal with these hazards. This lesson is designed to educate employees on the hazards of pulling a damaged meter, how to identify these hazards and then how to safely remove a damaged meter.

HAZARDS OF PULLING A DAMAGED METER

Meters can be damaged as a result of storms, attempted unauthorized turn-ons, a short in the wiring, a loose connection inside the meter enclosure or socket base, lightning, overloaded/overheated meter, or vandalism. Damage to the meter or socket creates a potential hazard. The hazards an employee faces when pulling damaged meters are created primarily when the meter or cover break or fall apart while it is being removed from its socket. Because the hands are in contact with meter while it is being pulled, the hazards include sharp edges, typically from the glass cover, which can cut the hands and electric contact to the hands when the meter and socket are energized. To protect employees from the cut and electrical contact hazards, the following safe work procedures have been established in the Safety Manual.

<u>802.02</u>

1 kv (Class 0) rubber gloves shall be worn when working energized circuits from 50 volts up to 600 volts when connecting, testing or inspecting low voltage apparatus where clearances are close or short circuit hazards exist, such as installing or removing meters.

Other potential hazards that exist when pulling a damaged meter include heat, and flying particles of glass, molten metal and other debris generated from electric arcs. To protect employees from the electric arc hazards the following safe work procedures have been established in the Safety Manual.

807.03
Employees exposed to or performing work on parts energized over 50 volts shall wear a company issued Flame Retardant shirt, full length sleeves down and secured around the wrist, over a Company issued light colored T-shirt or Polo shirt.

810.02
A hood shall be worn when working in energized meter sockets rated above 200 Amps, 200 amp meter sockets that are ganged from a common trough and all three phase meter installations with more than one meter feed from a common source.

812.01
Workers shall wear Company approved ANSI Z 87.1 safety glasses with side protection, prescription safety glasses with side protection, goggles or face shields when, there is a possibility of eye injury.

ASSESSMENT OF A DAMAGED METER, OR ENCLOSURE
The assessment of a damaged meter is accomplished through a visual inspection. Look for signs of damage to the meter, socket, or enclosure. Examples of visual damage include cracked or broken meter cover, holes drilled through the meter cover, smoked up meter cover, signs of smoke, burning or arcing in or around the meter, base or enclosure, enclosure pulled away from mounting structure, crushed enclosure openings cut into enclosure. The hazards of a damaged meter or enclosure include electrical contact, sharp edges and electric arc flash. To protect employees from these hazards the following safe work procedures have been established in the Safety Manual.

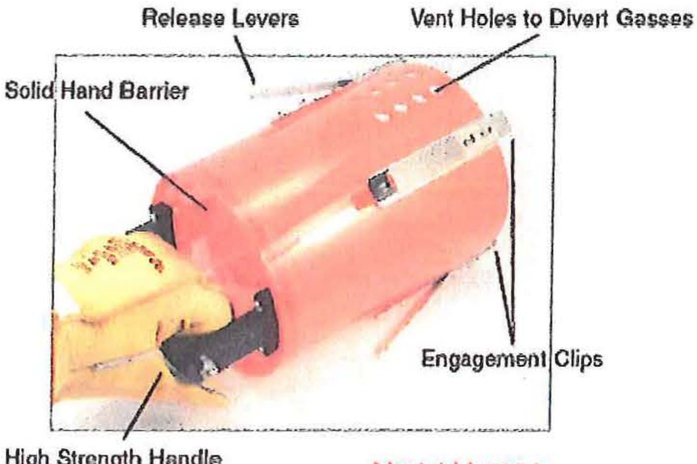
2301.0.1
All metering equipment shall be treated as energized until tested for voltage if a visual inspection reveals the possibility of a fault on the meter enclosure and/or meter.

2301.0.12
No attempt shall be made to remove the meter until the service has been de-energized if a visual inspection of the metering installation reveals that the removal of the meter may cause a fault.

PROCEDURES FOR REMOVAL OF METER THAT HAS A BROKEN OR CRACKED COVER, USING A "METER PULLER" DEVICE

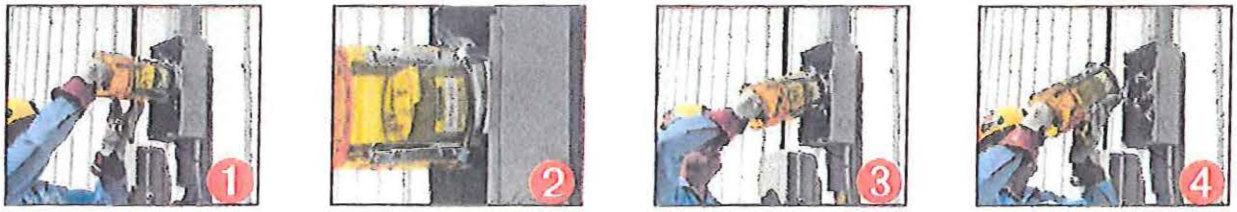
If the only assessed damage to the meter, socket or enclosure is determined to be a broken or cracked meter cover, use a "meter puller" device to safely remove the meter. Use of the meter puller device does not change the PPE requirements for pulling a meter. To protect employees and customers from the cut hazards of broken glass, the following safe work procedures have been established in the Safety Manual.

2301.0.8
All broken glass shall be removed from the meter and the customer's premises and disposed of in a safe manner if breakage occurs. Broken or cracked glass shall be removed before shipping.



Model M-002A

Meter Removal



1. Slide the MeterPuller over the meter.
2. Push until clips snap over meter's metal band.
3. Rock up & down to loosen the blades.
4. Pull the meter away from the base.

LESSON PLAN

CURRICULUM: Electric Serviceperson	CODE:	2Q011L
TOPIC: Single Phase, Self Contained Electric Meter Change-Outs	PAGE NUMBER:	1 of 6
PREPARED/REVISED BY: S. Widak, J. Heilman/A. Harris & D. Kirmer	REVIEWED DATE:	12/05/00
	REVISED DATE:	02/16/04

OBJECTIVES:

At the conclusion of this lesson, the employee will be able to do the following:

I PROPERLY NOTIFY THE CUSTOMER OF COMPANY BUSINESS AND PERFORM THE NECESSARY PRE-REMOVAL PROCEDURES.

II PROPERLY REMOVE AN EXISTING METER AND INSPECT THE METER ENCLOSURE OR SOCKET BASE, AND WIRING.

III PROPERLY REINSTALL AND RESEAL A METER.

TRAINING AIDS:

- 2 Wire and 3 Wire Single Phase Socket Meters
- Display Board with Various Types of Meter Enclosures
- Sealing Rings
- Lock Rings
- Pad Lock Seals
- Screwdriver
- ½" Insulated Nut Driver
- Meter with Burnt Blades
- Fort Knox Locks and Key
- Demand Reset Seals
- Wire Cutters
- Tab Seals

INTRODUCTION:

The technique used to change out a customer's meter seems relatively simple. However, for an employee to perform the work safely and to protect the safety of the general public, a thorough understanding is mandatory as there are many different electric meter types, bases, and adapters. There are also a number of inspections which must be made before changing out the meter. Another important aspect in this procedure is recognizing and reporting suspected diversion tactics.

PRESENTATION:

I. Customer notification & pre-removal procedures.

A. Customer notification.

1. Verify that you are at the correct address.

2. Before performing any type of work on a customer's premises attempt to notify the customer of your presence.

3. Go to the front door and attempt to contact the customer.

   a. Identify yourself as a Company employee.
   b. Make sure your Company ID is displayed at all times while on the premises.
   c. Inform the customer of your purpose for being there.

4. If the customer is not home:

   a. Proceed with your work if you can gain access to the meter.
   b. If locked gates, dogs, or other obstacles prevent you from getting to the meter, leave a preprinted message at the customer's premise. The message:

      i. Is designed to inform the customer that work needs to be performed on their electric meter.
      ii. Supplies a phone number which the customer can call in order to reschedule the work.

B. Pre-Removal Procedures.

1. Check the meter number against the order. This will help you verify that you are at the correct location. If meter number does not match with the address, contact your supervisor for assistance.

2. Determine type of meter and if you are qualified to perform the change out. Meters which you are qualified to work *on must:*

   a. Be either single phase, self-contained socket meters.
   b. Have a CL rating of 100, or 200.
   c. This information is normally found on the meter nameplate. Some older meters may not have complete information. If there is any doubt, call your supervisor for assistance.

3. Record meter read (kWh) and kW (if a demand meter), on the meter order.

4. Visual inspection:

   a. Check to be sure that the meter is not upside-down. If upside-down, follow Departmental procedure for suspected diversion.
   b. Check the security of the socket base or enclosure's sealing device. If the seal is cut, follow Departmental procedures for suspected diversion.

c. Check for mesh between the first gear and worm gear.

   i. The worm gear is on the disk shaft.
   ii. If the gears do not mesh, follow Departmental procedure for suspected diversion.

d. Check for objects (insects, matchbook, toothpicks, etc.) blocking the disk. If there is blockage, follow Departmental procedures for suspected diversion.

II. Removal of an existing meter and inspection of meter, socket base, enclosure, and wiring.

A. Safety:

1. Line side lugs remain energized before, during, after the change out procedure.

2. Before performing **ANY** meter work, don personal protective equipment: hard hat, rubber gloves/protectors, eye protection, and nomex shirt for the entire change-out procedure. Also, hoods if required.

B. Remove the padlock seal and any other sealing device (lock ring, Company padlock, or Fort Knox Lock) if present.

C. Remove the sealing ring or lid to the socket base or enclosure.

D. Removal of a socket meter.

1. 60, 100, 150, and 200 amp socket bases:

   a. Use the lower jaws as a fulcrum and pull the blades from the line side jaws with a downward force on the meter before withdrawing the lower blades.
   b. Some 200 amp socket bases have bypass handles without jaw releases. For convenience to the customer, use these bypass handles when performing a change out.
   c. Other 200 amp socket bases have jaw release bypass handles.
   d. In order to remove the meter, it **will be necessary** to pull the bypass handle up to release tension on the socket jaws.
   e. Hold the meter in place with one hand while operating the bypass handle to prevent the meter from falling to the ground as the tension on the socket jaws is released.
   f. **REMINDER** -- with the bypass handle in the up position, the load side lugs are **still** energized.

E. Inspection of meter, enclosure, socket base, and wiring after meter removal.

1. Check tab seal or wire seal for security -- if bent or reused, follow Departmental procedure for suspected diversion.

2. Check condition of potential link.

    a. The potential link must be closed and the potential link secured.
    b. If the potential link is open or the screws are loose, follow Departmental procedure for suspected diversion.
    c. A 120V, 2 wire has not potential link.

3. Check meter blades. Burnt or charred blades indicate a loose connection. If burnt or charred:

    a. Remove the meter and blank the socket base.
    b. Make an Service Investigation Order (S.I.O.) for replacement of the meter block.

4. Check lugs in meter socket -- if burnt, charred, or cracked, make an S.I.O. for replacement of meter block.

5. Check for unauthorized jumpers:

    a. On the back of a socket meter.
    b. Inside the enclosure or socket base from the load side to the line side connections.
    c. Use the Multimeter to check for voltage between load side lugs and neutral.
    d. Follow Departmental procedure for suspected diversion if jumpers or voltage are present.

6. Broken meter base (cracked, split, etc.) -- follow Departmental procedure for suspected diversion.

7. Holes drilled in back of meter base -- if you discover holes drilled in the meter base follow Departmental procedure for suspected diversion.

F. Inspection of socket base or enclosure wiring.

1. Check line side for proper voltage with Voltmeter.

    a. Socket bases.

        i. On 2 Wire Meters:

            1) 120 volts from left line side lug to neutral.
            2) Neutral must be connected to right side lug with wire jumper.

        ii. On 3 Wire Meters:

            1) 120 volts from either line side lug to neutral.

2) 240 volts between line side lugs.

2. If the voltage is not correct:

   a. **DO NOT** install meter.
   b. Notify your supervisor for assistance and further instruction.

3. Check load side of socket base or enclosure for voltage (backfeed).

   a. With voltmeter, check from neutral to each load side lug -- **NO** voltage should be present.
   b. If voltage is present, notify Meter Department.

III. Installing and resealing the new meter.

A. Installation of the new socket meter.

1. Verify new meter is correct for installation.

2. Check the potential link:

   a. The potential link must be closed, and a connection made between the potential link screws. If so, proceed.
   b. If no connection exists, move potential link back to proper position and tighten screws.
   c. If link or screws are missing, return the meter to the Central Electric Meter Shop.
   d. A 120V, 2 wire meter has no potential link.

3. When visible, check for mesh between the first wheel and the worm gear:

   a. The worm gear is on the disk shaft.
   b. If the gears do not mesh, do not install this meter; use another. Return the defective meter to the Central Electric Meter Shop with a note indicating no mesh.

4. Make sure a tab seal is installed in the new socket meter. If the new socket meter has no tab seal, return the meter to the Central Electric Meter Shop with a note indicating that no tab seal was found.

5. Tighten line side and load side lugs in the meter socket base with the appropriate tool.

6. Install the new meter:

   a. 60, 100, 150, and 200 amp socket bases:

i. Line up load side jaws and load side meter blades. Press to connect.
ii. Using the bottom jaws as a fulcrum, rock the line side blades into line side jaws of the meter socket base.
iii. You may need to push in on the top and bottom of the meter several times until the meter is all the way in.
iv. **<u>DO NOT</u> twist the meter, this could spring jaws.**
v. **<u>DO NOT</u> pound meter in with your hand or a tool. A broken cover may result in serious injury.**
vi. **<u>DO NOT</u> use a lubricant when installing a socket meter.**
vii. ***REMEMBER*** that when the bypass handle is up, the service is already on when installing the meter in a 320 amp socket base and those 200 amp socket bases with the jaw-release bypass handle.

1) Extra care should be taken when installing the meter because both the line side and load side are already energized.
2) While holding the meter in place with one hand, lower the bypass handle with the other hand. This will increase tension on the socket jaws.
3) This will hold the meter in place, along with routing all of the customer's load through the meter instead of the bypass mechanism.

B. Sealing meter and socket base/enclosure.

1. Reinstall socket base/enclosure lid and seal with the appropriate device(s).

2. If applicable, reset the demand mechanism and install a demand spring lock seal.

a. Black for January through June.
b. White for July through December.

3. Final visual inspection of installation and meter.

a. Make sure the socket base/enclosure lid is installed correctly, over the top lip of the enclosure.
b. Make sure the sealing ring is installed correctly over lip of meter socket base.
c. Make sure the disk is rotating in the proper direction.
d. Make sure the meter is installed right side up.

C. Complete all necessary documentation.

SUMMARY:

A job such as changing a kWh meter is very important for the proper operation of the Company. An incorrect meter installation could cause billing errors, loss of equipment, and added man-hours for correction. It is also important that we correct hazards or defects found at the time of installation. To let hazards or defects go unrepaired could jeopardize the safety of our customers, as well as fellow employees.

TESCO Hot Socket Gap Research

and the use of this data in the development of tools for the early detection and handling of dangerous field conditions

Table of Contents

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www.tesco-advent.com

PART 1: Introduction

The deployment of new AMI meters has resulted in an increase in the occurrence of fires reported at the meter box. Initial concerns are whether these fires were caused by meters or meter sockets or something else. Our laboratory investigation could find no indication of fires being caused by the meter. Empirical investigation revealed a variety of sources in the meter box including loose or broken connections, bad or missing insulation or other electrical hazards. The most common cause and the symptom most commonly supported by the evidence was heat generated at the meter socket jaw to meter blade interface. The cause of this heat source is a worn meter socket jaw. A compelling need for early detection devices and inspection processes to identify dangerous field conditions prior to catastrophic failure was quickly identified.

Of the potential causes for temperature rise, energy dissipated as heat due to contact resistance seemed likely; however our research showed that the temperature rise generated by contact resistance is not sufficient to cause the significant meter deformation observed in the field. Instead, electric arcing across small gaps between meter stabs and compromised socket jaws was found to be the source of the elevated temperatures and eventual destruction of meters which failed catastrophically. Compromised jaws were further defined through lab experiments to be jaws whose required insertion force (of the meter stab) is significantly less than that of a standard socket jaw. A threshold of 3 to 5 pounds of force per jaw was found to be the threshold between safe and unsafe conditions.

Conditions required to create these situations are not unusual in typical residential meter installations once a meter has been inserted into a box that has a compromised socket jaw. Elevated temperatures can be created under typical, residential power consumption levels. As arc temperatures can approach 11,000 degrees Fahrenheit (about 6,100 degrees Celsius), they allow for a relatively fast heat transfer from the arcing location (meter stab) to internal components of the meter. We were able to repeatedly simulate these conditions and results in our lab, on a variety of meters. We then observed and tested a variety of socket jaws, and determined that insertion force is a measurable parameter that differentiates good jaws from jaws that create hot socket conditions. Some compromised meter socket jaws were readily identified by visual inspection while others were not. A go/no-go tool was designed based on the lab data to determine if a particular meter socket jaw was compromised or not.

This paper aims to:

1) Support the theory that most meters damaged by heat were likely exposed to arcing at the socket jaws.

2) Demonstrate conditions that facilitate arcing in meter sockets

3) Suggest characteristics of socket jaws that can be used as indicators of conditions that facilitate arcing and the destruction of meters.

4) Explain the tool we developed that indicates a potentially dangerous socket jaw.

5) Discuss what can be done to leave the installation safer than when you found and identified the dangerous socket jaw.

PART 2: Observations from the Field

Some of our research was funded by large investor-owned utilities and some was funded by meter manufacturers. This paper is based solely on data from the research performed in conjunction with the meter manufacturers. No Utility data is used as part of this report.

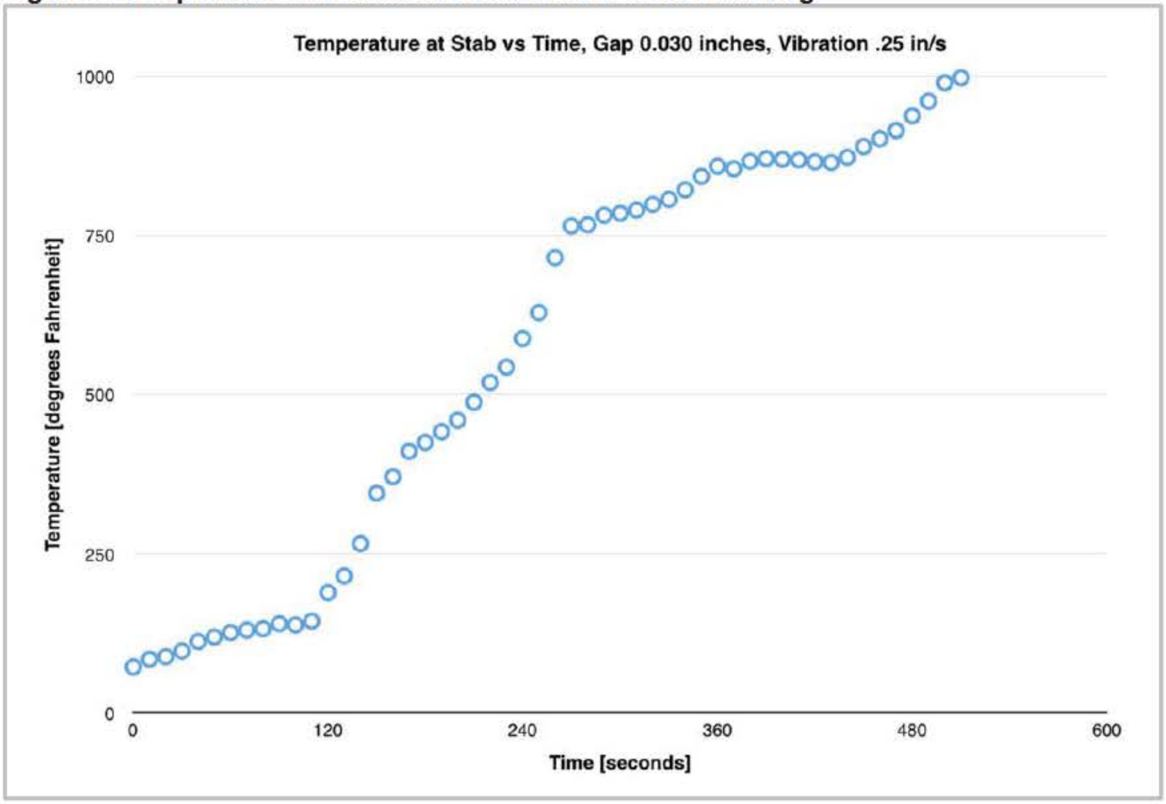
Through our own meter shop we have access to thousands and tens of thousands of returned AMR and pre-AMR meters that have been scrapped. Heat damaged meters were sorted and cataloged for similarities and to help identify patters. Initially we did not have access to many meter sockets as utilities typically don't have ownership and control of the sockets. In most cases sockets belong to the customer. We have been able to secure a supply of used meter boxes from the field so this problem was transitory in nature only.

A common characteristic of the heat damaged meters was a roughening of the surface of the meter stab (or stabs) that were exposed to the most heat, shown in Figure 1. The roughening was pitting and carbon deposits, the result of an electrical arc contacting the surface.

Figure 1. Pitting and Discoloration of a Hot Socket Meter Stab Returned from the Field

Laboratory experiments simulating anything other than micro-arcing (e.g. contact resistance, small blades, water in the meter, contamination in the meter) failed to provide the elevated temperatures required for catastrophic failure of the meter. We set up experiments that aimed to correlate an increase in measured resistance at the contact to an increase in surface temperature under load. In the most extreme case with a high resistance tungsten pad representing a poorly conducting surface, the temperature rise over a full day was less than 100 degrees Fahrenheit (less than 40 degrees Celsius). In contrast, when we were able to control the arcing at the jaw-stab connection, we observed temperature rises of over 1,500 degrees Fahrenheit (over 815 degrees Celsius) in less than ten minutes, shown in Figure 2. These experiments were conducted under a 25 amp load; this is on the high side of what a typical house would be drawing. The damage on the meters produced by controlled arcing was indistinguishable from the damage on most burnt meters returned from the field.

Figure 2. Temperature Rise at Meter Stab with Controlled Arcing



Anecdotal evidence from the field showed that the same pitting and roughening of the corresponding meter jaw socket could also be seen. Our study of collected sockets is covered in Part 4.

PART 3: Conditions for Arcing

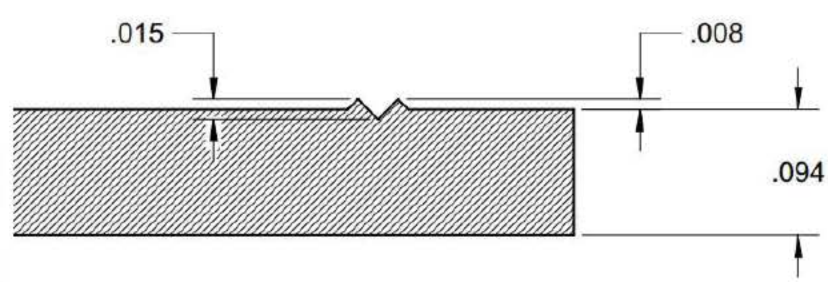
Paschen's Law suggests arcing will occur at certain gap sizes between two plates at different voltage potentials. Based on research conducted by German physicist Friedrich Paschen, the breakdown voltage necessary to create an electric arc between two electrodes is a function of air pressure and gap distance.

Theoretical calculations suggest that if arcing was indeed causing hot sockets, we would expect about an .015 inch gap present between a compromised socket jaw and meter stab (see calculations in Appendix 1). This size gap can be present in exceptionally loose jaws, or ones with obstructing debris. We found that gap size and a potential differential between the electrodes (meter socket jaw and meter blade) were necessary but not sufficient to induce arcing. Two additional elements were required; nominal current and a catalyst. The nominal current was found to be more than 10 mA (the amount of energy required to simply power the meter from the line side of the service) and 0.25 amps (the lowest current tested other than just the electronics on the meter).

We were able to demonstrate repeatable arcing and resulting temperature rises when we applied moderate levels of vibration to a jaw and stab connection with this size gap, under otherwise normal power conditions. This is when we began to produce damaged meters in our lab that appeared very much like the meters removed from hot sockets, specifically the appearance of the pitting on the surface of the stabs.

Vibration was used as a catalyst to the arcing and to sustain the arcing. In a steady state (constant power, no vibration), an arc will quickly deform the plated-copper on both the meter and stab, creating conductive and non-conducive features. The difference in height between the peaks and valleys of these features can be in the same size range as the gap that allowed the arcing, illustrated in Figure 3. These features would either help or hurt sustaining the arc beyond our control, as they could open or close the gap in a way. When we opened the gap slightly, and introduced vibration (opening and closing the gap at a fixed frequency), we were able to consistently sustain the arcing to durations that would cause significant meter damage. This led us to hypothesize if and how this could occur outside the lab. We quickly found our minimum vibration threshold capable of producing arcing can be obtained quite easily and often if meters are installed near highways, near washers or dryers, or even near a frequently traversed walking area in frame construction homes.

Figure 3. Size of Surface Features from Arcing on a .094 inch (2.39mm) Thick Meter Stab

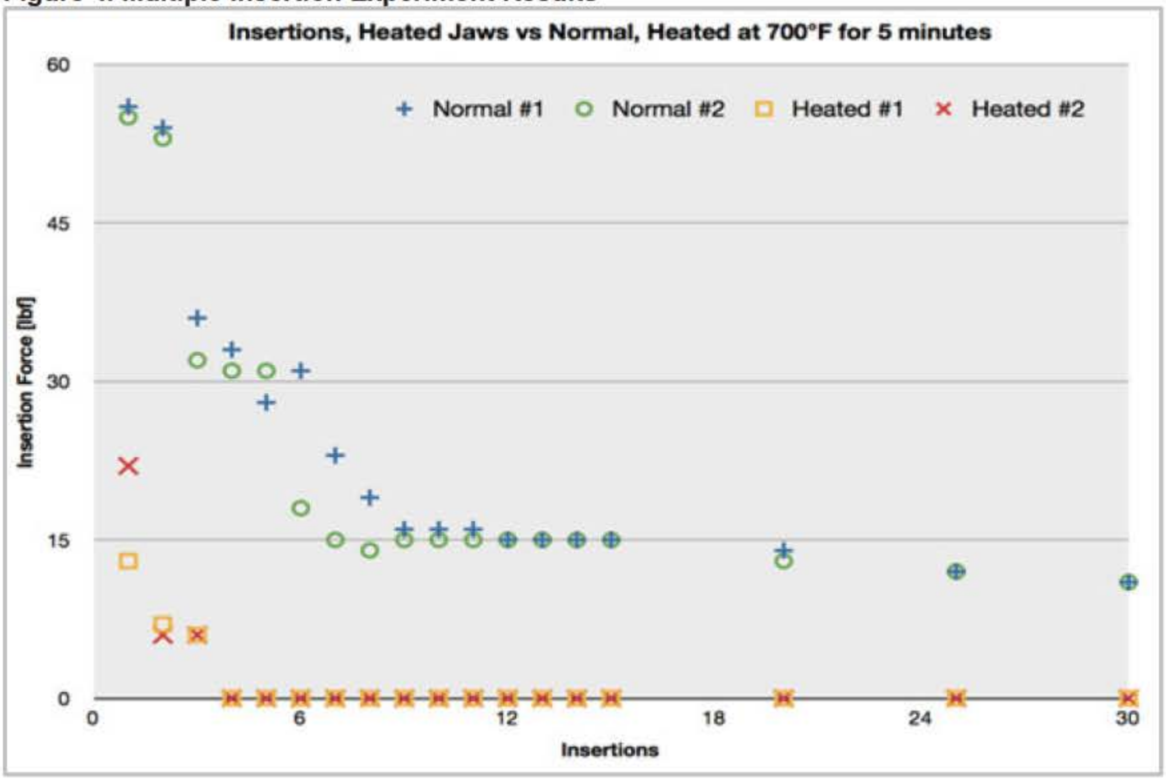


PART 4: Characteristics of Socket Jaws

A this point we were satisfied that we had found a way to create and observe a mode of failure that agreed with field observations, and the hypothesis of others working to understand this problem. Although we identified other sources of heat and fire in meter enclosures, the vibration and socket meter jaw gap created incendiary meters that matched the meters found in our meter shop which has been exposed to high heat. Our research on arcing was handed off to utilities and meter manufacturers who have the ability to continue the study on a much larger scale, and come up with alarm protocols for early detection of hot sockets as well as to design meters which can withstand a hot socket better than earlier generations of AMI meters. Our concern shifted to finding a way to flag potentially problematic jaws in the field during AMI installations or at any other time where the utility has an opportunity to inspect the meter enclosure.

We noted that visual observations of the mating surfaces and potential gaps could be subjective. We focused on finding features which could be measured and then research these features to see if we could identify a danger threshold that could be inspected for. Our understanding of mechanical fatigue and creep led to a test where the insertion force into a jaw was measured and recorded on multiple insertions into the same jaw. This data showed exponential decay of the insertion force with each meter removal and insertion. Initially high insertion force above 40lbs quickly dropped and stabilized around 15lbs after the first five to ten insertions. When the jaws were heated to the maximum allowable temperature (as per ANSI C12.1; C12.10 and C12.7) under heavy load conditions before the test (400 degrees Fahrenheit, about 200 Celsius), the decay on average stabilized at 15lbs in slightly fewer insertions then in cold tests. This was still nothing indicative of a problem as the conditions were still normal for what the jaws were designed to withstand. Finally when preheated to 700 degrees Fahrenheit (about 370 Celsius), we repeatedly observed a rapid decay to zero pounds insertion force, within the first two or three insertions. 700 degrees Fahrenheit was quickly reached at the jaw in our arcing tests, and was the temperature where noticeable damage that deemed a meter a "hot socket" meter occurred (e.g. plastic melting on the meter around the stab, pitting on the meter blade and the socket jaws). The difference in holding force between normal and heated jaws is illustrated in Figure 4. We drew a threshold line under 15lbs at 10lbs, and developed a tool that simulated a stab being pushed into a socket jaw with 10lbs force. We distributed the tool for testing in the field.

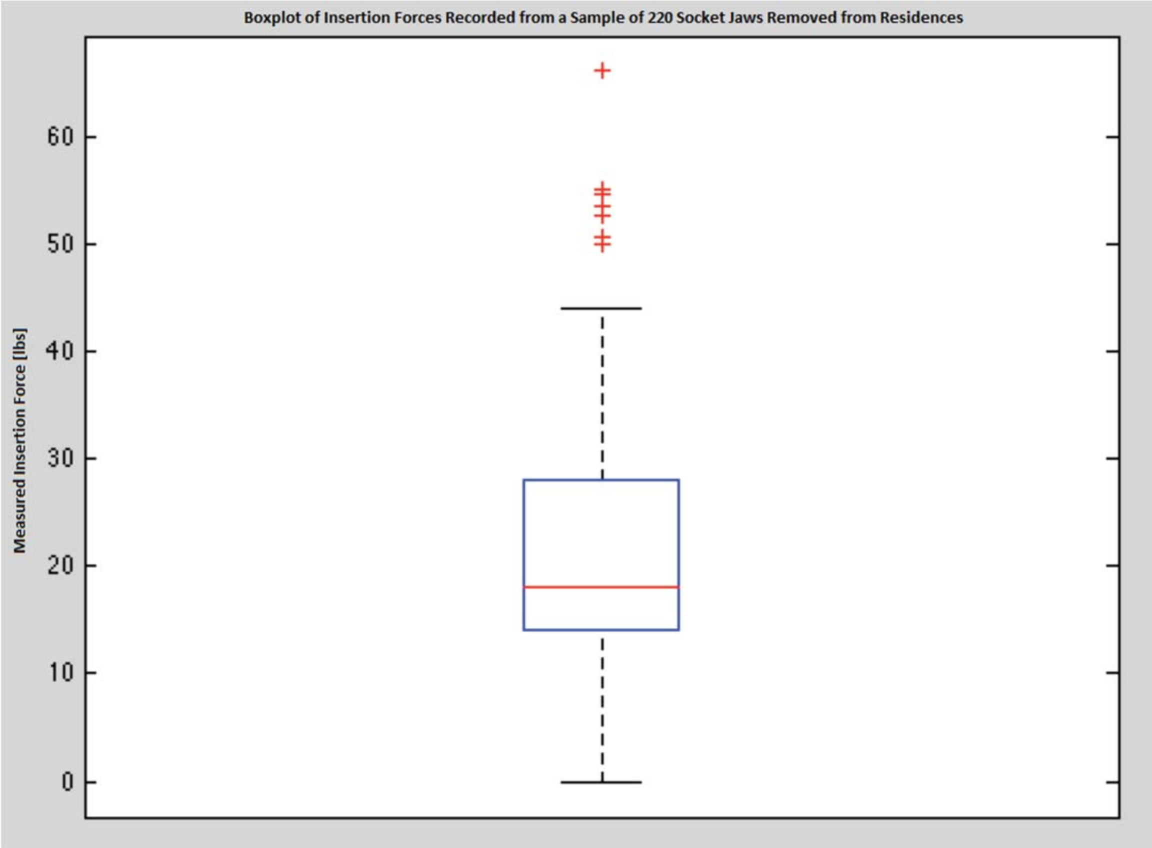
Figure 4. Multiple Insertion Experiment Results



A well-defined minimum holding force for meter socket jaws hasn't yet been specified by ANSI or UL. ANSI C12.7 defines the outer dimensions of the jaw, but doesn't specify gap size or holding force. UL 414 focuses on maximum insertion forces to keep the operator safe and prevent damage to the socket and meter in sections 5 and 19, but also doesn't define a specific minimum holding force. UL 414 section 14 comes closer to defining a holding force by requiring a meter in a socket with no supplementary insertion force cannot move over 1/16th of an inch out of the socket by its own weight. As modern plastic meters have become much lighter than their mechanical counterparts, this would mean a very light holding force would be acceptable; what may be sufficient to hold one meter may fail to hold a heavier meter in the same socket.

As we had been conducting our experiments and tests, we had meanwhile collected a sample of sockets pulled from homes by local contractors. Of close to 50 sockets (200 plus jaws), we found two jaws that had evident signs of abnormal temperature elevation; pitting, a gap, and discoloration. Both jaws had a measured insertion force of zero lbs. The insertion data we collected from all the collected jaws in shown in Figure 5.

Figure 5. Insertion Forces from Collected Socket Jaws



PART 5: Hot Socket Gap Indicator (HSGI)

The hot socket gap indicator (HSGI) was developed to search out meter sockets with holding forces close to the five pound threshold. The HSGI was also designed to not slip into a meter socket if the socket had at least a holding force of ten to twelve pounds of force, giving the user a safety margin of roughly five pounds. Also every insertion of any meter stab into the meter socket jaw will degrade the meter jaw by some amount. This is also part of the reason for the safety margin as we know that the next meter insertion will weaken the meter jaw by some unknown amount, leaving the jaw and the meter closer to the danger zone.

A second tool was also introduced with the same dimensions as the meter stab (0.094 in nominal) and tin plating to reflect the same plated stab being introduced to the meter socket jaw. This tool was introduced to handle two situations found during the field testing of the original tool. The first is the use of meter man's grease during AMI installations. This grease has been introduced during some AMI deployments to allow the meter techs a faster and easier meter insertion. This grease temporarily decreases the holding force of the meter socket jaw to less than the force measured by the narrower blade on the original tool. The second tool flags sockets with six to eight pounds of holding force. The second situation found in the field are sockets that are manufactured with two parallel sides that are not intended to touch, but are parallel to each other. This design is to allow 100% blade to socket contact when a meter is inserted in the meter jaw. The narrower blade thickness of the first design failed this meter socket as a result of this gap, even though the holding force was in excess of the danger zone. The wider blade thickness eliminated this issue and correctly passed good versions of this meter socket type and failed fatigued socket jaws.

The original tool has been the preferred tool for utilities without this style meter socket jaw and who do not use grease or lubricant on their meter socket jaws. The issue found with the socket lubricant is that after several years this lubricant dries out and the meter is “cemented” into the socket jaw. When that meter is removed for testing or replacement the meter jaw will tend to come with the meter and although the situation for a hot socket did not exist with the “cemented in” meter, the socket after meter removal is now a “hot socket” with one or more jaws that no longer have the required minimal holding force. The greater safety margin of the original tool has also made this one the preferred option of many utilities. Both are valid tools based on the same design criteria and data, the first provides a larger safety margin and the second handles more field situations.

The HSGI has been designed to be simple and easy to use. The stab is attached to a red block that acts against a 10lbsf spring. In the initial state the indicator always shows red, when the stab is pressed against a good jaw the red is pushed back and hidden with the operator exercising roughly ten to twelve pounds of force on the tool. When the tool is pressed against a bad jaw the red stays visible. The spring is rated for over one million compression cycles by the spring manufacturer. After assembly each HSGI is inspected for spring force within tolerance (plus or minus one pound) and cosmetic defects. Since a HSGI shouldn’t see one million compressions in five years and that is the longest a tool should be in the field without inspection, we have a five-year calibration date on each unit so the unit can be sent back to us and inspected, refurbished, calibrated or replaced. The design has been drop tested in a range of usable temperatures (32F to 120F, C), and has been tested for electrical insulation up to 3,000V. The HSGI should still be used with Personal Protective Equipment (PPE). The tool is useful for testing jaws where grease buildup hides a gap or signs of elevated temperature, the lubrication effect of the grease has not been found to throw off the tool. The beveled edges on the thicker standard model allow the tool to work consistently on the full range of jaw designs we’ve acquired, eliminating misreading due to angle of insertion or removal (for tools designed to measure the insertion force by being inserted into the meter socket).

PART 6: Conclusion

TESCO’s Hot Socket Gap Indicator is a simple and reliable diagnostic assistant for flagging potential hot sockets. The jaws that it indicates as bad should be further observed for signs of unusually weak holding force, discoloration, debris, and pitting from arcing. If these signs are present, the jaw or socket should be replaced to prevent overheating of the meter and the possibility of fire. AMI deployments have made hot sockets a front page issue, as removing a meter from an old socket and forcing a new one in can actually create a problem. However, the deployments are also an opportunity to observe and flag sockets that are potentially dangerous.

We at TESCO designed the tool after a successful effort to replicate a common mode of failure observed in the field; overheating due to arcing. Our goal was to develop a tool that can help reduce the number of meter fires. The HSGI is in the first line of defense, along with operators who have an understanding of what to look for to identify hot sockets. We feel obligated to share what we learn, and help the industry develop knowledge and diagnostic methods to prevent catastrophic situations.

Appendix 1. Theoretical Calculations

Based on research conducted by German physicist Friedrich Paschen, the breakdown voltage necessary to create an electric arc between two electrodes is the following function of air pressure and gap distance between two electrodes:

$$V_{arc} = \frac{apd}{\ln(pd) + b}$$

In the equation, p is the air pressure between the electrodes, d is the distance between the electrodes, and a are b are constants with the values 43.6 V/(Pa(m)) and 12.8 respectively. For our purposes, the two electrodes creating the arc were a meter stab and socket jaw. With a 240 Volt potential difference across the electrodes, representing the standard maximum voltage provided to residential power customers, and standard air pressure (101325 Pa), d is found to be approximately 0.015 inches.

It is also of note that by finding the resistance of the air between the electrodes – $R_{air} = \frac{\rho d}{A}$ where ρ is air resistivity, A is the cross-sectional area being examined and d is the distance being considered – and substituting that into Ohm's law – $I_{arc} = \frac{V_{arc}}{R_{air}}$ – one can subsequently determine the current produced in an arc. At 20 degrees C, air resistivity ranges between 1.3 x 10^16 to 3.3 x 10^16 ohm(m). Arc temperature has a direct relationship with arc current, as current increases, temperature increases. The arc temperatures typically seen in the conditions present in power meters are about 11,000 degrees Fahrenheit.

CERTIFICATE OF SERVICE

15-WSEE-211-COM

I, the undersigned, certify that a true and correct copy of the above and foregoing Notice of Filing of Staff 's Report and Recommendation was placed in the United States mail, postage prepaid, or hand-delivered this 26th day of September, 2016, to the following:

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