



**ROOT CAUSE ANALYSIS
FOR
150 EAST MARKET STREET
NETWORK EVENT ON
MARCH 14, 2014**

Prepared by T&D Engineering
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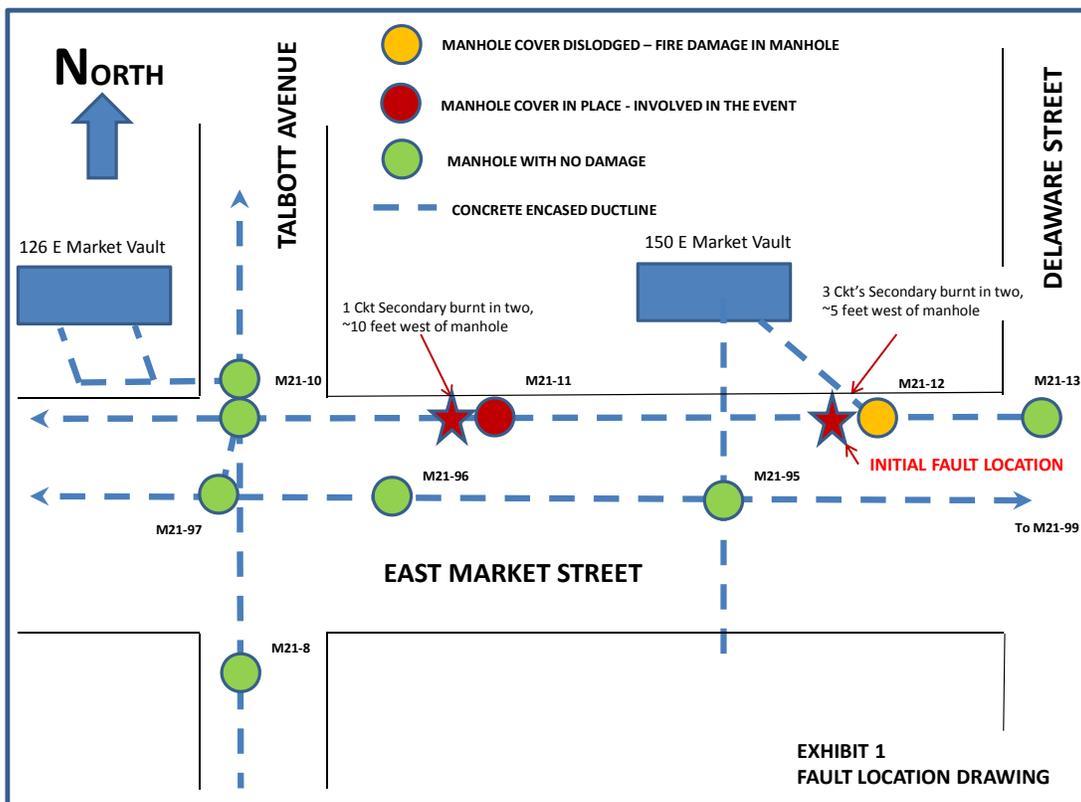
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1.0 INTRODUCTION

On Friday, March 14, 2014 at 8:06 PM EDT a reportable network event occurred at 150 E Market Street. This area is served by the Sub 3 secondary network. The event involved a secondary network fire with one manhole cover becoming dislodged. There was no property damage or injuries to the public. The secondary fire burned itself out in approximately 16 minutes. It was not necessary to de-energize the Sub 3 secondary network to extinguish the fire.

Exhibit 1 below shows the layout of IPL facilities in the area of the event.

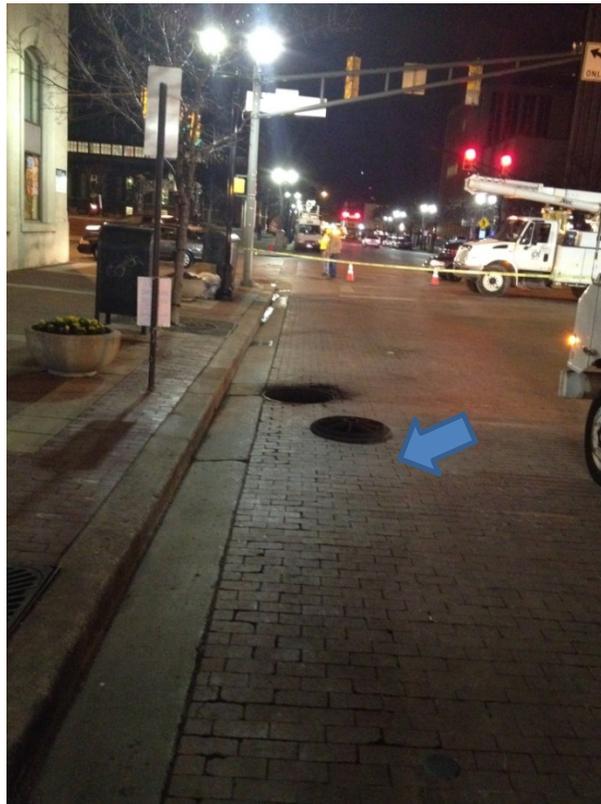


2.0 BACKGROUND

In March of 2013, manhole M21-12 was inspected and no issues were found that would contribute to the event on March 14th. During inspections, any minor issues like a missing cable rack saddle or duct shield would be taken care of at the time of inspection. Just west of this manhole is where the event is believed to have started.

The other manholes in the area M21-10 and M21-11 were last inspected in December 2012 and manhole M21-13 was last inspected in February 2013. No critical issues were noted in these inspections. Critical issues would be things like a swelled or leaking splice or damaged cables. As noted above, any minor issues are addressed during the inspection.

The weather condition on the night of March 14, 2014, was clear with temperatures in the mid 50's. There had been heavy rain and snow in the two days before on March 12th and 13th. According to the National Weather Service office in Indianapolis, 1.29 inches of water equivalent precipitation had fallen during that period. During the period of December 2013 through March 13th, 2014, 55 inches of snow fell in Indianapolis across 32 days. Through the end of January, the City of Indianapolis had spread 34,000 tons of salt, which is more than they spread for an entire winter period.



Manhole Cover Dislodged in the Event on March 14, 2014

3.0 SEQUENCE OF EVENTS

The following sequence of events has been developed using information from IPL records and from the Indianapolis Fire Department CAD records and their incident reports.

NETWORK EVENT ON MARCH 14, 2014 150 E MARKET STREET - SUB 3 NETWORK SEQUENCE OF EVENTS

Time	Event Description
3/14/2014	Pre-Event
21:05	Network SCADA Network Protector Status <ul style="list-style-type: none">• 126 E Market Street – UG 303 Protector is CLOSED• 126 E Market Street – UG 304 Protector is OPEN• 126 E Market Street – UG 308 Protector is CLOSED• 126 E Market Street – UG 309 Protector is CLOSED• 150 E Market Street – UG 305 Protector is CLOSED• 150 E Market Street – UG 309 Protector is CLOSED
	Event
21:06	Network SCADA shows secondary current spike at 126 E Market Street vault Network SCADA shows secondary current spike at 150 E Market Street vault Sub 3 Feeder Breaker UG 304 Opens at the substation
21:16	Cover on Manhole M21-12 is dislodged (Estimated Time)
21:17	911 Center receives call reporting explosion in the street in front of 156 E Market Street, dispatches IFD units
21:19	IFD first units on the scene, establishes Market Street Command
21:22	Sub 3 Feeder Breaker UG 307 Opens at the substation Network SCADA shows secondary currents have returned to pre-event levels Secondary Fire is out, cables have burned themselves into the clear as designed
21:33	IFD Market Street Command requests IPL, DPW, and Citizens Energy to respond to the scene
21:44	IPL Trouble Truck 242 dispatched
22:11	IPL Trouble Truck 242 arrives on scene, stood by until IPL Network Crews arrived

After confirming the secondary fire was out, IPL crews inspected the manholes along Market Street between Talbot and Delaware Street. Damage was evident in manhole M21-12 and minor damage in manhole M21-11. In manhole M21-12, there was damage to the primary cable on UG 304, UG 307, and UG 701. The damage to UG 701 was to the cable jacket, this circuit did not relay out of service.

The decision was made to repair UG 307 and UG 701 primaries first and restore those circuits to service. (UG 701 was removed from service to make repairs to the cable jacket)

On Sunday, March 16, 2014, IPL Network crews completed pulling in and splicing the new primary cable for UG 304 and UG 307. That work was completed on Sunday afternoon at 3:30 PM EDT and load was restored to both circuits Sunday evening.

4.0 INVESTIGATION AND ANALYSIS

The investigation into the cause of the network event at 150 E Market Street began as soon as the fire was out and it was safe to begin looking into the manholes and vaults.

4.1 Market Street Facilities

The facilities involved in the event on March 14, 2014 included the following:

1. Manhole M21-12 – this manhole is in the curb lane on the north side of Market Street in front of 156 E Market Street near the vault at 150 E Market Street. This manhole had a solid cover. This manhole contained four primary circuits; UG 301 (#1 copper 15 kV PILC), UG 304 (4/0 copper 15 kV PILC), and UG 307 (#1 copper 15 kV PILC) network primaries, UG 701 (350 MCM copper 15 kV PILC) a non-network 4 kV primary feeder. The manhole contained four circuits of 350 MCM copper PILC 600 Volt class secondary cable.
2. Manhole M21-11 – this manhole is in the curb lane on the north side of Market Street. This manhole had a solid cover. The manhole contained four primary circuits; UG 301 (#1 copper 15 kV PILC), UG 304 (4/0 copper 15 kV PILC), and UG 307 (#1 copper 15 kV PILC) network primaries, UG 701 (350 MCM copper 15 kV PILC) a non-network 4 kV primary feeder. The manhole contained four circuits of 350 MCM copper PILC 600 Volt class secondary cables.
3. Manhole M21-13 – this manhole is east of manhole M21-12 in the curb traffic lane on the west side of Delaware at Market Street. This manhole has a vented cover. This manhole contained 5 primary circuits; UG 301 (#1 copper 15 kV PILC), UG 304 (4/0 copper 15 kV PILC), UG 306 (#1 copper 15 kV PILC), and UG 307 (#1 copper 15 kV PILC) network primaries, UG 701 (350 MCM copper 15 kV PILC) a non-network 4 kV primary feeder. There was no visible damage in this manhole. The manhole contained 2 circuits of 350 MCM copper PILC 600 Volt class secondary cables.
4. 150 E Market Street Vault – this is a two bay 120/208 volt secondary network vault. It contains two 1,000 KVA network transformers served from UG 305 and UG 309.

4.2 Observations during the Event

The event was first observed by the public who reported an explosion in the street in front of the Subway Restaurant at 156 E Market Street. A call was placed by the public to 911. The Indianapolis Fire Department (IFD) dispatched Engine 7, Ladder 7, Squad 7, and Battalion Chief 7 to the scene.

Upon arrival the crew of Engine 7 found heavy smoke coming from the manhole in front of 156 E Market Street (M21-12). They observed one manhole cover that been dislodged in front of 156 E Market Street. They also observed what they believed to be smoke coming from other utility structures in the area. This later turned out to be steam vapor. The Incident Commander requested that IPL be dispatched to the scene along with Citizens Gas and DPW.

IFD personnel checked the adjacent buildings and did find light haze in the basement of 156 E Market Street. It appeared to be entering from the utility conduits. No hazardous levels of Carbone Monoxide were noted in the IFD incident report.

IFD units stood by until IPL representatives arrived on the scene. At no time did IFD attempt to put water on the manhole that was smoking. IPL has asked IFD not to put water on a smoking manhole unless IPL representatives are on site and ask them to do so.

4.3 Observations after the Event

IPL network crews arrived on the scene at 11 pm. At that point the secondary fire was declared out and IPL began accessing the damage. The following is a summary of what was found immediately following the event.

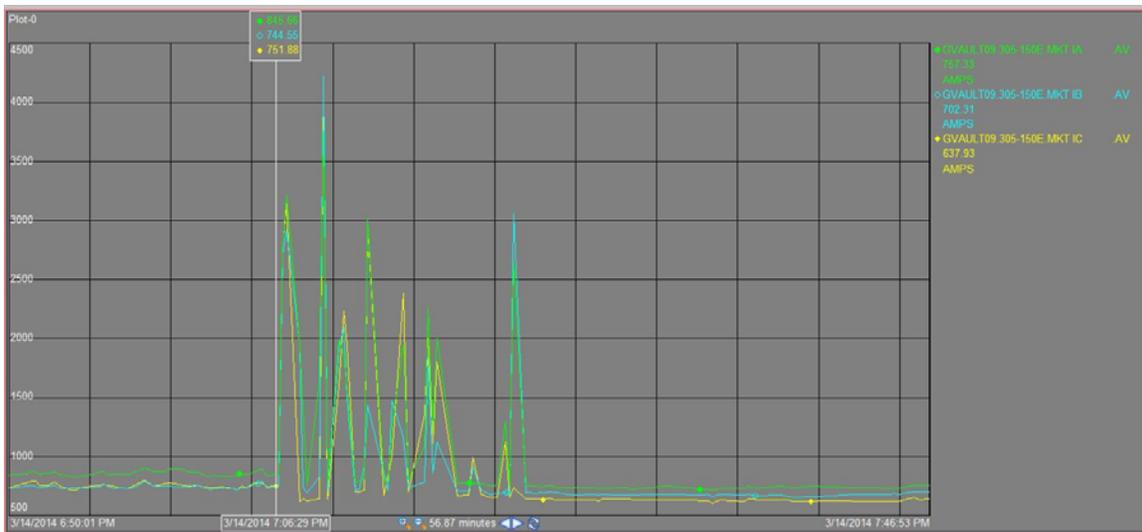
1. 150 E Market Street Vault
There was no cable damage in the vault. One run of secondary cable was replaced between manhole M21-12 and the vault due to cable damage in the manhole.
2. 126 E Market Street Vault
There was no cable damage in the vault.
3. Manhole M21-12
This manhole cover was laying upside down about 18 inches to the northwest of the manhole. There was damage to primary cables for UG 304 and UG 307. Both of these circuits did relay out of service from the damage. There was damage to the jacket on primary circuit UG 701 but it did not relay out of service. No visible damage was noted on primary circuit UG 301. There was damage to the secondary cables in this manhole. One circuit of secondary was burnt in two approximately five feet west of the manhole in the duct line/conduit. It is believed this is where the event started.
4. Manhole M21-11
This manhole cover remained in place in the ring. The initial visual inspection did not show any damage in this manhole. There was a circuit of secondary burnt in two in the duct line/conduit approximately 10 feet to the west of this manhole toward manhole M21-10.

5. Manhole M21-13

This manhole cover remained in place in the ring. The initial visual inspection did not show any damage in this manhole. Crews did note elevated temperatures in this manhole; they measured the wall temperature at 145° F. Citizens Energy was notified.

4.4 Network SCADA Information

This was the first significant network event since the Network SCADA system was placed in-service in 2013. Analog and status data from the network relays were reviewed following the event. This data was used to help establish the sequence of events and confirm that the secondary network fire did self-clear.



Secondary Currents on UG 305 Unit at 150 E Market Vault

4.5 Swiveloc Manhole Covers

The section of Market Street from the Circle to Delaware did not have Swiveloc manhole covers. Most of the manhole covers were solid covers with a few vented covers. The City of Indianapolis has announced plans to repave that stretch of Market Street as part of the Circle Renovation Project. Therefore, IPL had postponed the installation of Swiveloc covers on that section of Market Street in an attempt to coordinate with the City's project. The City has now delayed the start of their project past 2015. IPL plans to re-examine their project plans and evaluate proceeding with the installation of Swiveloc covers on the section of East Market Street from the Circle to Alabama Street.

5.0 FINDINGS

Summary of findings are:

1. Manhole M21-12 was inspected in March of 2013 and no issues were found that would contribute to the event on March 14th.
2. Manhole M21-11 was inspected in March of 2013 and no issues were found that would contributed to the event on March 14th.
3. All protective devices appear to have operated correctly for this event.
4. There was no evidence of steam leaks in any of the manholes involved in this event. The 2013 Anomaly Assessment conducted by Citizens Energy did not show any leaks in the area of this network event. Their 2014 Assessment was conducted in April 2014 and did not show any leaks in the area of this event.
5. The initial secondary fire likely burnt towards the stronger electrical source which was the vault at 150 E Market Street. The fire reached manhole M21-12 and involved all the secondary cables in this manhole, also causing damage to the primary cables of UG 304, UG 307, and UG 701.
6. Visual inspection of the cables removed from the ductlines did show evidence of corrosion on the outer jacket. Corrosion on the cable jacket will typically be caused by a chemical reaction.
7. Significant amounts of road salts had been put down by the City of Indianapolis during the winter. This would likely result in residual salt contamination in the manhole and in the duct line and could contribute to the corrosion observed on the cable jacket

6.0 CONCLUSIONS and RECOMMENDATIONS

The following is a description of what is believed to have occurred on the night of March 14, 2014, based on the investigation conducted by IPL after the event on East market Street.

1. Steam has been ruled out as a contributing factor for this particular network event.
2. It is believed the heavy rains and snow in the two days prior to the event were a contributing factor in addition to the salt contamination from road salts this past winter.

3. The cable jacket on the one circuit of secondary cable between manhole M21-13 and M21-11 was compromised from the corrosion noted on certain cables removed during repairs. The corrosion is likely from exposure to the road salts over the years.
4. The compromised cable jacket along with the moisture from the snow and rain in the days prior as well as possible salt contamination resulted in the initial fault on the secondary cable between manholes M21-11 and M21-12.
5. The secondary did not initially clear and continued to burn back towards the source at the 150 E Market Street vault. Once the fire burned into manhole M21-12, the additional secondary cable became involved. The fire damaged the jacket on primary feeder UG 304 causing it to fault and relay out of service. The secondary fault cleared itself at the same time the fire damaged the jacket on primary feeder UG 307, causing it to fault and relay out of service. From the network SCADA information it appears the fire burned for a total of 16 minutes.
6. The damaged secondary cable between manhole M21-11 and M21-10 was likely from a weak spot in the cable and it failed from the fault current flowing from the vault at 126 E Market Street towards the fault in manhole M21-12.

6.1 Recommendations

1. Continue manhole inspections noting the condition of the cable jacket, where possible. Generally, the cables are wrapped in fire proofing tape making inspection of the cable jacket impossible.
2. Continue installation and review of Swiveloc locking manhole covers. While these covers will not prevent an event from occurring, they will restrain the cover from becoming dislodged if an event does occur.
3. Install Swiveloc locking manhole covers on Market Street in 2014 from the Circle to Alabama Street. This takes the project past the City Market. This will also place Swiveloc covers on the remaining manholes around all four spokes of the Circle in addition to the ones on Market Street. In all about 50 Swiveloc covers will be installed.

APPENDIX

The following are pictures that were taken on Saturday, March 15, 2014 after the damaged cables had been removed by IPL crews.



Picture 1 - Damaged Secondary Cable



Picture 2 - Damaged Secondary Cable



Picture 3 - Damaged Secondary Cable