Rick Kernan

Presents

Feeder Reroute using Eaton Vaultgard

and

Fault Locating using Eaton Vaultgard

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Presentation Overview

- Denver Network Stats
- Network Reroute Overview
- Step by Step Reroute Process
- Vaultgard Screen Shots
- Labor Savings
- Fault Locating with Vaultgard
- Conclusion

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Denver Network Stats

- Vaultgards
  - 127
- Protectors
  - 803
- Networks
  - 13 – 3 Feeder
- Substations
  - 5

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Network Reroute Overview

Each of Xcel Energy's 13 networks consists of 3 separate feeders that are fed from the same substation buss. There is no distribution on the underground network. On occasion, it is necessary to reroute a network from one source to another source. This source could be a difference buss in the same substation or from a different substation due to capacity issues, new construction or substation issues.

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Network Reroute Overview

In the last 5 years the Xcel Energy Underground Network has executed more the 15 feeder reroutes. A scheduled feeder reroute or “cut” usually will start at 1pm on a Saturday. In most cases a feeder cut will require an open transition or a drop and pick. This open and close is scheduled for 2 am. All effected buildings are notified of the temporary outage several weeks before the feeder cut.

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Step by Step Reroute Process

The first step is to identify the source to be used and the route must be identified. This is usually done by the network engineer. In an emergency, the route and source are identified by the lead network employees. All substations, manholes and buildings must identified and all effected customers must be notified. The Underground department coordinates with the substation department to switch out the networks as needed. For this presentation, the blue network will become the orange network as seen in the next few slides.

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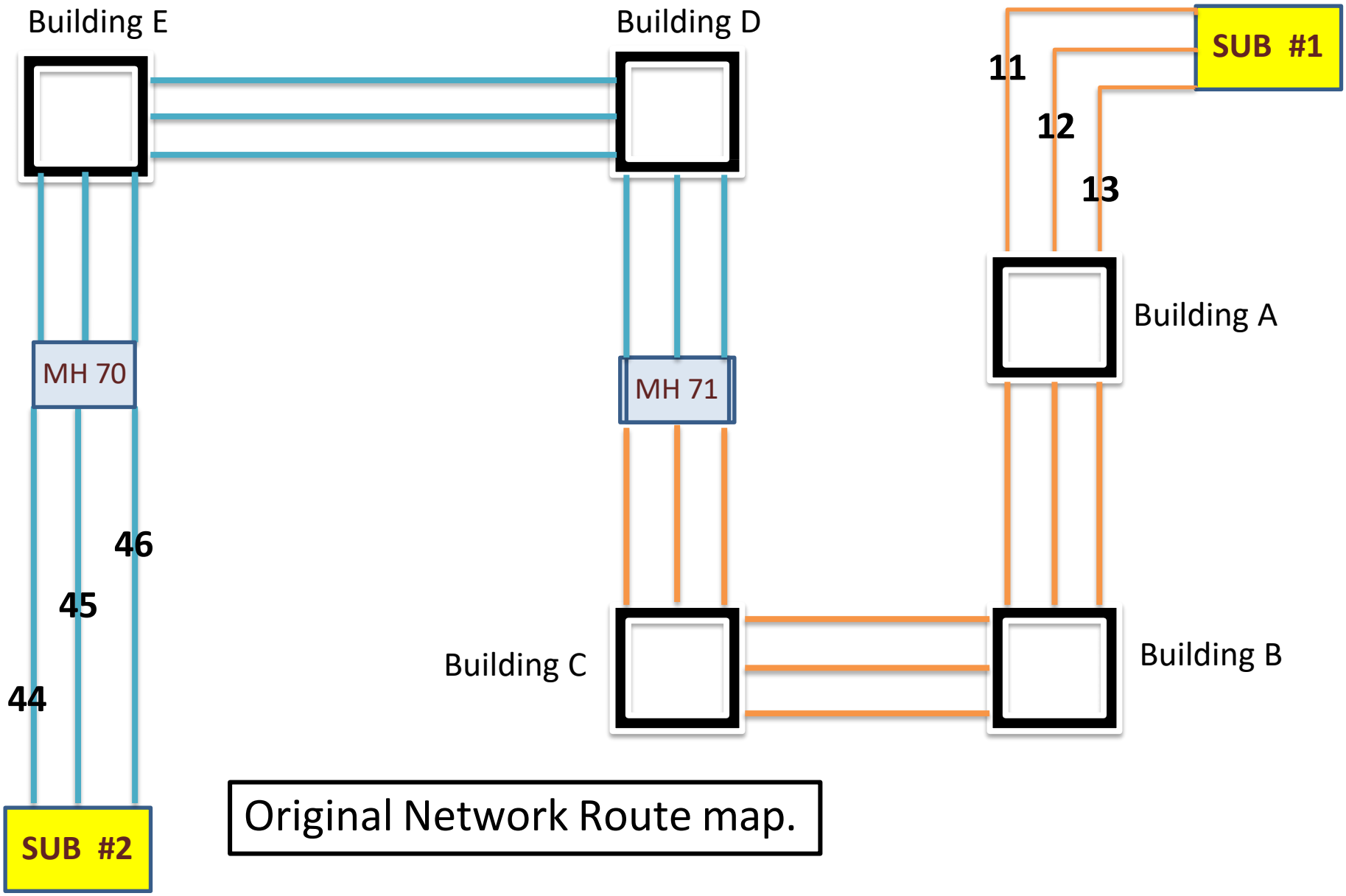
Step by Step Reroute Process



Original Network Route map.

Step by Step Reroute Process

On the day of the cut, the person in charge will have the substation department open the first set of feeders, feeder 11 and feeder 44 for this example. The feeders will be grounded, and a clearance issued. All crews will begin the reroute process.

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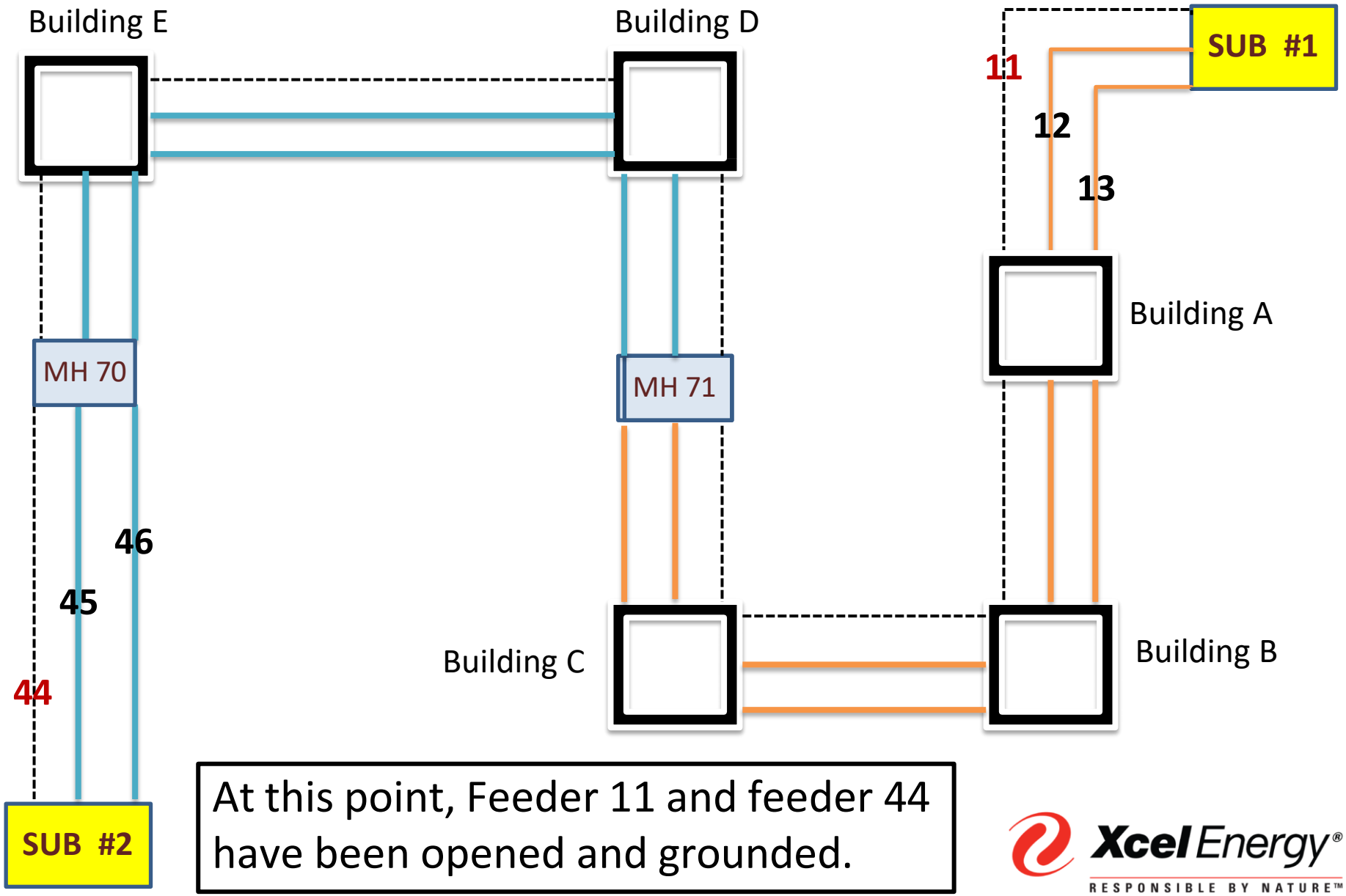
Step by Step Reroute Process



At this point, Feeder 11 and feeder 44 have been opened and grounded.

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Step by Step Reroute Process

At this point, all protectors on feeder 11 and feeder 44 will be Remote Open Blocked Opened with Vaultgard and left in ROBO until later in the feeder cut. In previous feeder cuts, a crew would go to every effected building and manually open the protector. This could be as many as 30 locations and could take up to 2 hours.

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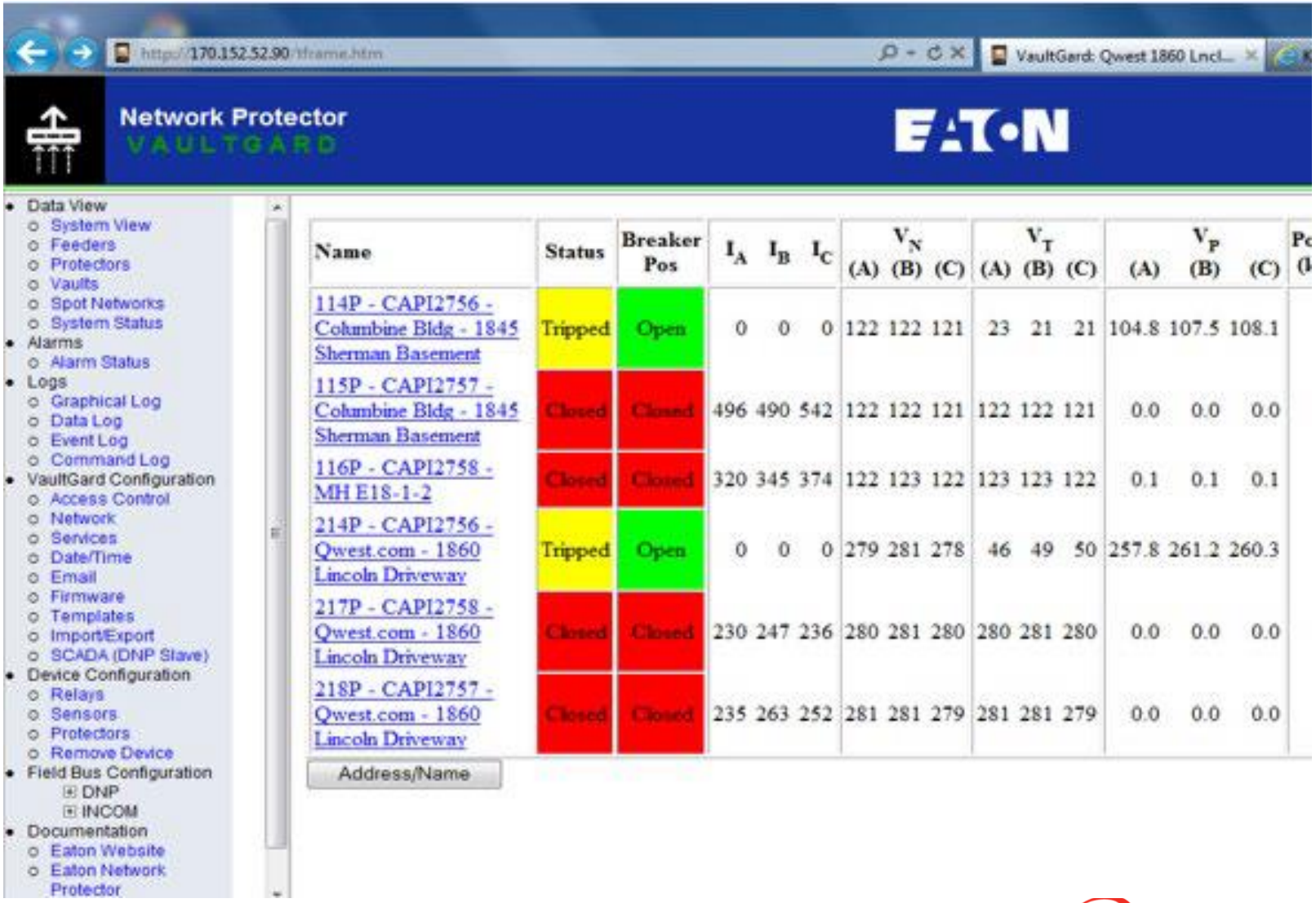
Step by Step Reroute Process

Name	Status	Breaker Pos	I_A	I_B	I_C	V_N (A)	V_N (B)	V_N (C)	V_T (A)	V_T (B)	V_T (C)	V_P (A)	V_P (B)	V_P (C)
*Dominion Plaza - 30th Fl - Bank 1 - CAPI 2759 - 909P	Closed	Closed	196	191	195	280	282	280	280	282	280	0.2	0.1	0.1
*Dominion Plaza - 30th Fl - Bank 1 - CAPI 2760 - 768P	Closed	Closed	227	230	243	281	282	279	281	282	279	0.0	0.0	0.2
*Dominion Plaza - 30th Fl - Bank 1 - CAPI 2761 - 769P	Closed	Closed	221	231	240	281	283	280	281	283	280	0.1	0.1	0.0
Dominion Plaza - 30th Fl - Bank 2 - CAPI 2759 - 708P	Closed	Closed	41	45	37	290	291	292	290	292	292	0.0	0.2	0.1
Dominion Plaza - 30th Fl - Bank 2 - CAPI 2760 - 774P	Closed	Closed	45	50	43	290	292	290	290	292	290	0.3	0.0	0.1
Dominion Plaza - 30th Fl - Bank 2 - CAPI 2761 - 957P	Closed	Closed	40	44	34	291	294	292	291	294	292	0.1	0.2	0.1

This is a view with the feeder closed.

Step by Step Reroute Process



Name	Status	Breaker Pos	I_A	I_B	I_C	V_N (A)	V_N (B)	V_N (C)	V_T (A)	V_T (B)	V_T (C)	V_P (A)	V_P (B)	V_P (C)	Po (I
114P - CAPI2756 - Columbine Bldg - 1845 Sherman Basement	Tripped	Open	0	0	0	122	122	121	23	21	21	104.8	107.5	108.1	
115P - CAPI2757 - Columbine Bldg - 1845 Sherman Basement	Closed	Closed	496	490	542	122	122	121	122	122	121	0.0	0.0	0.0	
116P - CAPI2758 - MH E18-1-2	Closed	Closed	320	345	374	122	123	122	123	123	122	0.1	0.1	0.1	
214P - CAPI2756 - Qwest.com - 1860 Lincoln Driveway	Tripped	Open	0	0	0	279	281	278	46	49	50	257.8	261.2	260.3	
217P - CAPI2758 - Qwest.com - 1860 Lincoln Driveway	Closed	Closed	230	247	236	280	281	280	280	281	280	0.0	0.0	0.0	
218P - CAPI2757 - Qwest.com - 1860 Lincoln Driveway	Closed	Closed	235	263	252	281	281	279	281	281	279	0.0	0.0	0.0	

This is a view with the feeder open.

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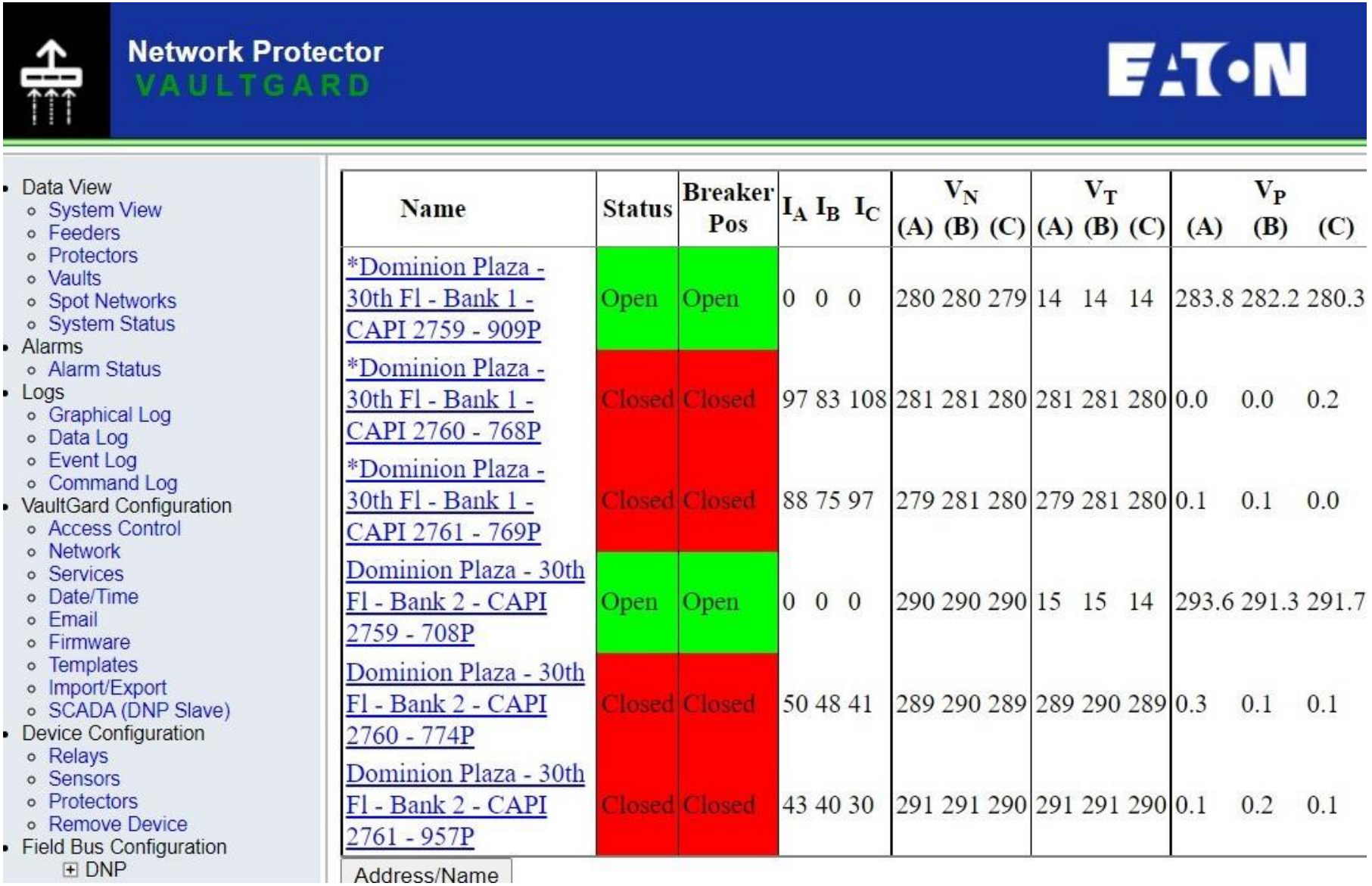
Step by Step Reroute Process



Name	Status	Breaker Pos	I_A	I_B	I_C	V_N (A)	V_N (B)	V_N (C)	V_T (A)	V_T (B)	V_T (C)	V_P (A)	V_P (B)	V_P (C)
*Dominion Plaza - 30th Fl - Bank 1 - CAPI 2759 - 909P	Open	Open	0	0	0	280	280	279	14	14	14	283.8	282.2	280.3
*Dominion Plaza - 30th Fl - Bank 1 - CAPI 2760 - 768P	Closed	Closed	97	83	108	281	281	280	281	281	280	0.0	0.0	0.2
*Dominion Plaza - 30th Fl - Bank 1 - CAPI 2761 - 769P	Closed	Closed	88	75	97	279	281	280	279	281	280	0.1	0.1	0.0
Dominion Plaza - 30th Fl - Bank 2 - CAPI 2759 - 708P	Open	Open	0	0	0	290	290	290	15	15	14	293.6	291.3	291.7
Dominion Plaza - 30th Fl - Bank 2 - CAPI 2760 - 774P	Closed	Closed	50	48	41	289	290	289	289	290	289	0.3	0.1	0.1
Dominion Plaza - 30th Fl - Bank 2 - CAPI 2761 - 957P	Closed	Closed	43	40	30	291	291	290	291	291	290	0.1	0.2	0.1

This is a protector in ROBO

Step by Step Reroute Process

Once the junction straps have been reconfigured in manhole 71, feeder 11 is re-energized. Feeder 44 is isolated between the substation and manhole 70. Feeder 44 is now feeder 11. There are now opposite feeders in the buildings. The protectors that were energized and are opposite feeders are in Remote Open Blocked Open status to prevent tying the networks together.

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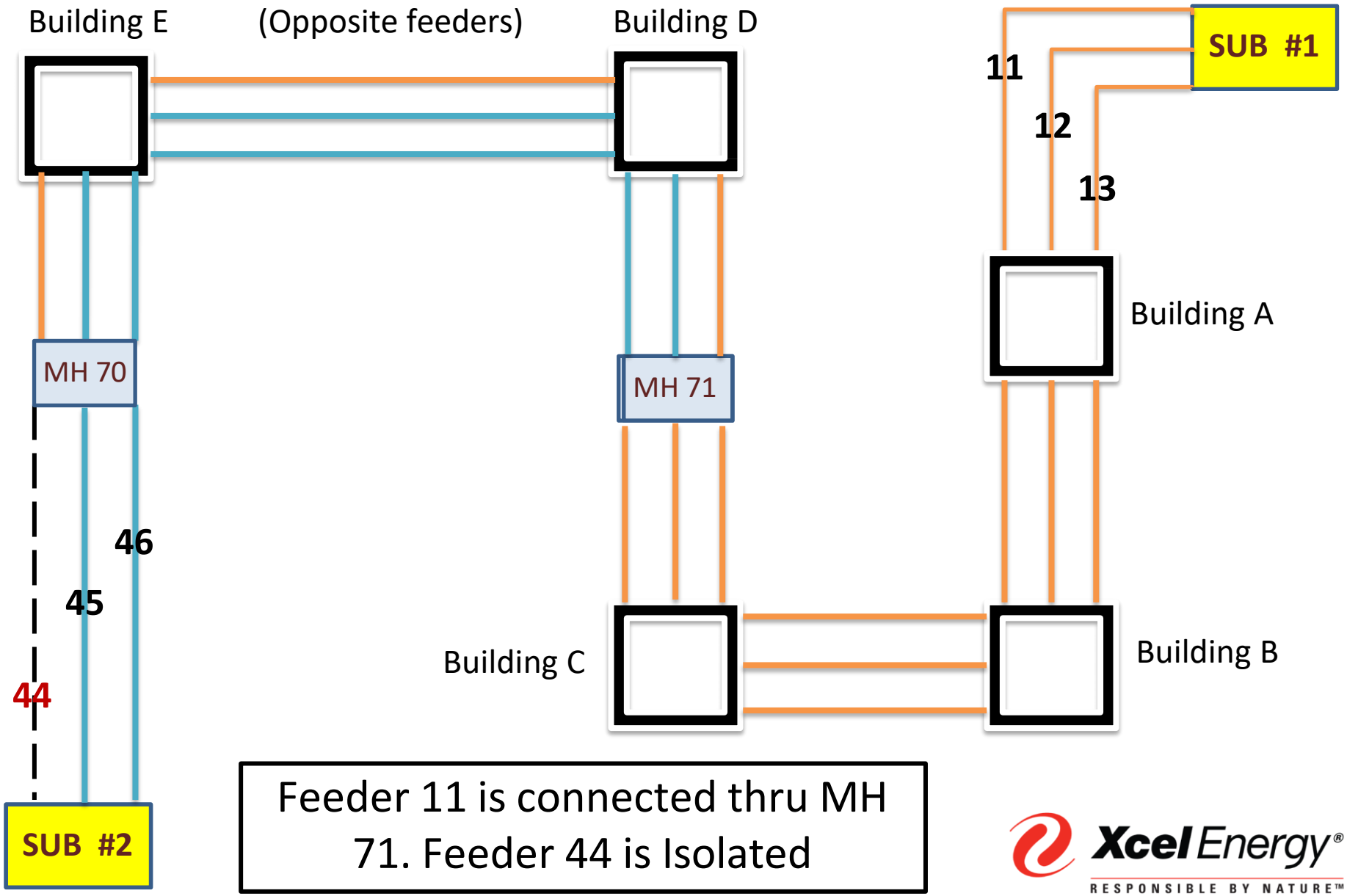
Step by Step Reroute Process



Feeder 11 is connected thru MH 71. Feeder 44 is Isolated

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Step by Step Reroute Process

The next 2 feeders, 12 and 45, are opened and grounded. As with the first set of feeders, all protectors on feeder 12 and feeder 45 will be Remote Open Blocked Open with Vaultgard and left in ROBO until later in the feeder cut. In previous feeder cuts, a crew would go to every effected building a 2nd time and manually open the protector. Once again, this could be as many as 30 locations and could take up to 2 hours.

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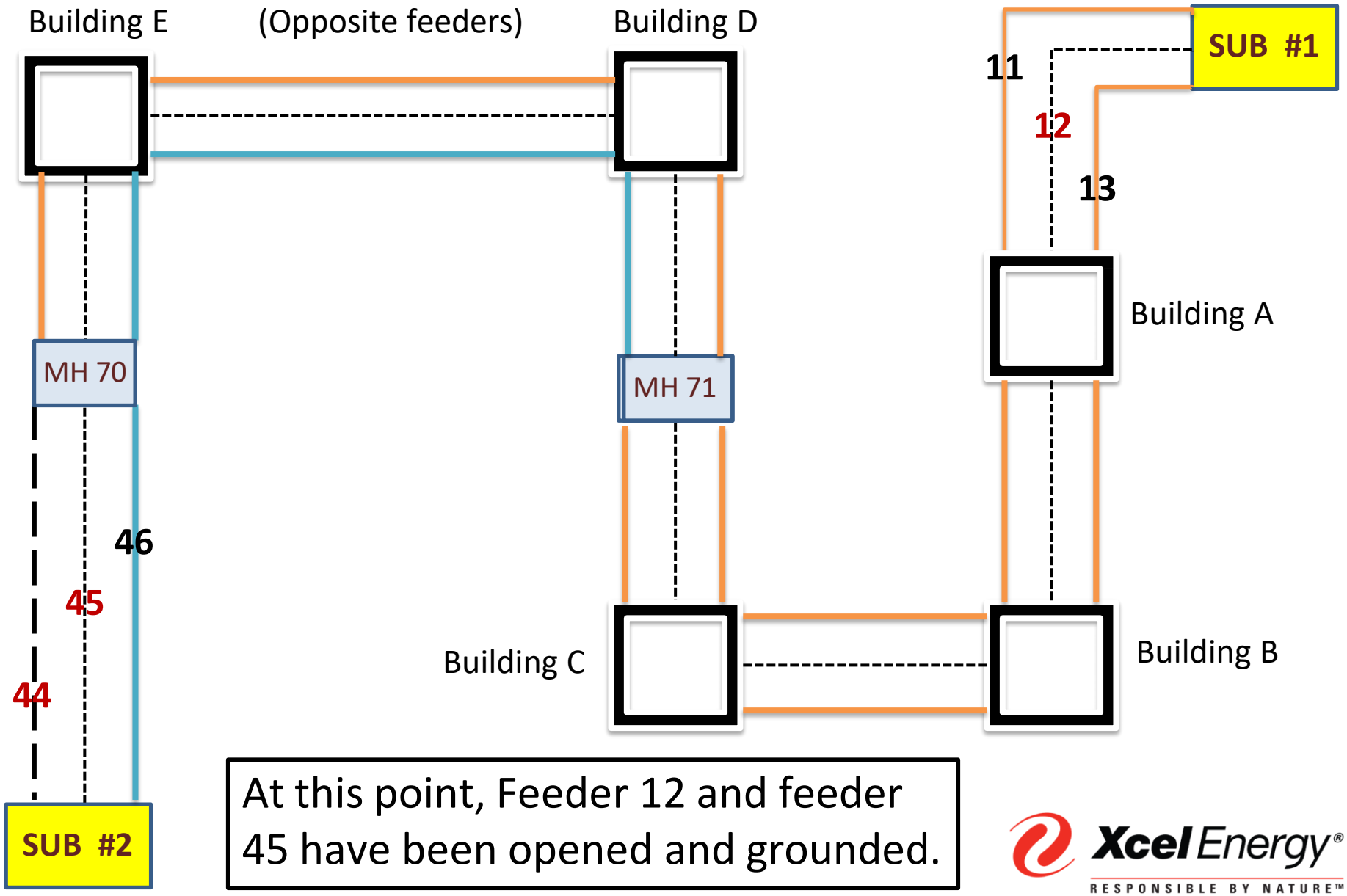
Step by Step Reroute Process



At this point, Feeder 12 and feeder 45 have been opened and grounded.

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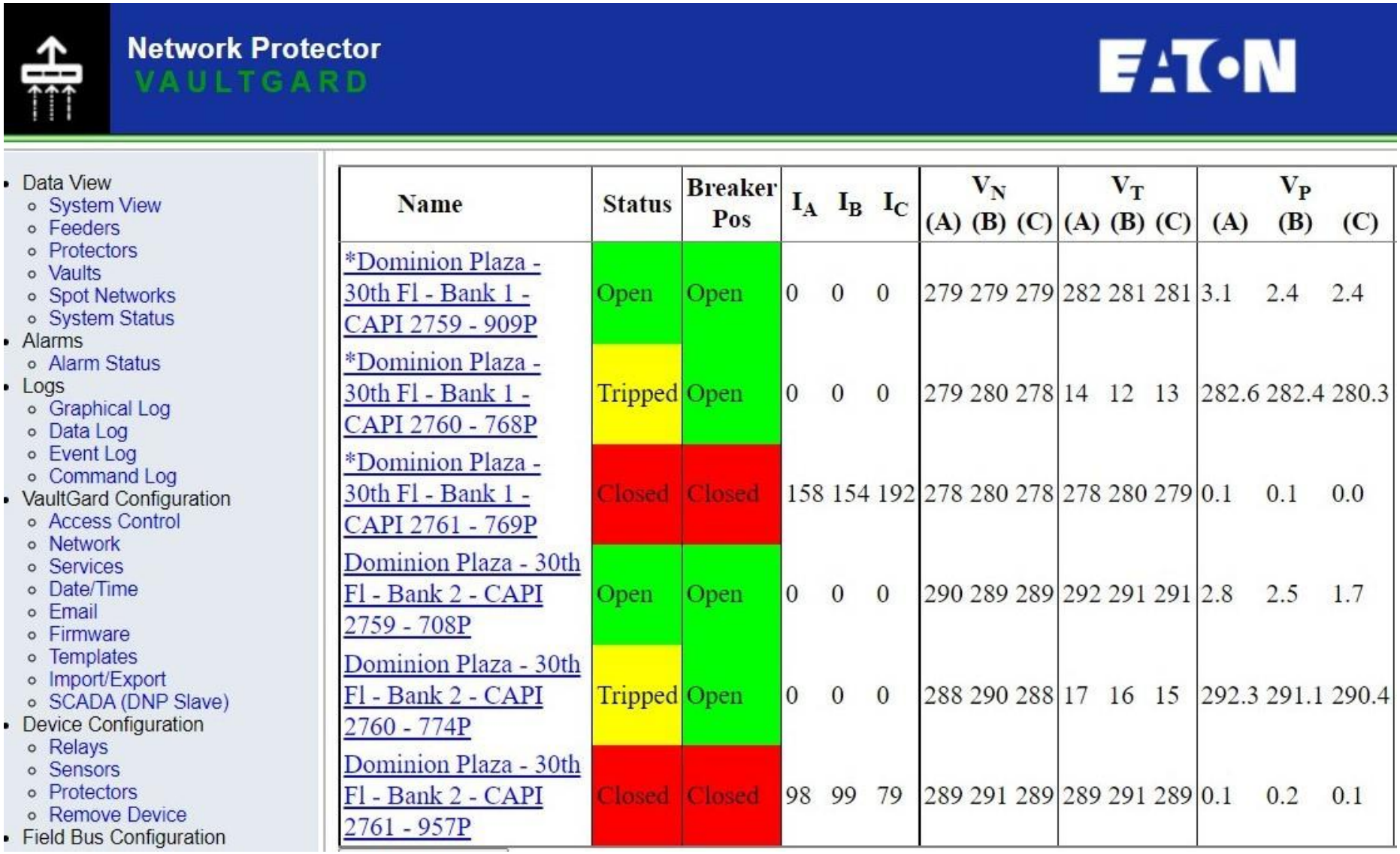
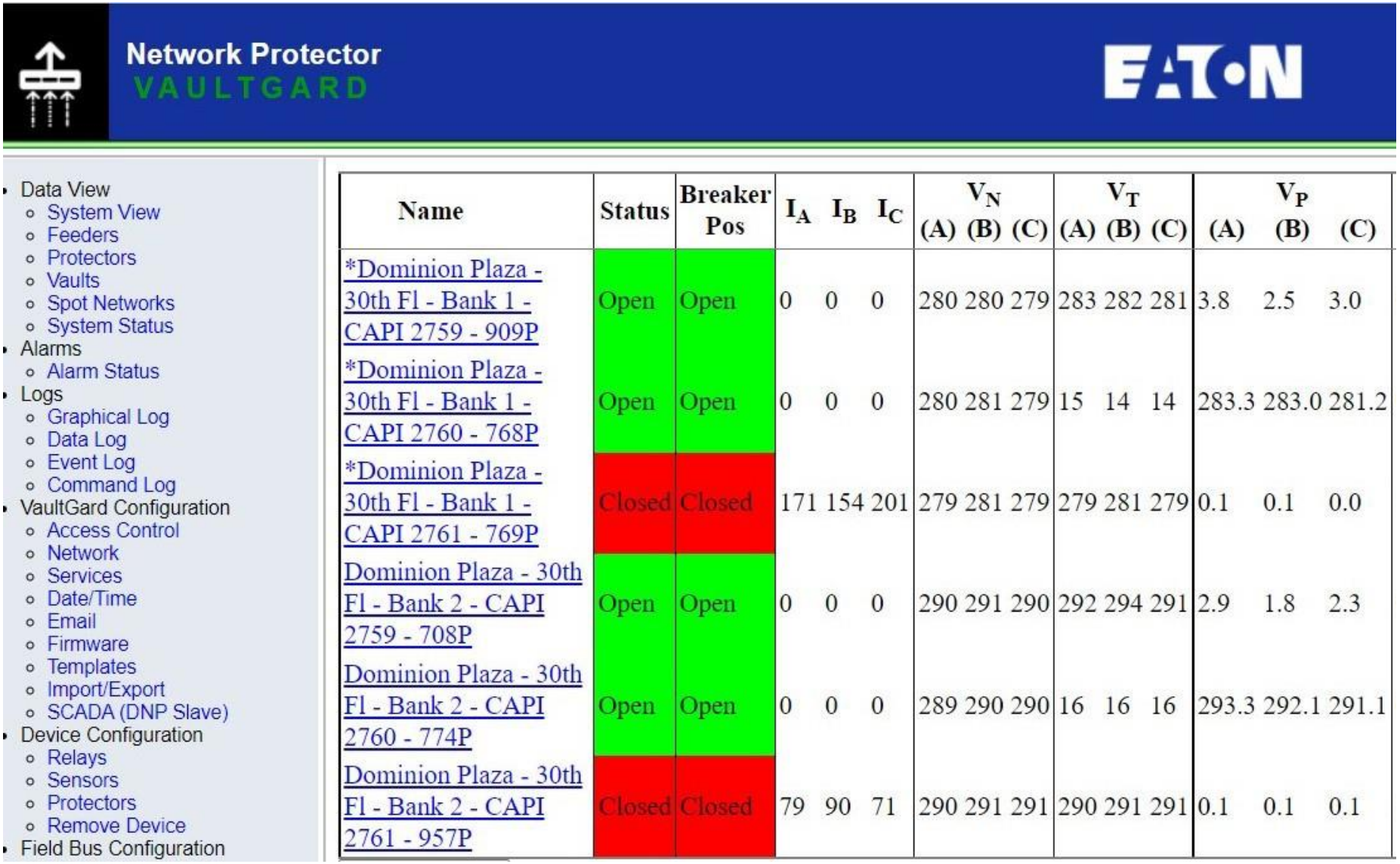
Step by Step Reroute Process



Name	Status	Breaker Pos	I_A	I_B	I_C	V_N (A)	V_N (B)	V_N (C)	V_T (A)	V_T (B)	V_T (C)	V_P (A)	V_P (B)	V_P (C)
*Dominion Plaza - 30th Fl - Bank 1 - CAPI 2759 - 909P	Open	Open	0	0	0	279	279	279	282	281	281	3.1	2.4	2.4
*Dominion Plaza - 30th Fl - Bank 1 - CAPI 2760 - 768P	Tripped	Open	0	0	0	279	280	278	14	12	13	282.6	282.4	280.3
*Dominion Plaza - 30th Fl - Bank 1 - CAPI 2761 - 769P	Closed	Closed	158	154	192	278	280	278	278	280	279	0.1	0.1	0.0
Dominion Plaza - 30th Fl - Bank 2 - CAPI 2759 - 708P	Open	Open	0	0	0	290	289	289	292	291	291	2.8	2.5	1.7
Dominion Plaza - 30th Fl - Bank 2 - CAPI 2760 - 774P	Tripped	Open	0	0	0	288	290	288	17	16	15	292.3	291.1	290.4
Dominion Plaza - 30th Fl - Bank 2 - CAPI 2761 - 957P	Closed	Closed	98	99	79	289	291	289	289	291	289	0.1	0.2	0.1

Feeders 11 and 12 are open. Feeder 11 is ROBO'd

Step by Step Reroute Process



Name	Status	Breaker Pos	I_A	I_B	I_C	V_N (A)	V_N (B)	V_N (C)	V_T (A)	V_T (B)	V_T (C)	V_P (A)	V_P (B)	V_P (C)
*Dominion Plaza - 30th Fl - Bank 1 - CAPI 2759 - 909P	Open	Open	0	0	0	280	280	279	283	282	281	3.8	2.5	3.0
*Dominion Plaza - 30th Fl - Bank 1 - CAPI 2760 - 768P	Open	Open	0	0	0	280	281	279	15	14	14	283.3	283.0	281.2
*Dominion Plaza - 30th Fl - Bank 1 - CAPI 2761 - 769P	Closed	Closed	171	154	201	279	281	279	279	281	279	0.1	0.1	0.0
Dominion Plaza - 30th Fl - Bank 2 - CAPI 2759 - 708P	Open	Open	0	0	0	290	291	290	292	294	291	2.9	1.8	2.3
Dominion Plaza - 30th Fl - Bank 2 - CAPI 2760 - 774P	Open	Open	0	0	0	289	290	290	16	16	16	293.3	292.1	291.1
Dominion Plaza - 30th Fl - Bank 2 - CAPI 2761 - 957P	Closed	Closed	79	90	71	290	291	291	290	291	291	0.1	0.1	0.1

Feeders 11 and 12 are open and are ROBO'd

Step by Step Reroute Process

Once the junction straps have been reconfigured in manhole 71, feeder 12 is re-energized. Feeder 45 is isolated between the substation and manhole 70. Feeder 45 is now feeder 12. Again, there are opposite feeders in the buildings. The protectors that were energized that are on opposite feeders are in Remote Open Blocked Open status to prevent tying the networks together.

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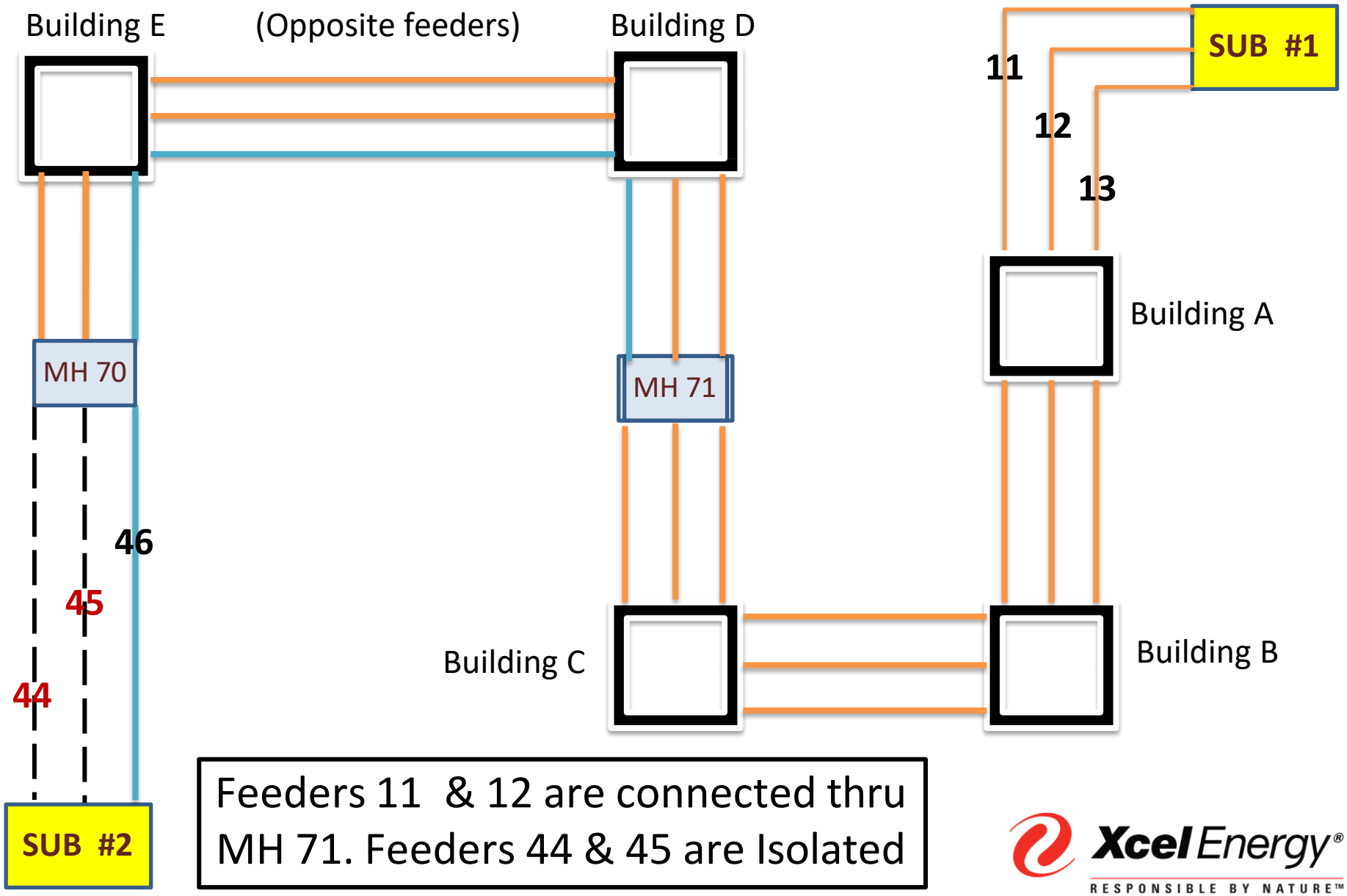
Step by Step Reroute Process



Feeders 11 & 12 are connected thru MH 71. Feeders 44 & 45 are Isolated

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Step by Step Reroute Process

Now we have 2 feeders on the new source and the protectors are in ROBO. At this point we will start to look at our positive sequence phasing voltage and the positive sequence phasing angle. They might be very close of wildly out of sync depending on the source.

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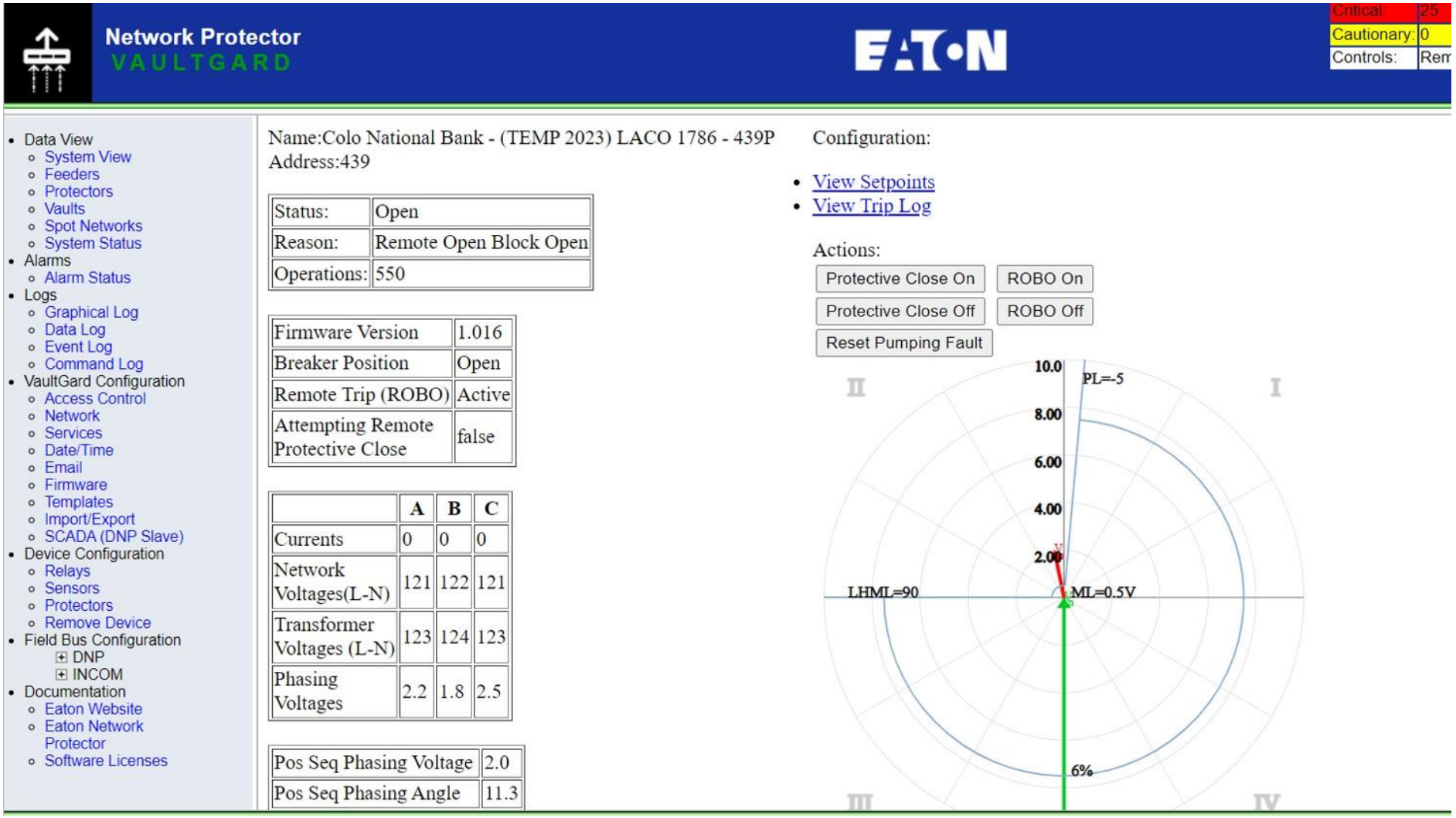
Step by Step Reroute Process



Positive sequence phasing voltage 2.0 volts

Positive sequence phasing angle 11.3 degrees.

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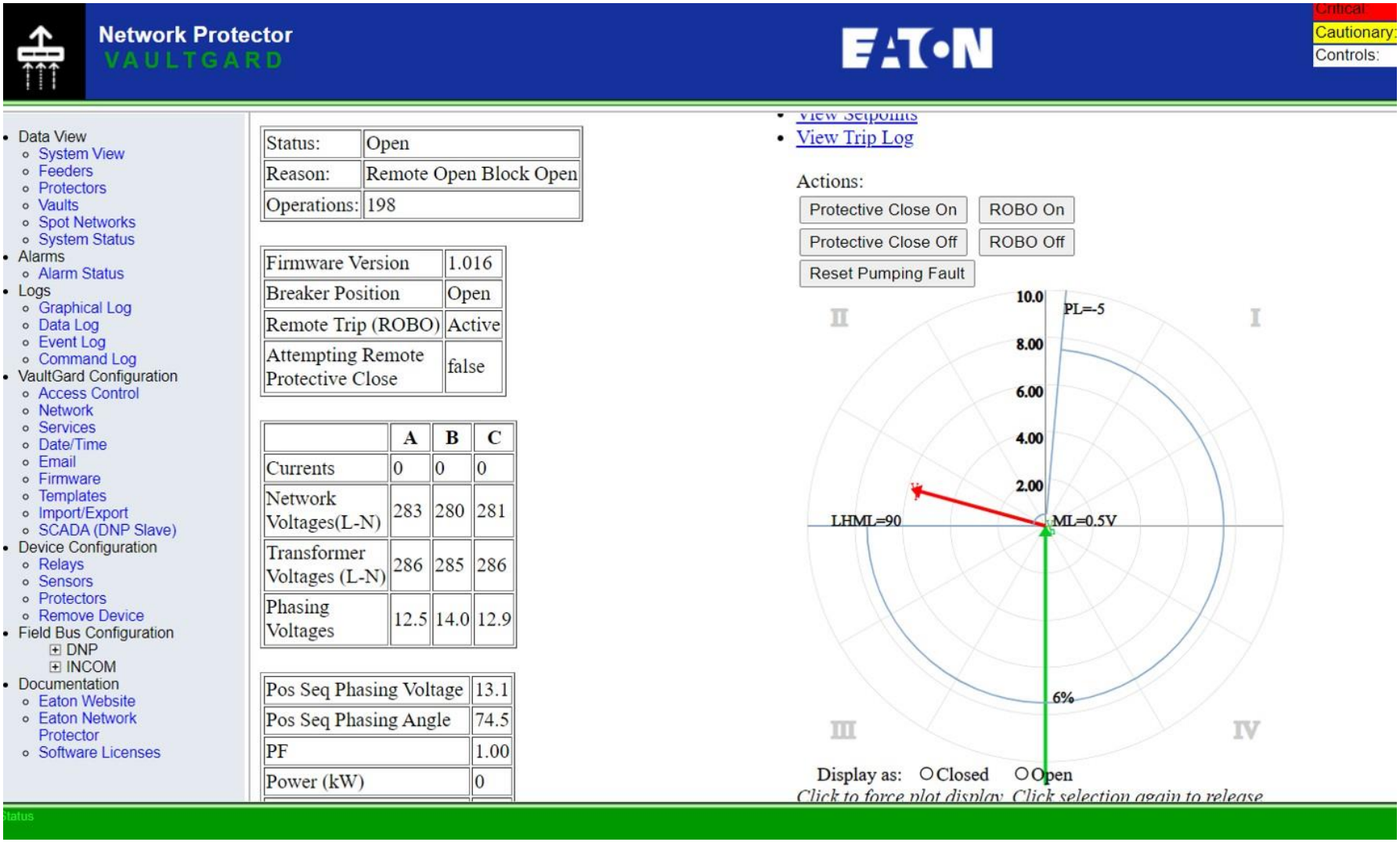
Step by Step Reroute Process



Positive sequence phasing voltage 13.1 volts

Positive sequence phasing angle 74.5 degrees.

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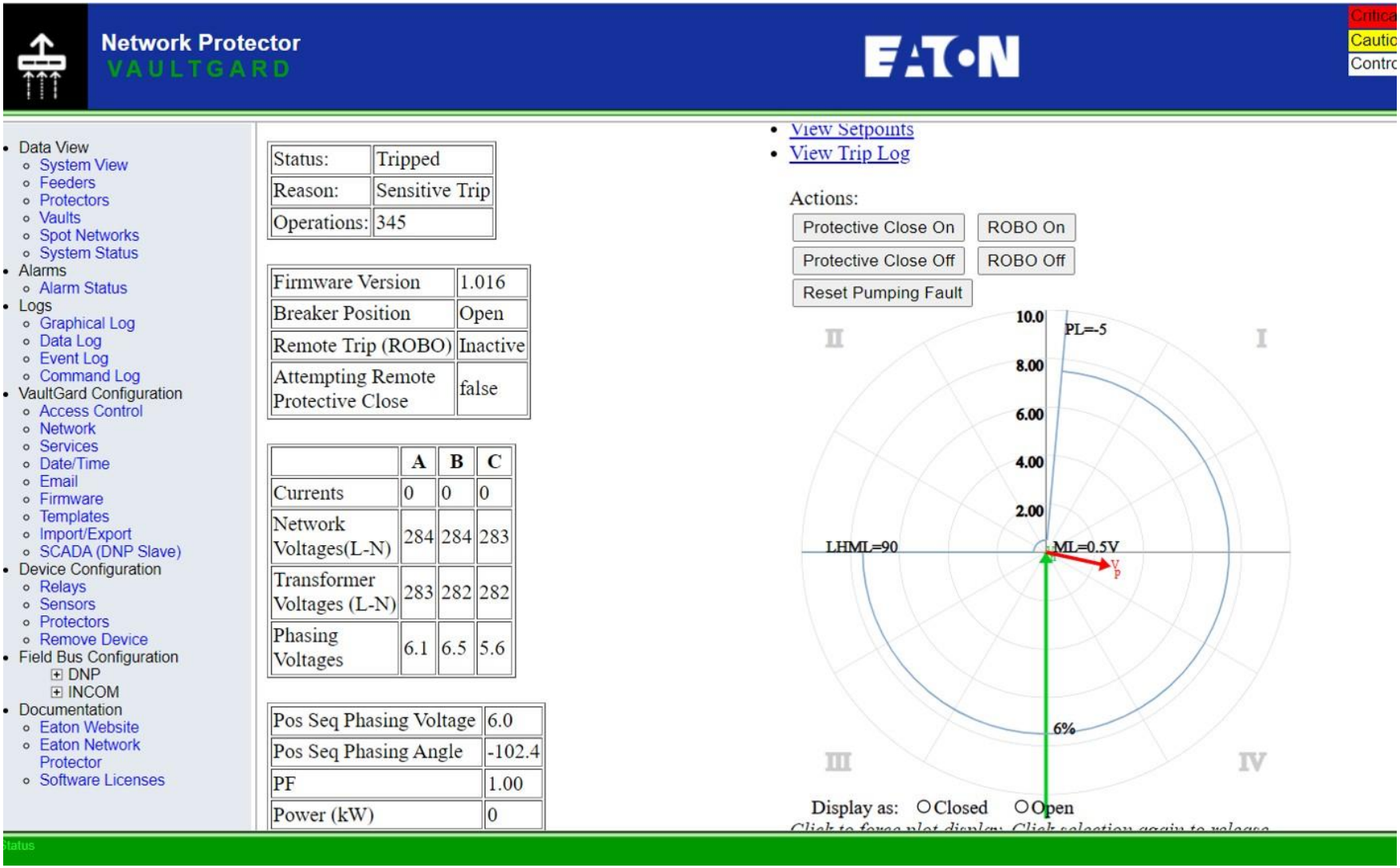
Step by Step Reroute Process



Positive sequence phasing voltage 6.0 volts

Positive sequence phasing angle -102.4 degrees.

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Step by Step Reroute Process

After looking at the phasing voltage and angles, We will change the settings on all relays that are on feeder 44. These changes are made so the protector will not close when the ROBO is removed. The protector will close on a dead buss. Protectors that were on feeder 45 will remain in ROBO until the final feeders are open.

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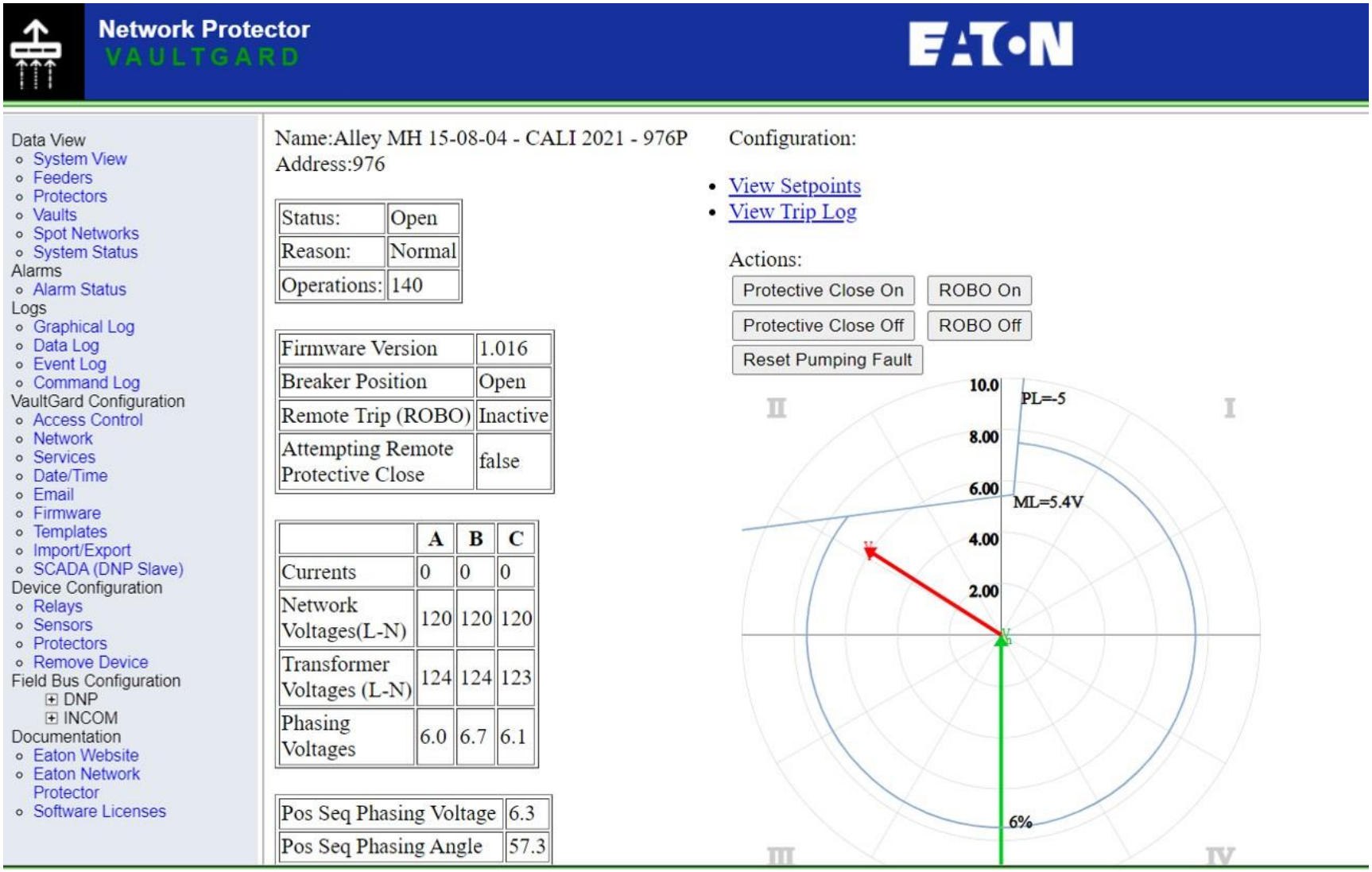
Step by Step Reroute Process



The protector is open, the handle in the automatic position and the relay settings have been changed. This protector will close on a dead buss.

Step by Step Reroute Process

On the original feeder cut procedure, at 2am the crews would go to the buildings for a 3rd time. The crews would manually open the protector on feeder 46 and then manually close the protectors on feeder 11 and 12, completing the momentary planned outage on the building. When using vaultgard, all of the protectors on feeder 11 will automatically close when feeder 46 is opened at the substation. Once the protectors on feeder 11 close, the ROBO on the protectors on feeder 12 is removed.

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Step by Step Reroute Process

After confirming the protectors on feeder 12 have closed the protectors on feeder 11 with the temporary settings are then ROBO'd and the original settings are re-applied. The ROBO is then removed. When feeder 13 is energized, the protectors will close completing the feeder reroute. On the old procedure, the crew would go to the building for a 4th time to put the protectors back to the automatic position.

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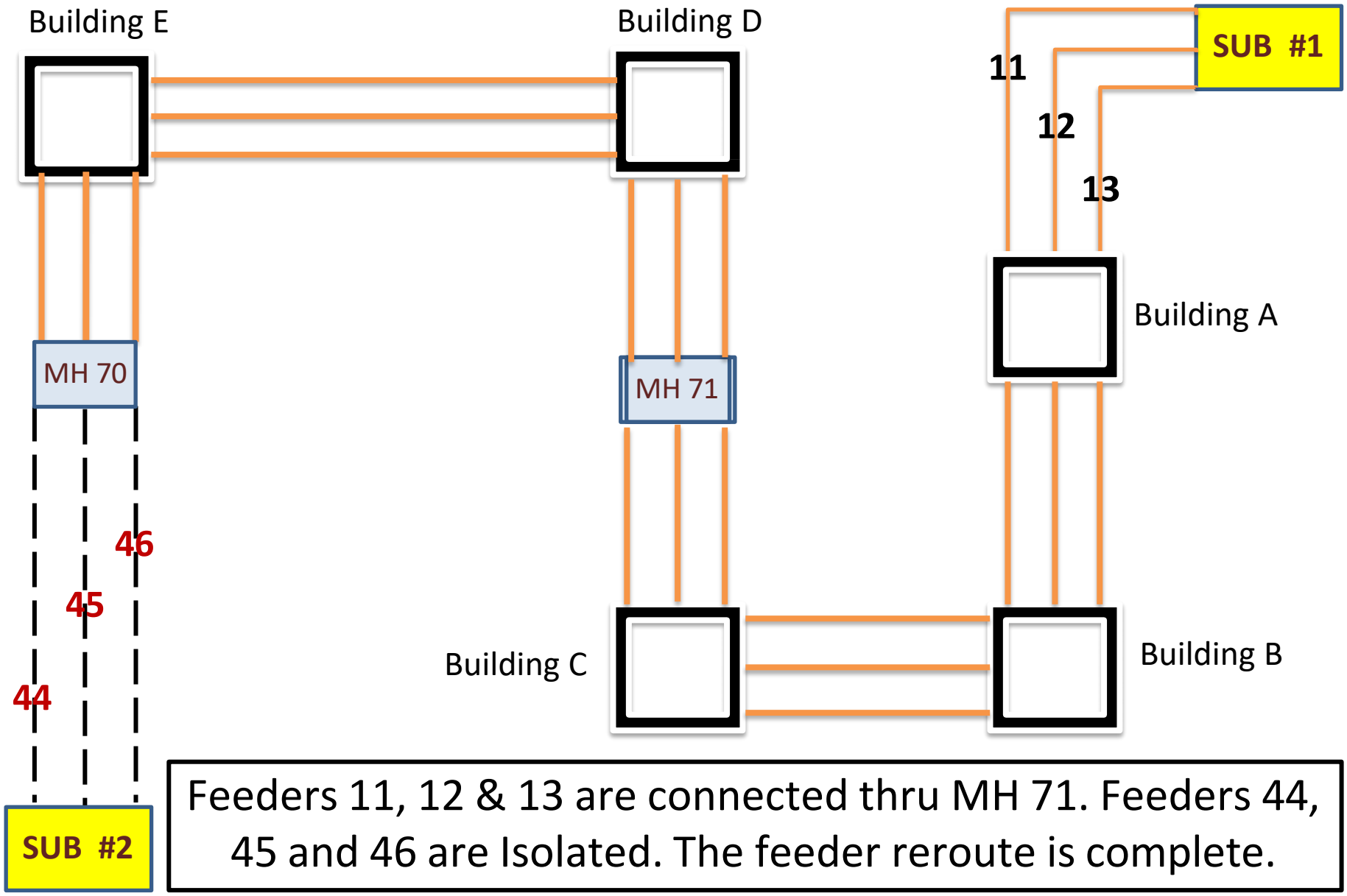
Step by Step Reroute Process



Feeders 11, 12 & 13 are connected thru MH 71. Feeders 44, 45 and 46 are Isolated. The feeder reroute is complete.

Conclusion

As you can see, using vaultgard for a feeder reroute is a labor-saving device. Instead of sending crews to an affected building 4 different times, a 2-man crew can manipulate the relays, monitor the system loads in real time, allow switching outside of the vault and cut over multiple buildings within seconds. This procedure saves time, money and improves safety by minimizing employee exposure and risk.

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QUESTION?

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Fault Locating using Eaton Vaultgard

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Fault Locating Using Vaultgard

Xcel Energy has developed a procedure to use Vaultgard when a circuit lockout occurs.

- Step #1 – Check Vaultgard emails.
- Step #2 – Plot the emails on the feeder map in the order they came in.
- Step #3 – Download Event Logs from all Vaultgards associated with the locked out circuit.
- Step #4 – Evaluate all event logs. Separate all events into categories.
- Step #5 – Dispatch crew to projected area & start fault finding.

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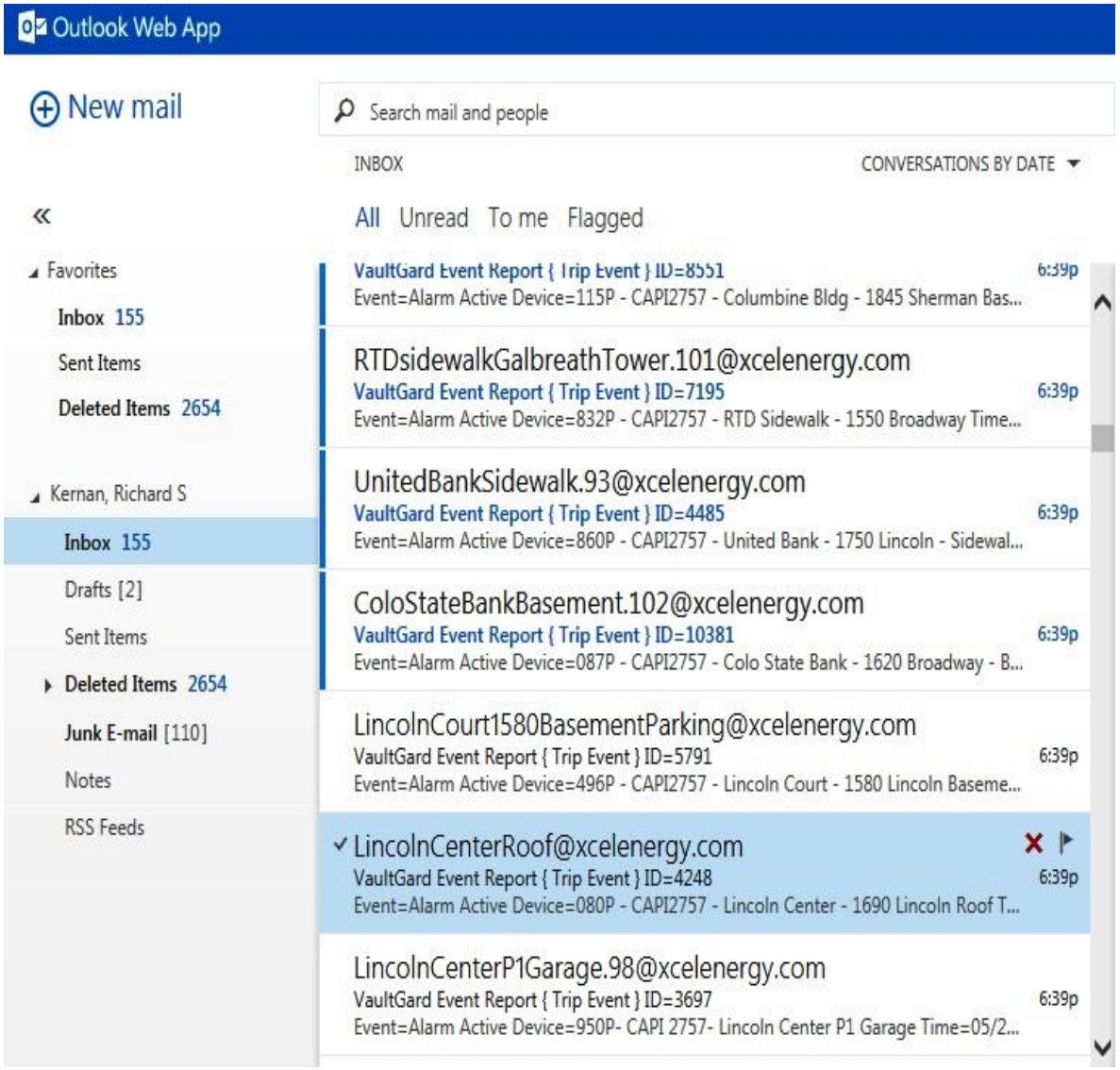
Step #1 – Check Emails



These are emails from a circuit lockout #1. The order they come in is the key to finding the area where the fault is located.

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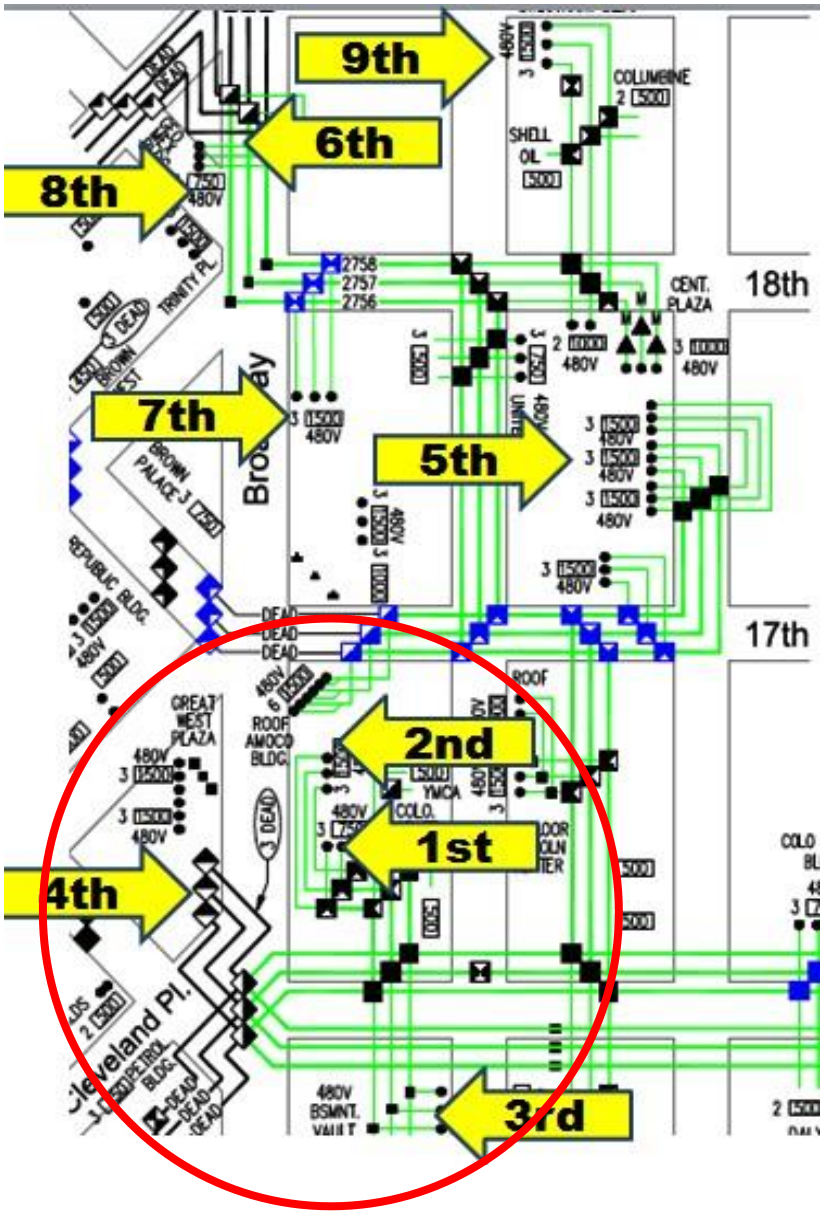
Step #2 – Plot Emails on Map



Plot the Vaultgard emails on feeder map in the order they report. The first 4 emails will determine where employees will start the fault finding process.

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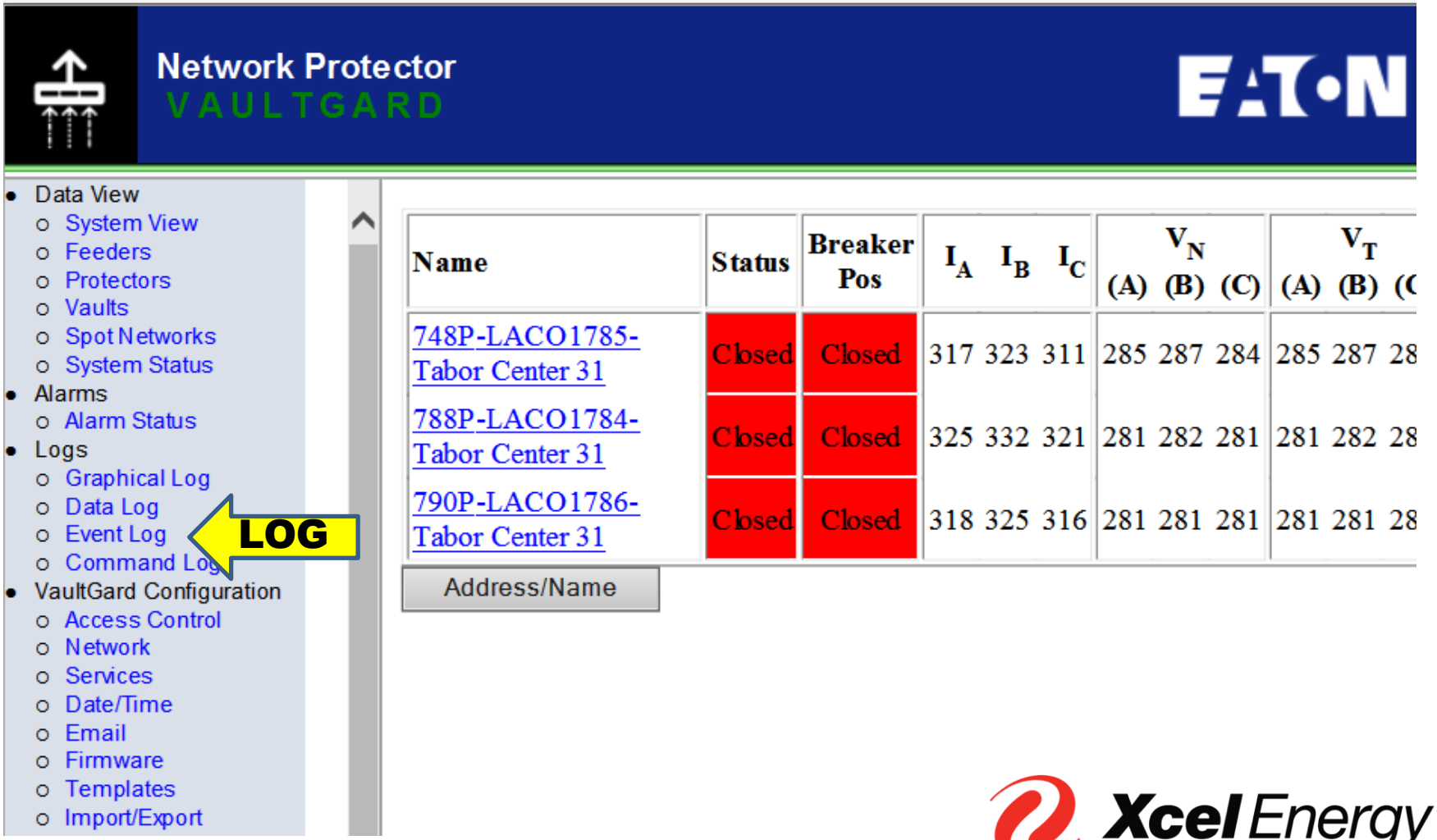
Step #3 – Open Event Log

Click on the Vaultgard Event Log button.



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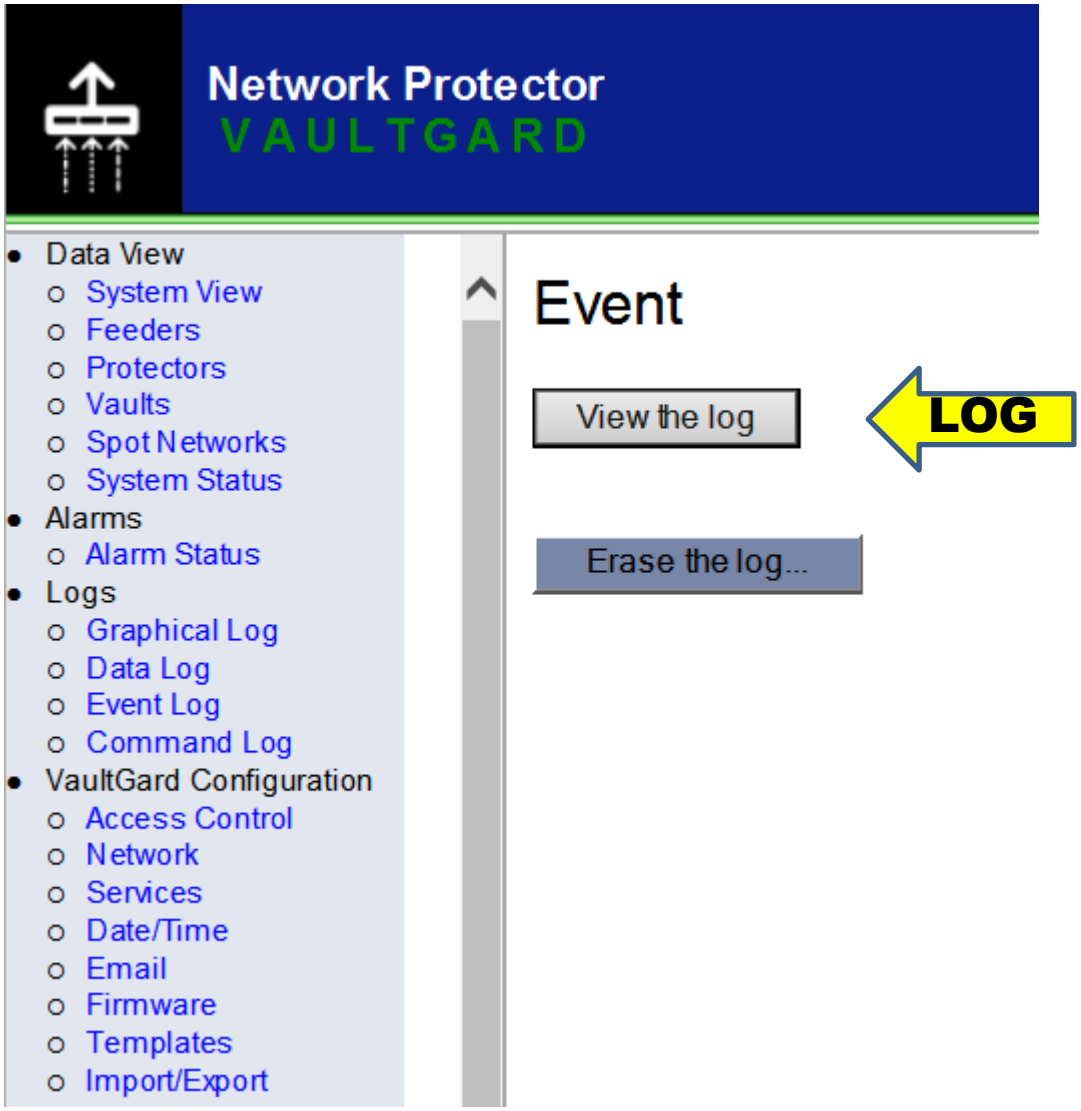
Step #3 – Download Event Log



Click on the Vaultgard "View the log" button. Download the event log of every Vaultgard associated with the locked out circuit into an Excel spread sheet.

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Step #4 – Evaluate Event Log

This spread sheet is the combined event logs of all the Vaultgards associated with the faulted circuit. It has been sorted by time to capture the fault event. It is very important to notice the comments in the "Parameter Display Name" column. The fact there is only "Trip Event" in this column indicates a cable fault is the likely cause of the lockout.

	A	B	C	D	E
1	Date	Time	Time(seconds)	Device Display Name	Parameter Display Name
2					
3	5/25/2017	18:39	23.894298	496P - CAPI2757 - Lincoln Court - 1580 Lincoln Basement Parking	Trip Event
4	5/25/2017	18:39	23.927144	080P - CAPI2757 - Lincoln Center - 1690 Lincoln Roof	Trip Event
5	5/25/2017	18:39	24.114642	227P - CAPI2757 - Soho Bldg - 1800 Glenarm - Sidewalk	Trip Event
6	5/25/2017	18:39	24.36413	950P- CAPI 2757- Lincoln Center P1 Garage	Trip Event
7	5/25/2017	18:39	24.413596	832P - CAPI2757 - RTD Sidewalk - 1550 Broadway	Trip Event
8	5/25/2017	18:39	24.491027	860P - CAPI2757 - United Bank - 1750 Lincoln - Sidewalk E Side	Trip Event
9	5/25/2017	18:39	24.82233	087P - CAPI2757 - Colo State Bank - 1620 Broadway - Basement	Trip Event
10	5/25/2017	18:39	25.212713	081P - CAPI2758 - Lincoln Center - 1690 Lincoln Roof	Trip Event
11	5/25/2017	18:39	25.255871	503P - CAPI2757 - United Bank - 1700 Lincoln - Bsmnt - 1st Bank	Trip Event
12	5/25/2017	18:39	25.287772	115P - CAPI2757 - Columbine Bldg - 1845 Sherman Basement	Trip Event
13	5/25/2017	18:39	25.347354	481P - ELAT2757 - Amoco Bldg - 1690 Broadway - 36th Fl E Bank	Trip Event
14	5/25/2017	18:39	25.919534	071P - CAPI2757 - Daly Bldg - 1576 Sherman Alley	Trip Event
15	5/25/2017	18:39	26.49674	124P - CAPI2757 - United Bank - 1751 Lincoln - 120 V - W Side	Trip Event
16	5/25/2017	18:39	26.835828	811P - CAPI2757 - Mellon Financial - 18th & Sherman - 8th Fl	Trip Event
17	5/25/2017	18:39	26.882441	085P - CAPI2757 - YMCA - 1625 Lincoln MH E 16-0-4	Trip Event
18	5/25/2017	18:39	27.180366	825P - CAPI2757 - Galbreath Tower - 1560 Broadway	Trip Event

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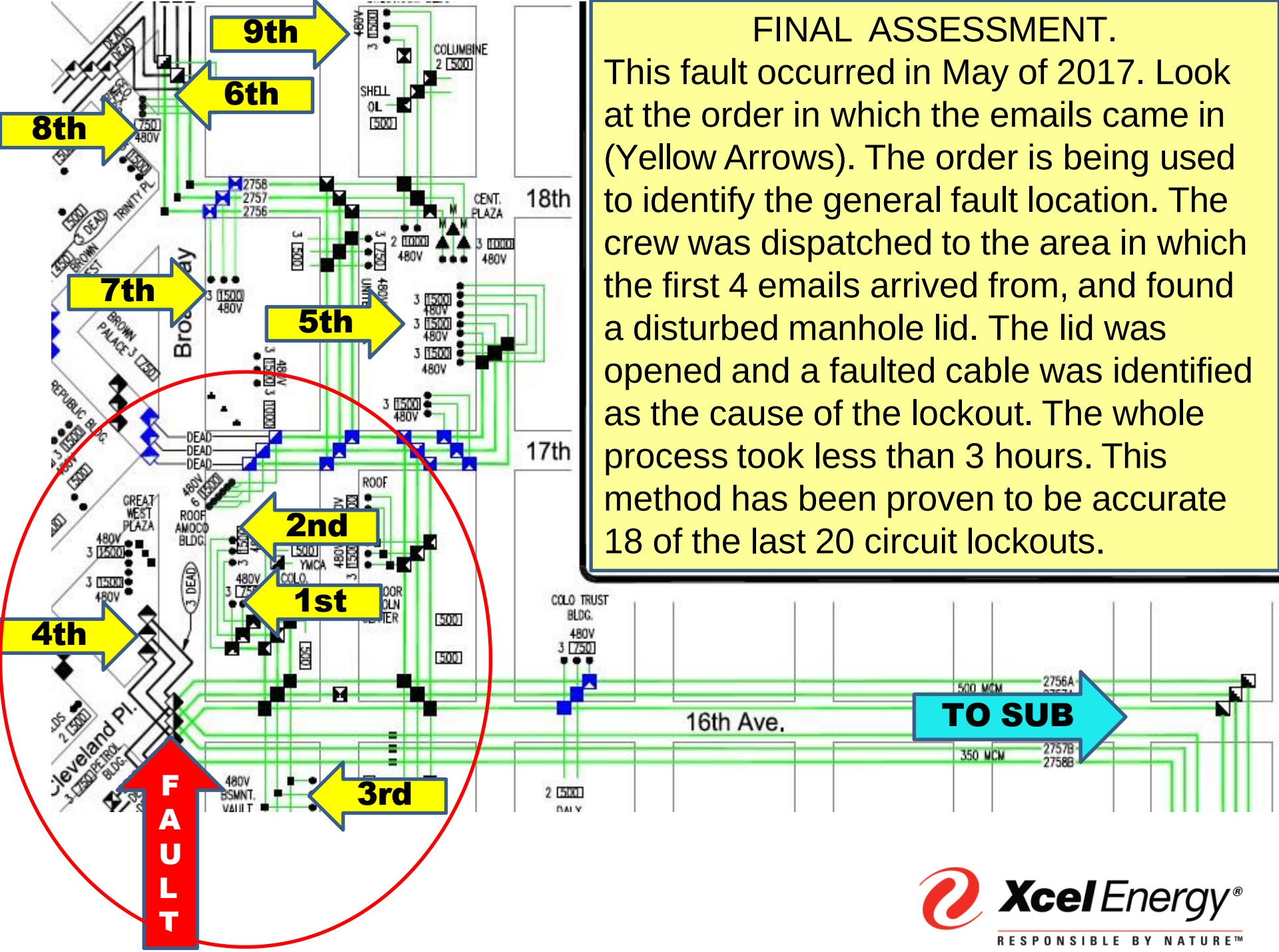

FINAL ASSESSMENT.

This fault occurred in May of 2017. Look at the order in which the emails came in (Yellow Arrows). The order is being used to identify the general fault location. The crew was dispatched to the area in which the first 4 emails arrived from, and found a disturbed manhole lid. The lid was opened and a faulted cable was identified as the cause of the lockout. The whole process took less than 3 hours. This method has been proven to be accurate 18 of the last 20 circuit lockouts.

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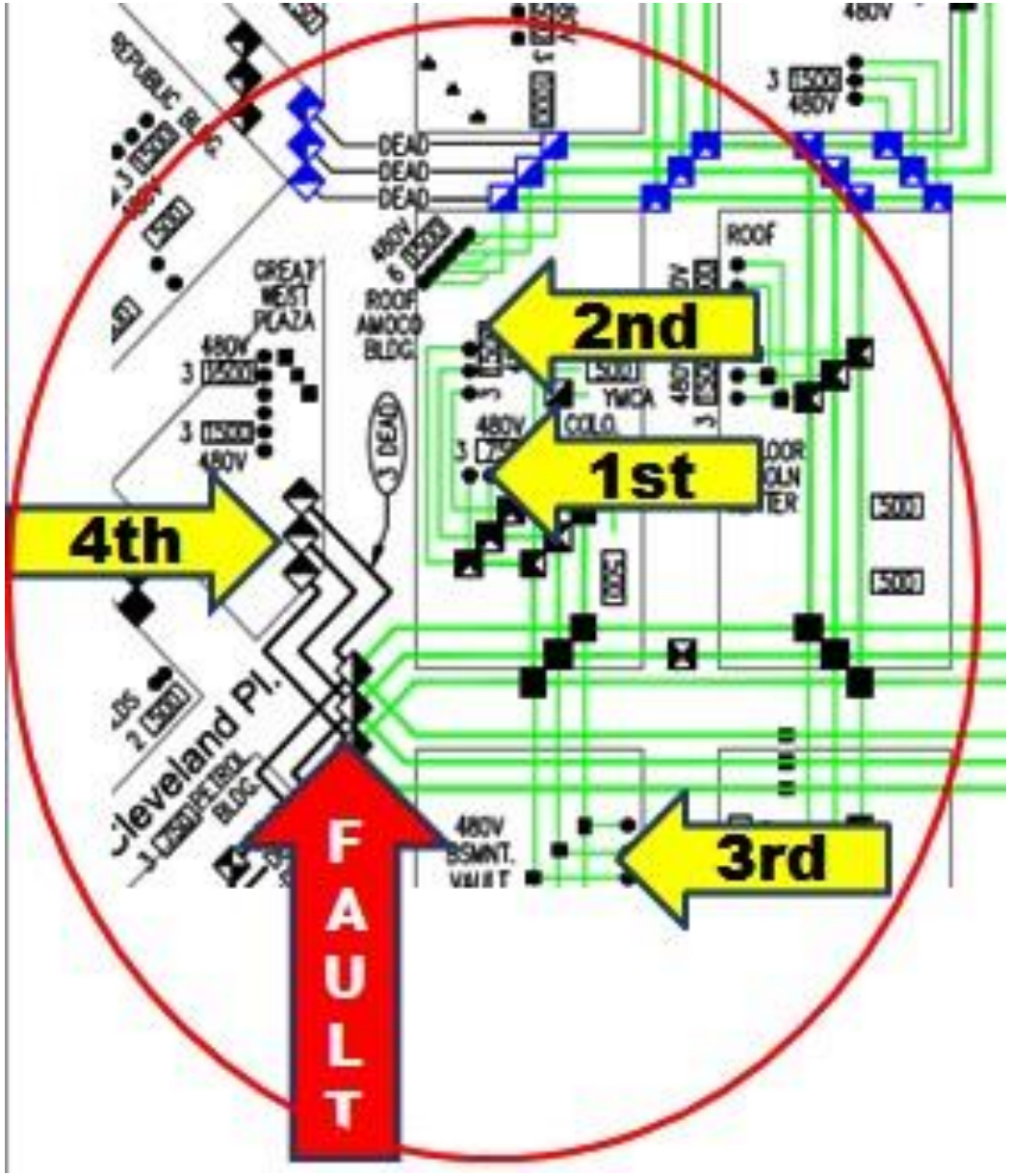
Map – Fault #1



This is a larger view of the previous slide.

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QUESTION?

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