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MICRO-ARC DETECTION AS PART OF YOUR AMI SYSTEM



Southeastern Meter School Module 400

Wednesday March 20 3:00 PM – 3:45 PM

Tom Lawton



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WHAT IS THE POINT OF MORE FLAGS?



- Why should we pay attention to new features in our meters?
 - We already have too much data and too many flags to investigate.
- Answer: Safety, Reduced Operational Costs and better power delivery to our customers with fewer power interruptions



What we will Cover today

- What is Micro-Arc Detection?
 - Location and Purpose of Arc Sense in Meter Base
 - Description of Operation
 - Block Diagram
 - Circuit Diagram
 - Important Parameters and Take Aways
- Your Data & You
 - How is Micro-Arc Data Captured
 - How do I make use of it?
- Micro-Arc Detection in the Wild
 - PSEG LI Micro-Arc Case Study
 - AvanGrid Case Study Preliminary Findings



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LOCATION AND PURPOSE OF DETECTOR

U.S. Patent

Mar. 14, 2017

Sheet 1 of 4

US 9,594,107 B1

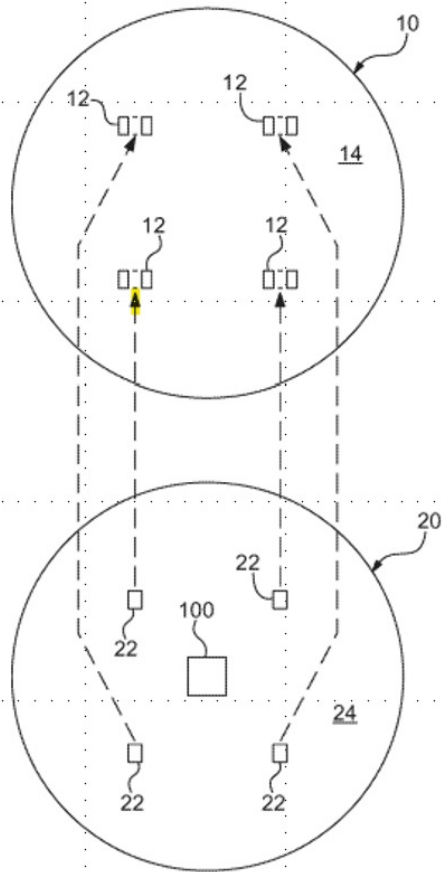


FIG. 1

U.S. Patent

Mar. 14, 2017

Sheet 2 of 4

US 9,594,107 B1

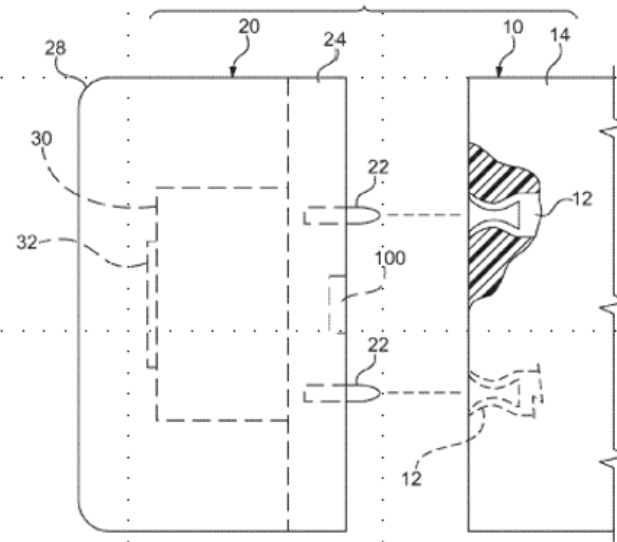


FIG. 2

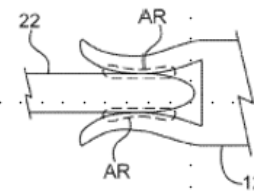


FIG. 2A



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BLOCK DIAGRAM

U.S. Patent

Mar. 14, 2017

Sheet 3 of 4

US 9,594,107 B1

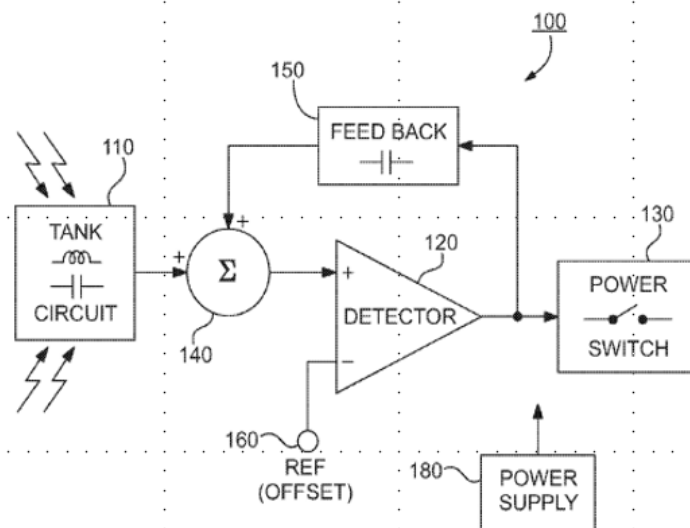


FIG. 3



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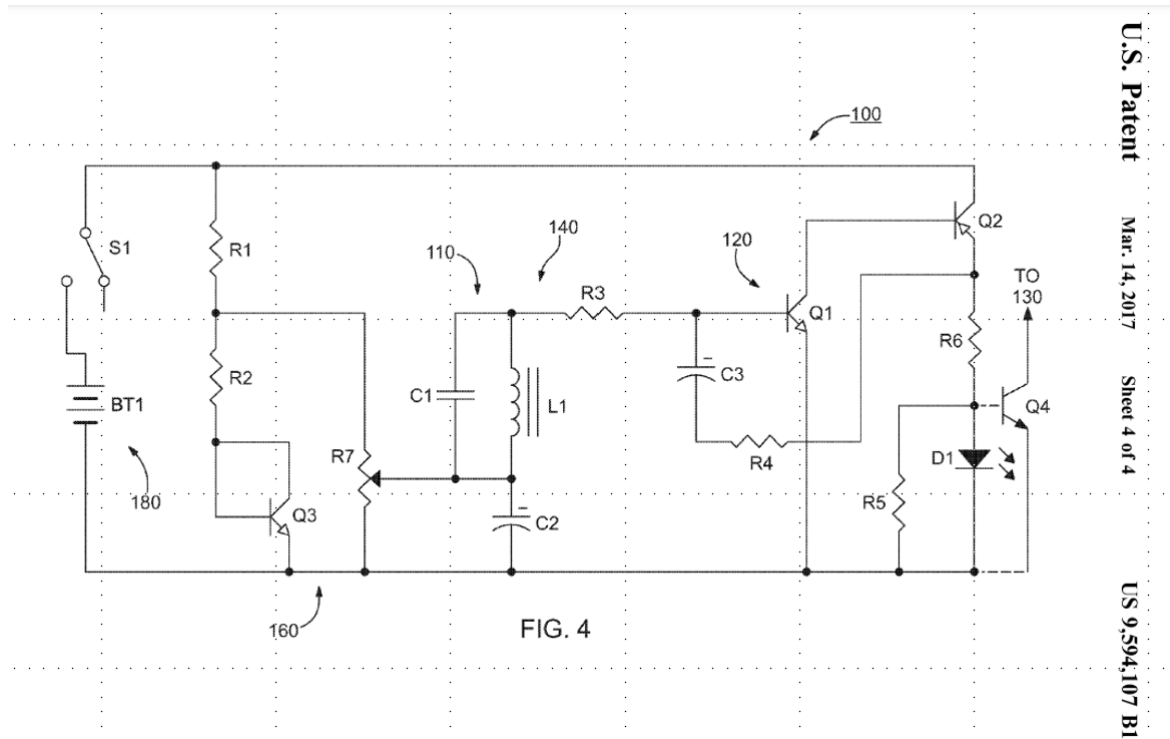
THEORY OF OPERATION TAKE AWAYS

- Sensor (100) embedded in meter base (24) within 4 inches of Stabs (22)
- FIG 2A. Arc will occur when Contact Surface Area (22,12) Compromised
- AND Vibration Occurs to Stimulate Arcing
- Arcing Produces EMF (~ 500 kHz) (low energy – UHF high frequency)
- Arc Detector (110): Tank Circuit (110) De-Tuned Resonant R,L,C Circuit*
- Electric Detector(120): Latches Occurrence High (\sim one second)
- Arc Count = One Second Resolution ($f(RC$ Time Constant) (150))
- Output (130) Logic High for One Second



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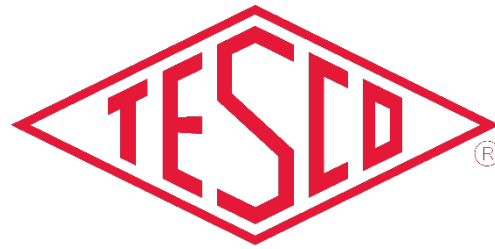
CIRCUIT DIAGRAM





ARC PROPERTIES: TYPE ONE AND TWO

- Type One:
 - “Jittering” type “intermittent” arcing (lower energy “heat” content)
 - Incipient Information... Contact Area Compromise Early Stages
- Type Two:
 - “Welding” type “longer duration” arcing (high energy “heat” content)
 - Significant Compromise of Contact Area and High Impedance
 - Later Stages, Thermal Runaway Condition



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YOUR DATA & YOU

Micro-Arc Detection as Part of Your AMI System



YOUR DATA & YOU

- Reporting and data is the lifeblood of a healthy Micro-arc detection ecosystem
- Alarms are good, but not enough
- High temp and vibration alarms
 - These are good alarms but are typically indicators of other issues (e.g. rusted sockets, site specific issues) or a late arriving flag for a failed socket.
- What should my settings be?





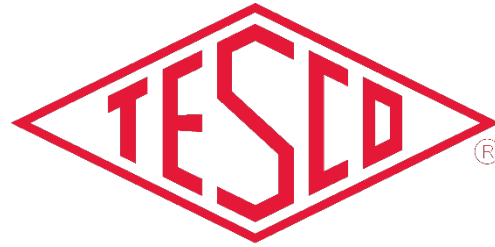
YOUR DATA & YOU: YOUR SETTINGS

- What should my settings be?
 - Depends on the utility
 - Each utility will have their own sweet spot when it comes to their problem sets; this can take a bit of time to dial in
 - Variables like:
 - Age of meter population
 - Type of meter sockets (lever bypass vs ring etc)
 - Climate (inland vs coastal)
 - Depends on the meter manufacturer
 - Itron and L+G implemented different data capture methods and provide disparate reporting formats and granularity of data capture



YOUR DATA & YOU: L+G SETTINGS

- L+G Settings
 - Captures raw arcs in Load Profile
 - Can capture 4-5 arcs/second
 - Can capture “highest rise”, “temp”, and other important co-variables
- Basic set-up is easy: select the number of arcs/day required to trigger an Arc Alarm*
 - *Currently tied to High Temp alarm



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PSEG LONG ISLAND CASE STUDY

PSEG Long Island, TESCO, L+G



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PROJECT BACKGROUND

- PSEG LI
 - 1.2 million connected customers (electric)
 - Fully AMI deployed, L+G Gridstream
 - Deployment commenced: 2018
 - Deployment completed: Spring 2022
- TESCO
 - Developed ArcSense® technology in-house
 - Worked with L+G to provide as a formal offering
 - PSEG LI offered to run a pilot program of ~4,500 meters
 - Pilot launched in Fall 2021
- L+G
 - Provided platform and access to load profile data for arc reads
 - Incorporating the technology into their next gen, Revelo® meter





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ARCSense® PILOT

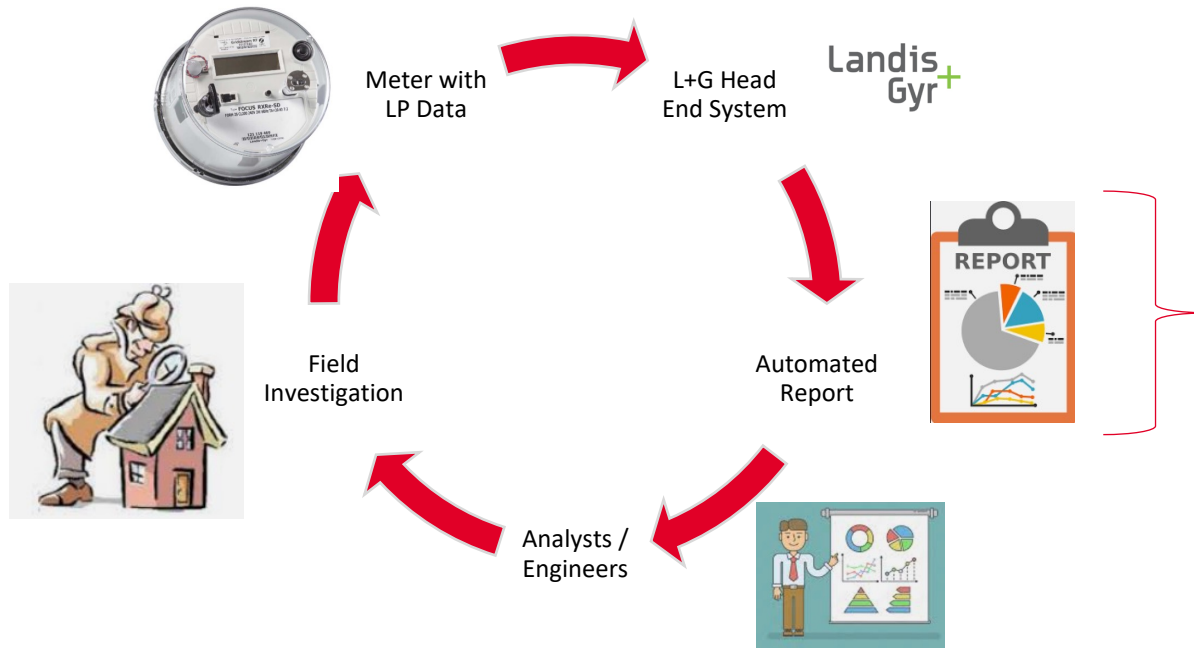
- Collaboration between PSEG Long Island, TESCO, and Landis + Gyr
- Pilot project included a total of ~4,500 meters in the field at various locations
- New technology developed by TESCO is integrated into an L+G Focus Meter
- The board detects the RF signature of a micro-arc
- Micro-arc data is captured and relayed within the load-profile data
 - Load-profile reporting was an open channel to provide the additional micro-arc data for reporting analysis





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ADDITIONAL LOAD PROFILE DATA IN DAILY REPORT



- Max arc count
- Sum of arc count
- Maximum temperature and timestamp
- Estimated blade temperature

A	B	C	D	E	F	G	H	I	J	K	L	M	N
RUN_DATE	CONFIGURATION_GROUP	METER	MAX_RISE	MAX_RISE_TIME	MAX_ARCCOUNT	KWH_ATMAXARCTM	MAX_ARCCOUNT_TIME	SUM_ARC_COUNT	MAXTEMP	MAXTEMP_TIME	MAX_KWH	MAXKWH_TIME	LATITUDE
7/4/2022	Arc_Sense	51775736	2	7/4/2022 11:45	7	0.3768	7/4/2022 11:45	7	40	7/4/2022 15:15	2.2746	7/4/2022 16:15	40.841446
7/4/2022	Arc_Sense	51775738	2	7/4/2022 19:15	6	1.3734	7/4/2022 19:15	6	40	7/4/2022 12:00	1.7136	7/4/2022 19:00	40.907032
7/4/2022	Arc_Sense	51775739	2	7/4/2022 19:15	6	0.5376	7/4/2022 19:15	6	51	7/4/2022 17:45	0.582	7/4/2022 15:30	40.911827
7/4/2022	Arc_Sense	51775741	2	7/4/2022 23:30	7	0.4872	7/4/2022 23:30	72	56	7/4/2022 8:00	1.119	7/4/2022 22:00	40.85447
7/4/2022	Arc_Sense	51775743	7	7/4/2022 16:30	20	1.0896	7/4/2022 16:30	40	66	7/4/2022 11:30	1.254	7/4/2022 16:15	40.854466



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TABLEAU DATA

Ranking

Arc Ratio

Comparison

Sum Arc

Select Date

04/18/2022

Top Max Arc

Max Arc Count	Meter	Account	Street	City	
40,819					04/18/22 06:15 PM
14,068					04/18/22 12:15 PM
566					04/18/22 11:00 AM

Top Sum Arc

Sum Arc Count	Meter	Account	Street	City
891,330				
77,215				
5,063				

Top Max Temp

Maxtemp	F	Meter	Account	Street	City	
55						04/18/22 09:15 AM
						04/18/22 09:00 AM
54						04/18/22 08:45 AM
53						04/18/22 09:30 AM

Ranking

Arc Ratio

Comparison

Sum Arc

Select Date

04/18/2022

Select Arc Ratio Group

0.00

Meter

Map Meter Location

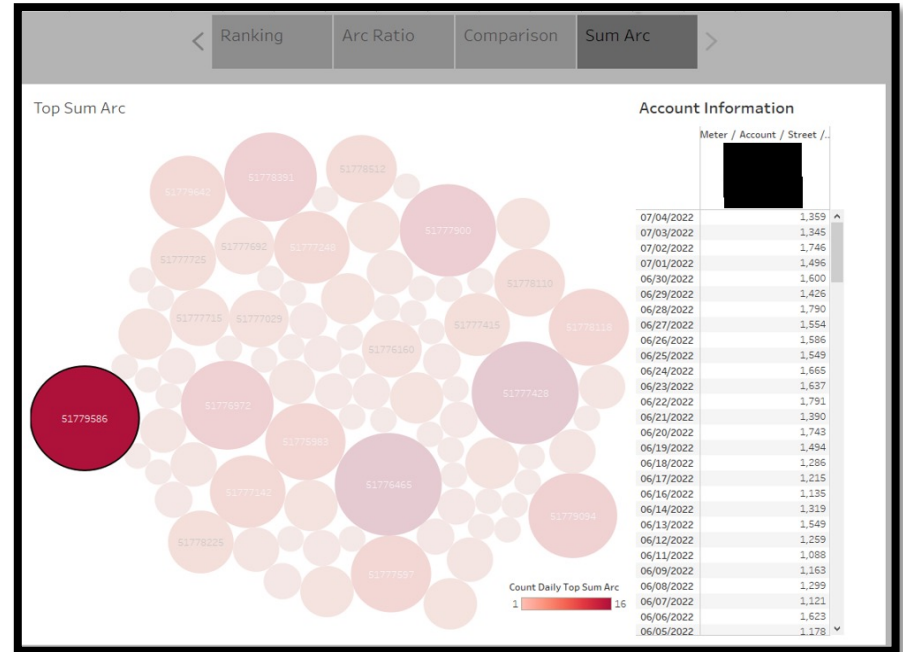
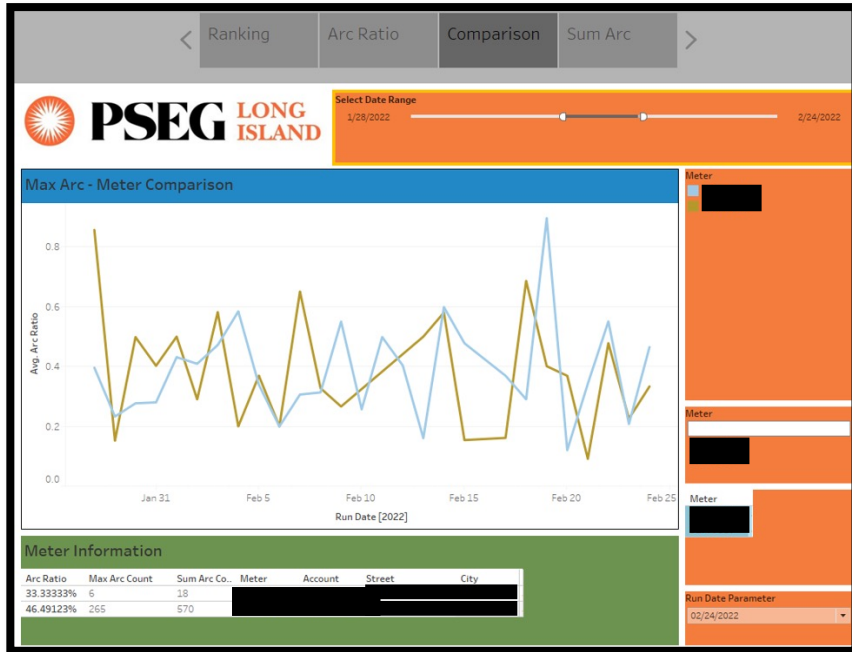
Meter Information

Arc Ratio	Max Arc Count	Sum Arc Co.	Meter	Account	Street	City
0.00000%	46	361				
	257	282				



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TABLEAU DATA





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ARCSense PRIORITY LIST

- Meters were selected based on below criteria:
 - High arc count: >100 arcs
 - Days of high arc: >=14 days
- Meters prioritized by number of days they appeared on Arc Sense Report
 - Priority 1 = 40-95 days of high arc
 - Priority 2 = 20-39 days of high arc
 - Priority 3 = 14-19 days of high arc
- Some meters with anomalous data profiles (high average arc counts or abnormal temp readings) were moved up in priority level

	A	B	C	D	E
1					
2		Meter Number	Priorit	Division	Date of Visit
3			1	Western Suffolk	4/29/2022
4			2	Western Suffolk	5/9/2022
5			3	Western Suffolk	5/9/2022
6			1	Western Suffolk	5/23/2022
7			1	Western Suffolk	5/23/2022
8			1	Central Nassau	5/24/2022
9			1	Central Nassau	5/24/2022
10			1	Central Nassau	5/24/2022
11			3	Western Suffolk	6/2/2022
12			1	Eastern Suffolk	6/22/2022
13			2	Eastern Suffolk	6/22/2022

- Priority 1 – 15 sites, 13 investigations showed issues at the site, 7 hot-socket compromised
- Priority 2 – 23 sites, 18 investigations showed issues at the site, 5 hot-socket compromised
- Priority 3 – 19 sites, 8 investigations showed issues at the site, 2 hot-socket compromised

Meter Numb	Prior	Date of Visit	Note	Meter Pan Brand	Meter Pan Type
	1	5/23/2022	Pan Damaged at Top Conduit Entry, 2 repair points on neutral	Murray	Bypass Lever
	1	4/22/2022	None	Milbank - Ring Type	Ring
	1	4/22/2022	Generator Present at house, dielectric grease found on meter	Milbank - Bypass Lever	Bypass Lever
	1	4/22/2022	found Open neutral at Next House	Murray-Bypass Lever	Bypass Lever
	1	4/22/2022	Damaged Weather head, Repairs to Neutral and Hot legs for feed across the street. Corrosion/oxidation on Phase A line	Anchor- Ring Type	Ring
	1	4/29/2022	none	Murray	Bypass Lever
	1	4/29/2022	part of ceramic broken on inside of pan	Anchor	Ring
	1	5/23/2022	none	Milbank	Ring
	1	5/23/2022	brand new pan and new service wires, some pitting on meter	Milbank	Bypass Lever
	1	5/26/2022	near window AC Unit	Anchor	Ring
	1	5/24/2022	open to elements and had been allowing water to drain into pan; meter pan jaws had dielectric grease. Meter Arced when re installed.	Not legible	Ring
	1	5/24/2022	Linkets at weatherhead instead of fuzzy boxes, discoloration on phase A load side of meter blade	Murray	Bypass
	1	5/24/2022	Burn Marks on Meter Pan Jaws	Milbank	Bypass Lever
	1	6/22/2022	corrosion inside meter pan	milbank	bypass
	1	6/24/2022	repair point on service drop. 1 block away from transmission line	murray	bypass



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PRIORITY CLASSIFICATIONS

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Meter Numb	Prior	Date of Visit	Note	Meter Pan Brand	Meter Pan Type
2		4/22/2022	repairs to wires at weatherhead	Crouse Hinds - Ring Type	Ring
2		4/29/2022	Meter located in Vicinity of Water Tower with Cell Antennas	murray	ring type
2		4/29/2022	House Behind LIE Barrier, near Road Noise	Anchor	ring type
2		4/29/2022	Meter located in Vicinity of Water Tower with Cell Antennas, RF detector reads 1.0 in vicinity of meter	Milbank	Bypass Lever
2		5/23/2022	2 repair points in neutral wire to weather head, meter is 1 mile from cell tower	Milbank	Bypass Lever
2		5/9/2022	of A Phase. Meter is in direct sunlight. Meter has illegal holes drilled and is being used as a raceway for Romex which is not properly insulated. Weatherhead has flexible insulation to meter pan.	Milbank	Bypass Lever
2		5/26/2022	Rusted conduit, Service wire Deteriorating	Murray	A Base
2		5/26/2022	None	?	Circular Style Socket
2		5/26/2022	meter within 40 feet of transmission lines	Anchor	Ring
2		6/2/2022		Milbank	Ring
2		5/23/2022	none	Murray	Bypass Lever
2		6/2/2022	Improper connection at weatherhead	Milbank	Bypass
2		6/2/2022	None, installed at meter bank	Delta	
2		6/2/2022	Repair Point, weatherhead has signs of wear	?	Socket
2		6/2/2022	conduit at meter pan is separated	Murray	Ring
2		6/22/2022	near several AC Units	anchor	socket
2		6/22/2022	neutral wire shows signs of heating up inside pan	milbank	bypass
2		6/24/2022	RF Readings 10-13	murray	bypass
2		6/24/2022	none	milbank	bypass
2		6/24/2022	not pulled, pan installed in siding	unknown	ring socket
2		6/24/2022	corrosion on weather head conduit	anchor	ring socket



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Mete Numb	Prior	Date of Visit	Note	Meter Pan Brand	Meter Pan Type
3		4/22/2022	Found Burned/damaged insulation on line side of A Phase	Murray Bypass Lever	Bypass Lever
3		4/22/2022	oxidation on 2nd phase, busy roadway	Crouse Hinds - Ring Type	Ring
3		4/29/2022	Meter located in Vicinity of Water Tower with Cell Antennas	not visible	Ring Type
3		4/29/2022	none	not visible	RING TYPE
3		AA			
3		5/23/2022	none	Murray	Ring
3		5/9/2022	none	Anchor	Ring
3		5/9/2022	Found Pan Jaws recessed due to meter installation, Found signs of Arcing, Found open insulation cover on "fuzzy box" at	Anchor	Ring
3			RF read 3.3 mw/m2 in area of meter. Meter is at busy roadway.		
3		5/23/2022	Linkets installed at wire to house instead of fuzzy boxes	Anchor	Ring
3		6/2/2022	None	Murray	Bypass
3		CC			
3		6/2/2022	Pitting on A Blade of meter	Murray	Bypass
3		6/22/2022	No customer not disconnected	nr	nr
3		6/22/2022	None	"POT Type"	
3		F			
3		5/24/2022	none	Not legible	Ring
3		6/24/2022	not pulled		ring socket
3		N			
3		6/24/2022	near AC Units, waterfront property	durham	ring socket



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FIELD INVESTIGATIONS

- PSEG Long Island Technicians and Engineers performed site visits
- Recorded various site conditions and measurements from each meter:
 - Condition of meter pan, conduit, weather-head, and secondary wires
 - Voltage and amperage
 - IR temperature reading on face of meter and on jaws
 - RF reading in area of meter
- Field Tools:
 - IR temperature laser
 - TESCO jaw tester
 - Multimeter
 - RF meter



Meter Engineering – Meter Investigation Report

Date:	Field Personnel:	Purpose of Investigation:
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Equipment Information

Meter Number:	Meter Form:	Meter Brand:	Meter Pan Type:
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Site Information

Repair Points at Wire at Secondary or at House?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
Generator Present?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
Damage to Meter Pan?	Yes <input type="checkbox"/>	No <input type="checkbox"/>
Description/Comment:		

RF Readings (Before Removing Meter)

	Top	Bottom
RF Readings Near Meter		
Comments:		

Measured Electrical Values (If Applicable and Safely Possible)

Voltage		
	Line (Volts)	Load (Volts)
Voltage (A-B)		
Voltage (A-C)		
Voltage (B-C)		
Voltage (A-Neutral)		
Voltage (B-Neutral)		
Voltage (C-Neutral)		

Current	
	Load (Amps)
A-Phase	
B-Phase	
C-Phase	
Neutral	

IR Temperature Readings (After Removal of Meter)

	Line	Load
IR Temp Gun Reading at Meter Pan Jaw (Phase A)		
IR Temp Gun Reading at Meter Pan Jaw (Phase B)		
IR Temp Gun Reading at Meter Pan Jaw (Phase C)		
IR Temp Gun Top of Meter at Meter Pan Jaw		N/A

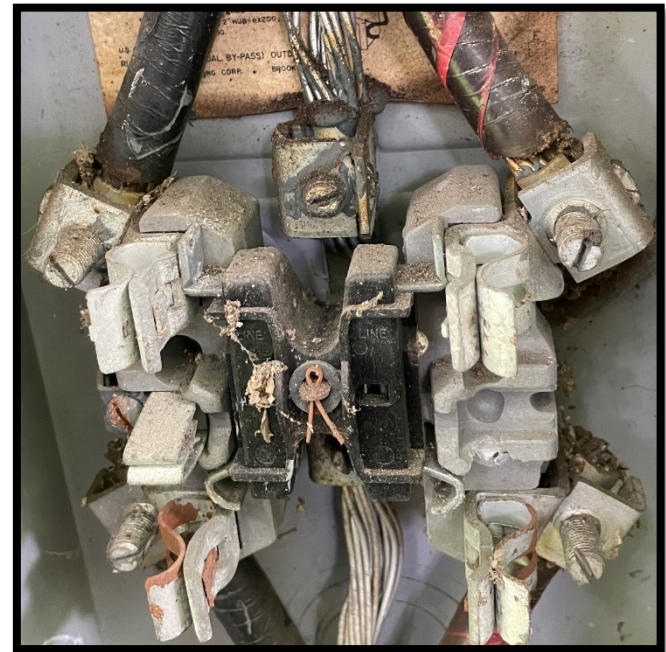
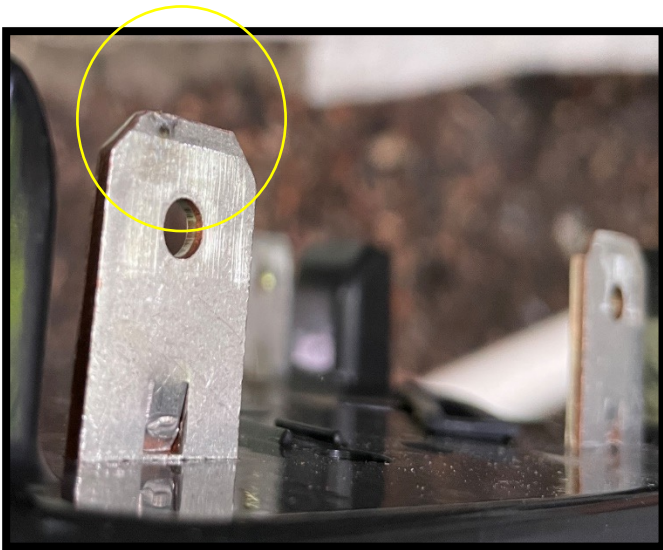


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METER 51****48 – DISCOLORATION ON METER BLADE

- Days on report with >100 Max Arc Count: 16
- Average arc count: 160
- Max Arc Count: 320
- Arc Sense Priority Level 3

- No previous reports of overheating or rise in temperature
- Pitting on meter blade
- Meter pan did not show any signs of damage or excessive weathering

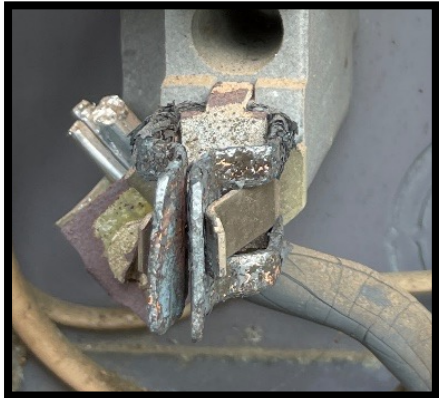




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METER 51****18 – HIGH TEMPERATURE ALERTS

- Originally a non-Arc Sense meter was at property
- Meter was reported by Analyst to indicate high temperature alerts
- Arc Sense meter was installed in Spring 2022 after high temperature alerts
- Arc count and temperature readings were high enough to warrant investigation
- Found brittle jaws inside meter pan; meter pan was replaced as a result

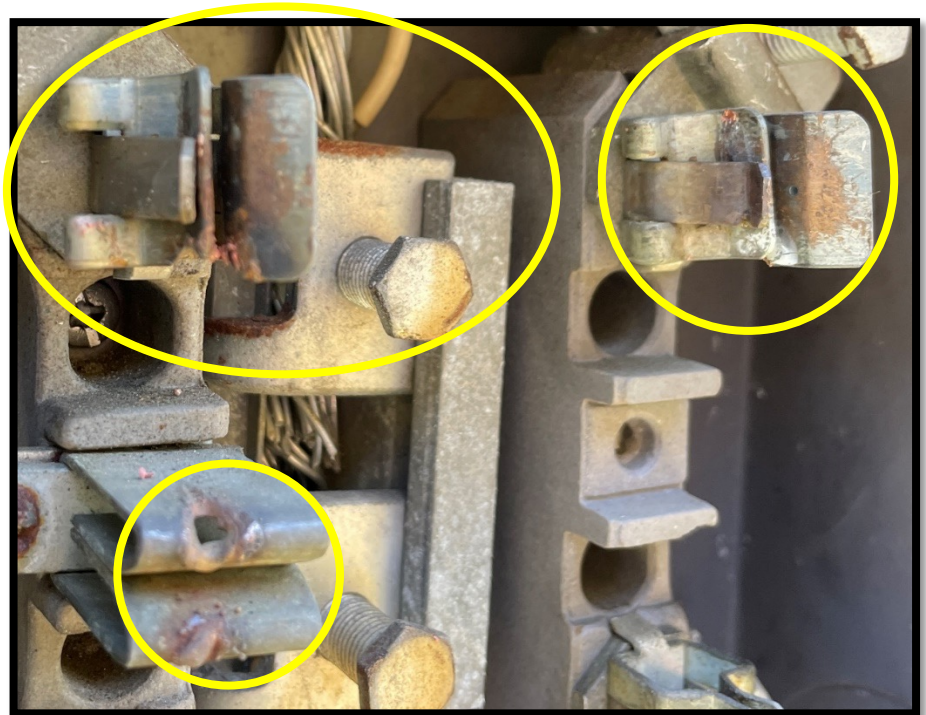




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METER 51****26 – METER PAN WITH RECESSED JAWS

- Days on report with >100 Max Arc Count: 18
- Average arc count: 278
- Max Arc Count: 539
- Arc Sense Priority Level 3
- No previous reports of overheating or rise in temperature
- Recessed springs and discoloration on the jaws
- Damaged neutral (as if someone tried to fix the jaws and an uninsulated screwdriver made contact between phase/neutral)

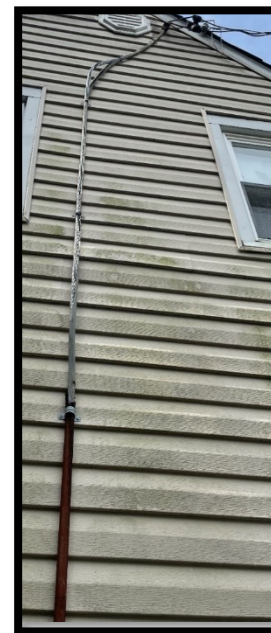
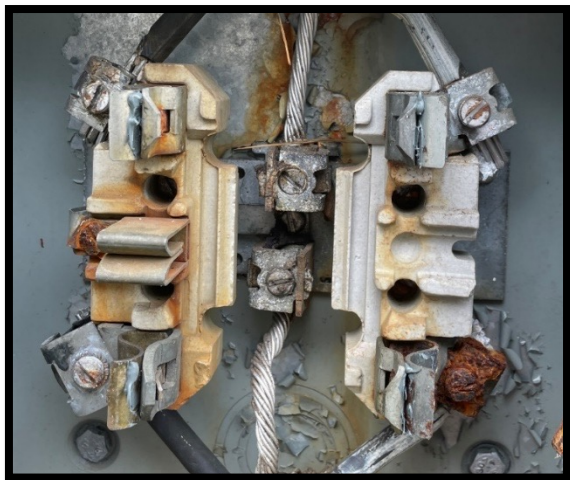




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METER 51****14 – CONDUIT ALLOWING WATER

- Days on report with >100 Max Arc Count: 43
- Average arc count: 233
- Max Arc Count: 473
- Arc Sense Priority Level 1
- No previous reports of overheating or rise in temperature
- Conduit allowed water to enter into the meter pan
- Screw terminal at C-phase load side was rusted and deteriorating
- Meter produced arcs when reinstalled





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METER 51****55 – WEATHER-HEAD CONDUIT DAMAGE

- Days on report with >100 Max Arc Count: 35
- Average arc count: 355
- Max Arc Count: 1601
- Investigation Priority Level: 2*
 - Moved to priority 1 based on recent top arc counts
- No previous reports of overheating or rise in temperature
- Meter not removed because customer was not home and it was a non-bypass pan
- Technician found damage to weather-head conduit





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METER 51****25 – WEATHER-HEAD + WIRE REPAIR POINTS

- Days on report with >100 Max Arc Count: 56
- Average arc count: 247
- Max Arc Count: 625
- Arc Sense Priority Level 1
- No previous reports of overheating or rise in temperature
- Damage at weather-head conduit
- Found repair points on neutral at triplex to house





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METER 51****25 – BROKEN CERAMIC INSIDE METER PAN

- Days on report with >100 Max Arc Count: 93
- Average arc count: 236
- Max Arc Count: 349
- Arc Sense Priority Level 1
- No previous reports of overheating or rise in temperature
- Technician found broken ceramic on the foundation inside the meter pan





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KEY PILOT INSIGHTS

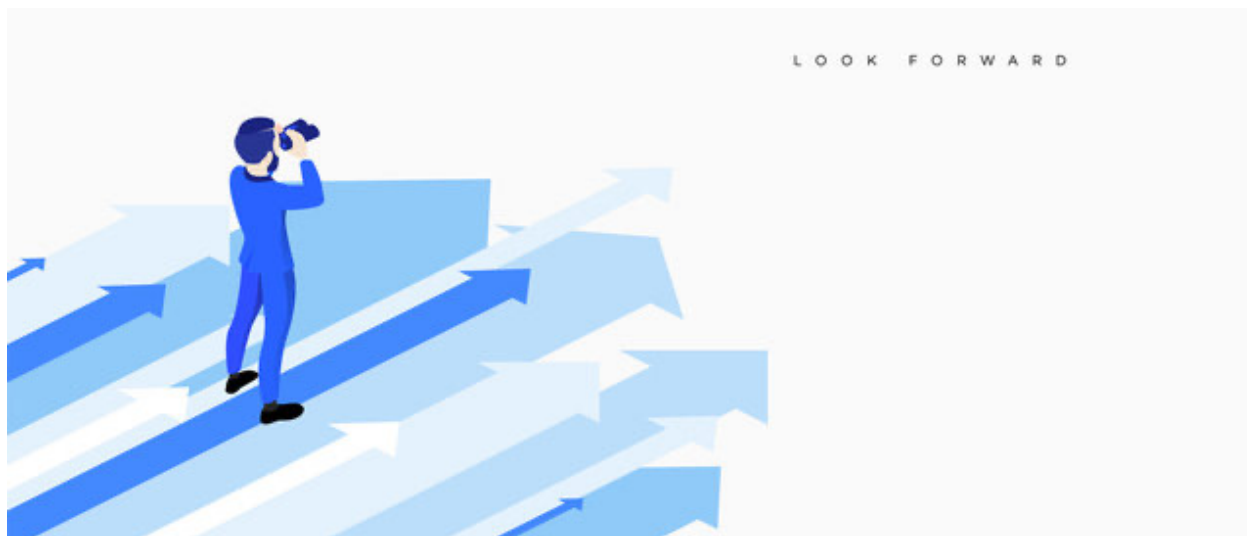
- Value in Arc Detection, Data, and Manpower
 - Arc Detection: helps to identify meters that may have safety issues
 - Uses load-profile channel to push as **data**
 - Data: allows for analytics to identify trends and identify quality issues
 - Pushed as daily report via L+G head-end to be interpreted by **manpower**
 - Manpower: Analyzes data, informs field force, provides investigation and response to potentially unsafe situations
- Specific problems that were identified in this study:
 - Brittle jaws & recessed jaws
 - Water damage
 - Hot socket situations
 - Current & future
- In the short duration of this project, customers were notified and pan was replaced, thereby avoiding a dangerous situation in the field



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LOOKING FORWARD

- Continuing to evolve
 - Prioritization Process
 - Tableau Dashboard
 - Field Force Checklist
 - Meter Manager Field Client
- Round table results with additional Arc Sense deployments





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ITRON METHODOLOGY – OVERVIEW

- Itron application TESCO micro arc detection tracks arcs as they occur over periods of time, rather than individual arcs
- Users establish how much of a given time period they need to witness arcs occurring, in order to trigger an Arc Recognition flag
- Users establish how many consecutive Arc Recognition flags they need to trigger an alarm

Arc Detection	Enable Arc Detection	True
	Arc Recognition Time Period	60
	Arc Recognition Count Threshold	30
	Number of Consecutive Arc Recognition Time Periods to Detect/Clear	5
	Clear Arc Recognition Count Threshold	0

- In this example, a meter must experience 5 consecutive periods of arcs experienced for 30 seconds within a 60 second period



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AVANGRID – ITRON DEPLOYMENT

- Avangrid is currently deploying Itron Gen 5 meters for their AMI transition.
- Installation started in November 2022, There are close to half a million meters in the field. The first two examples were from the first 30,000 or so deployed.
- Base settings triggered no alarms
- Queried database for any arc hits; data showed 8 meters with arc counts and single blocks exceeding criteria
- Investigated two of the meters that showed the greatest number of *SingleBlocksExceeded* (meters 1 and 3)

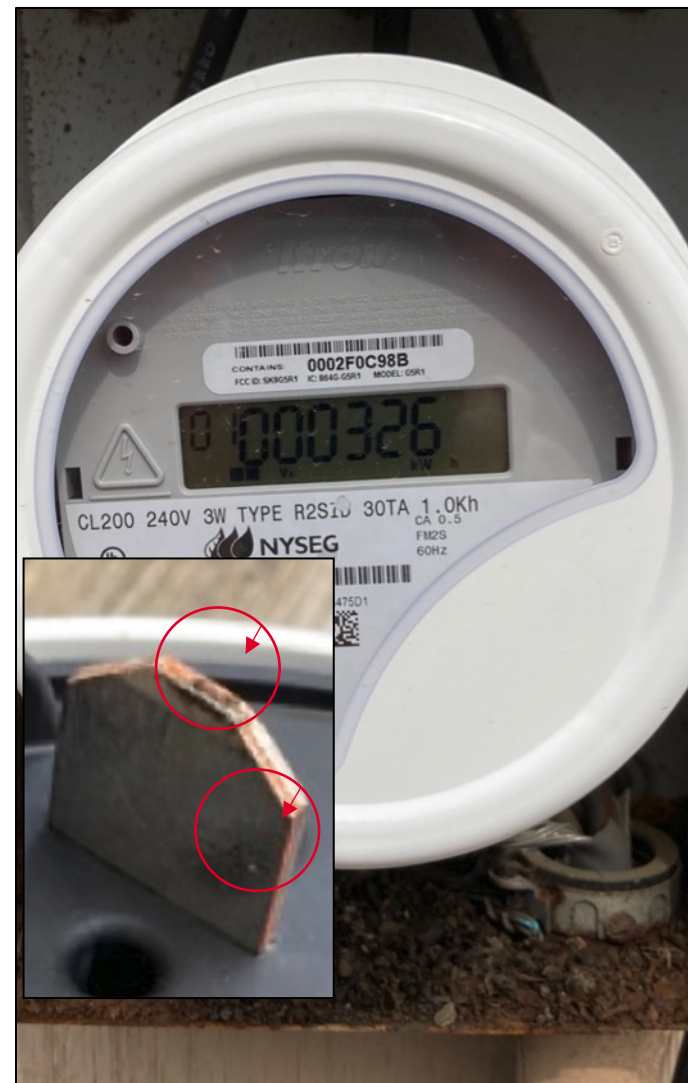
MeterName	TotalArcCount	SingleBlocksExceededCount	AlgorithmTriggeredCount	ArcsInLastBlock	ContiguousBlocksExceededCount	ClearBlockCount	Installed Date	Latitude	Longitude	DaysInService
Meter 1	28241	12	0	2	0	0	3/20/2023 11:10			15.02886277
Meter 2	9380	1	0	0	0	0	12/20/2022 10:32			105.0554947
Meter 3	5416	53	0	0	0	0	1/18/2023 1:00			76.45256648
Meter 4	462	6	0	0	0	0	1/12/2023 1:09			82.44664055
Meter 5	361	4	0	0	0	0	3/31/2023 11:21			4.021316477
Meter 6	271	3	0	0	0	0	11/23/2022 11:53			131.9994646
Meter 7	262	1	0	0	0	0	1/12/2023 11:23			82.01981185
Meter 8	61	1	0	0	0	0	2/6/2023 3:00			57.36904796



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AVANGRID – METER 1 FIELD FINDINGS

- The meter technician confirmed the presence of small burn marks and slight discoloration on the meter blade (picture below).
- He confirmed all service terminations were tight and he tested socket jaw tension using the Tesco Hot Socket Gap Indicator tool.
 - Jaw tension was good.
- Based on photo, it appeared meter was misaligned; after field visit and reinsertion of the meter, report showed zero incremental arc counts, on all six counters.

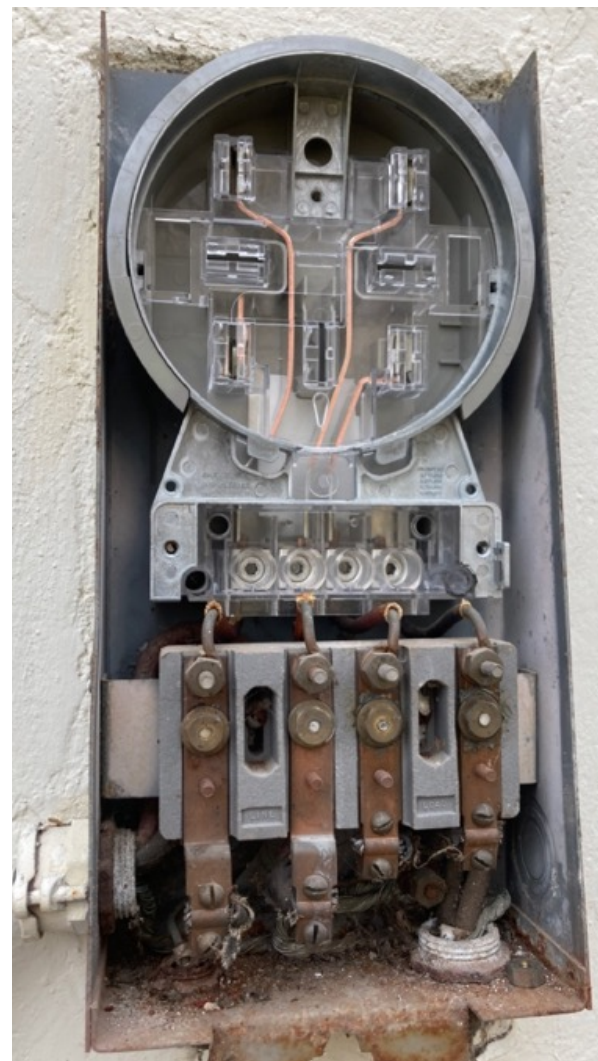




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AVANGRID – METER 2 FIELD FINDINGS

- A-Base to socket adapter
 - The adapter is new and was installed when the new AMI meter was set
- The meter technician said he used a magnifying glass to inspect the meter blades but didn't see any pit marks.
- He checked all external service connections and everything seemed to be OK (i.e. no loose connections, etc.).
- He used the TESCO Hot Socket Gap Indicator tool on the adapter and jaw tension looked good.
- Expected arcing occurring in older connection base to new socket adapter; arc passing through meter channel.
 - Additional inspection discovered a failing weather head where broken strands were creating arcs.





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AVANGRID – UNEXPECTED FINDINGS

- What was unexpected was the ability to the detection circuit to pick other safety or operational (or both) issues that could be addressed prior to leading to a catastrophic failure.
 - Failing distribution transformer
 - Broken strands at weather head – near separation of weather head
 - Failing equipment on the customer side of the Main service box in the house
 - The adapter is new and was installed when the new AMI meter was set
- These are just three of several examples. The common theme was arcing on the line and a direct line into the meter that was relatively close to the meter. These issues were only ever reported by one meter and not a series of neighboring meters.
 - Finding these issues required the use of additional RF detection equipment by the field technician.
- New protocols and checklists were recommended for field investigations of significant arc reports from the field





- What is Micro-Arc Detection?
 - Location and Purpose of Arc Sense in Meter Base
 - Description of Operation
 - Block Diagram
 - Circuit Diagram
 - Important Parameters and Take Aways
- Your Data & You
 - How is Micro-Arc Data Captured
 - How do I make use of it?



Why we need to pay attention to the flags and alarms we are receiving?

Answer:

- Safety
- Reduced Operational Costs
- Better power delivery to our customers with fewer power interruptions



QUESTIONS AND DISCUSSION



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