

FINAL REPORT OF INVESTIGATION A&I E18345

August 14, 2018

Arcing event

W-0020

Adopted by the Washington Metrorail Safety Commission at its meeting on February 13, 2020.

Washington Metrorail Safety Commission
777 North Capitol Street, NE, Suite 402
Washington, DC 20002



FINAL REPORT OF INVESTIGATION A&I E18345**SMS 20180814#73485**

Date of Event:	August 14, 2018
Type of Event:	Fire/Smoke
Incident Time:	01:45 hrs.
Location:	Alexandria Yard - Traction Power Sub-station (C99-TPSS)
Time and How received by SAFE:	01:45 hrs. via Safety Hotline
Safety Officer Response:	Yes
Time of Safety Officer Arrival:	05:56 hrs.
Time of Safety Officer Departure:	07:30 hrs.
Rail Vehicle:	N/A
Injuries:	None
Damage:	Yes – DC Circuit Breakers, Rectifiers
Emergency Responders:	SAFE, Alexandria Fire Department (AFD), POWER, ATC, RTRA, MTPD

Executive Summary

On Tuesday, August 14, 2018, at approximately 01:45 hrs., Rail Operations Control Center (ROCC) received a report of an active fire alarm and smoke coming from the Alexandria Rail Yard (C99) Traction Power Sub-station (TPSS). Alexandria Fire Dept (AFD) arrived on site and requested that both Dominion Power feeders to the C99 substation be de-energized prior to entry.

Upon entry into the TPSS, it was revealed that some electrical equipment had been burning/smoking. Power Maintenance Department (POWER) personnel and AFD assessed the situation after de-energizing the Dominion Power feeders. Subsequently, power was also removed from Franconia-Springfield Station (J03), which resulted in a service disruption.

Per POWER personnel, at C99 TPSS, the fire completely burned two Breaker Cubicles and caused damage to three additional Breaker Cubicles on the same section of the positive bus-bar. The two completely damaged Breaker Cubicles, (C99-22 and C99-50), were the "Cathode Breaker 22" and the "Positive to Positive Bus Tie Breaker 50" and their corresponding breakers, see Picture 2. Forensic inspection revealed that failed breakers

at C99 TPSS and the C99 TPSS incident breaker were overloaded and tripped under heavy load which initiated the burning of the arc chute.

Considering all the salient facts, SAFE has concluded and concurs with the POWER Report which revealed that the possible cause of the fire was the intense heat created inside the arc chutes of the Bus Tie Breaker 50, when it was partially opened, before tripping for an unknown reason.

Notification

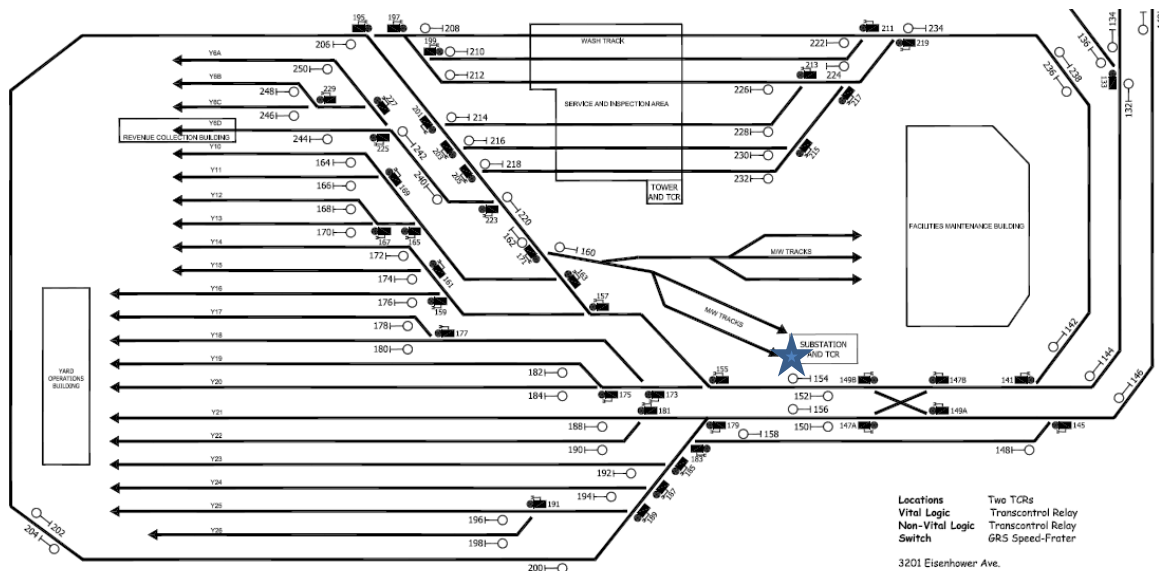
Title	Time	Comment:
FTA	01:45 hrs.	FWSO Email
TOC	01:45 hrs.	FWSO Email
Other	03:33 hrs.	CMC

Incident Site

The incident area was located at C99 – TPSS 3107

Field Sketch/Schematics





Investigation

Maintenance of Way Engineering (MOWE) Power Report

On Tuesday, August 14, 2018, at approximately 01:45 hrs., a fire event occurred at Alexandria Yard Traction Power Substation (C99 TPSS), on one section of the DC Feeder Breakers Line-up. All America Monitoring (a third-party alarm company), received a smoke detector alarm for C99-TPSS. Upon investigation of the alarm, the AFD found smoke emitting from the building and notified the Maintenance Operations Control (MOC) desk. Shortly after, POWER personnel arrived on the scene and requested that the Power Feeder from Dominion Power be de-energized to eliminate all power from coming into the building so AFD personnel could safely enter and extinguish the fire. Per MOWE POWER personnel, at C99 TPSS, the fire completely burned two Breaker Cubicles and caused damage to three additional Breaker Cubicles on the same section of the positive bus-bar. The two completely damaged Breaker Cubicles, (C99-22 and C99-50), are the "Cathode Breaker 22" and the "Positive to Positive Bus Tie Breaker 50" and their corresponding breakers, see Picture-2.

As a result, the Blue Line service was suspended, and the Yellow Line was operating with a 15 to a 20-minute delay, until around 7:00 AM.

NOTE: It appears that the fire started inside the Bus Tie Breaker 50 cubicle and spread to the adjacent cubicles and breakers which are also connected to the second section of the positive bus-bar as shown in Figure-1. Thus, the DC Cathode Breaker 22 cubicle is more damaged than the adjacent DC Feeder Breaker 36 and its cubicle. The severity is less on DC Feeder Breaker 34 and its cubicle than DC Feeder Breaker 37 and its cubicle. In general, all the DC breaker cubicles connected to the second section of the positive bus-bar and four breakers were damaged beyond repair (Picture 1-8). The fire also damaged control cables on the cable tray right above the burned switchgear, and there is also a visible smoke on the 4" conduit that runs from the Transformer Feeder Breaker 12 AC switchgear to Transformer 2 (Picture 9 and 10).



Figure-1, C99 TPSS DC Switchgear Lineup

Other than the above-mentioned equipment and cable raceways, visual surveys indicate that there is no visible damage that occurred on the Rectifiers, the Positive bus-bar and on the Track Feeder Cables.

Findings

- The arc chute is comprised of vertical steel plates arranged around and over the arc runners in such a way that the arc is drawn into the stack of steel plates and split into a number of small arcs that are cooled and extinguished as they move rapidly towards the top of the plates. The breaker is also equipped with an air puffer, mounted between the top and bottom main contacts and operated by the breaker mechanism.
- Thus, the arc chute stretches, cools and contains the arc created when the breaker contacts are partially opened. In doing so, the arc creates an ionized air, which is conductive, and burns in an ionized metal vapor which continually leaves the contact area and condenses on the surrounding metal shields. It is not possible to service the arc chutes or to replace parts, apart from cleaning as recommended by the manufacturer and on the PMI.
- It appeared that the DC Bus Tie Breaker, breaker 50 arc chute was completely burned by the fire due to excessive arcing during the arc interruption in the arc chute, (Picture 3 and 4). The fire may have been ignited by flammable dust and ionized metal particles in the presence of ionized air, inside a 40-year-old arc chute.
- Before Breaker 50 arc chute was completely burned, the fire and the extreme heat it created was puffed out of its chimney vent and spread to the adjacent cathode breaker 22. The heat and flames also damaged the above cable tray containing

control wires (Picture 6). It also appears that the fire inside the wiring compartment of these cubicles, which enclosed breaker 50 and 22, was ignited and totally burned by the intense heat on the back of the metal enclosed control wiring compartment, which first started by melting the control wire insulation and then caught fire.

Weather

At the time of the incident, the temperature was 74°F, and clear. SAFE has concluded that weather was not a contributing factor in this incident (Weather source: National Oceanic Atmospheric Administration (NOAA) - Location: Washington, DC.)

Immediate Mitigation

1. Removed all power to the building
2. Removed DC Breakers from cubicles.

Conclusion

SAFE concurs with the POWER Report which revealed that the possible cause of the fire was the intense heat created inside the arc chutes of the Bus Tie Breaker 50 before tripping for an unknown reason.

The Bus Tie Breaker arc chute of this breaker was completely burned by the fire created due to excessive arcing during arc interruption in the arc chute. The fire may have been ignited by flammable dust and ionized metal particles in the presence of ionized air, inside the arc chute. Circuit breakers and its arc chutes gather dirt, moisture and ionized metals described previously. This compromises the insulation, dielectric strength and the thermal performances of vital components of the breaker. The primary insulation of these components tends to degrade with time allowing moisture to penetrate it and the heat created during arc interruption can weaken the insulation. It appeared that all or part of these factors could have existed inside Breaker 50 switchgear assembly when the fire incident happened on August 14, 2018.

Considering all the facts gathered from this investigation, SAFE has no further concerns regarding this incident and recommends E18345 for closure.

Proposed Corrective Action

1. POWER shall take the appropriate action deemed necessary to support the prevention of repeated fire incident:
 - a. **POWER is in the process of reviewing a contract for the replacement and upgrade of the entire C99 Yard power systems. See Attachment 1**
 - b. **POWER repaired the damaged Traction Power (TP) equipment at Alexandria Rail Yard (C99) – Traction Power Substation 3107. Completed 8/24/2018. See Attachment 2**

Attachments

C99 Yard TPSS – Incident Progress Report

Last Update: 3/19/2019

Prepared by:

[REDACTED]

1. Design of C99 TPSS equipment and system are in review, equipment will be furnished by the blue line contract for installation by other. A contract for a full replacement and upgrade of the entire C99 Yard power systems will be prepared by HNTB, the traction power engineering consultant. Installation work is expected to start in FY20.

Attachment 1 – Incident Progress Report



Washington Metropolitan Area Transit Authority
Maintenance and Material Management System
Work Order Details

Page 1 of 3
MX76PROD

Work Order #: 14463137
Type: CM



Status: CLOSE
08/24/2018 13:09

Work Description: C99 TP POWER EQUIPMENT CAUGHT ON FIRE
Job Plan Description:

Work Information			
Asset: 457321	POWR, TRACTION POWER SUBSTATION	Owning Office: TRPM	Parent:
Asset Tag: C99YP02		Maintenance Office: POWR-TSSM-KHVT	Create Date: 08/14/2018 03:36
Asset S/N:		Labor Group: [REDACTED]	Actual Start: 08/24/2018 12:34
Location: 8620	C99, ALEXANDRIA YARD, WAYSIDE	Crew:	Actual Comp: 08/24/2018 13:09
Work Location:		Lead: [REDACTED]	Item: POWRTPSS
Failure Class: POWR029	DC BREAKER	GL Account: WMATA [REDACTED]	
Problem Code: 1262	BURNT	Supervisor:	Target Start:
Requested By: [REDACTED]		Requestor Phone: [REDACTED]	Target Comp:
Chain Mark Start:		Chain Mark End:	Scheduled Start:
Create-Mileage: 0.0		Complete-Mileage: 0.0	

Task IDs

Task ID

[REDACTED]

Component: Work Accomplish: Reason: Status: CLOSE Position: Warranty?: N

Planned Materials

Task ID	Item	Description	Storeroom	Issue Unit	Quantity	Unit Cost	Line Cost
	R59830103	FAN: ELECTRICALRATING: 120VAC/60HZ, TYPE: FLOOR	300	EA	4		
	067000258	COMPOUND, CONCRETE_SWEEPING:	300	BX	3		
	067000209	DUST-MIST, DISPOSABLE:	300	EA	24		
Total Planned							

Actual Labor

Task ID	Labor	Start Date	End Date	Start Time	End Time	Approved?	Regular Hours	Premium Hours	Line Cost
	[REDACTED]	08/14/2018	08/14/2018	06:00	16:00	Y	10:00	00:00	
	[REDACTED]	08/15/2018	08/15/2018	06:00	16:00	Y	10:00	00:00	
	[REDACTED]	08/24/2018	08/24/2018	06:00	14:00	Y	08:00	00:00	
	[REDACTED]	08/24/2018	08/24/2018	06:00	14:00	Y	08:00	00:00	
	[REDACTED]	08/22/2018	08/22/2018	06:00	14:00	Y	08:00	00:00	
	[REDACTED]	08/18/2018	08/18/2018	06:00	14:00	Y	08:00	00:00	
	[REDACTED]	08/21/2018	08/21/2018	06:00	14:00	Y	08:00	00:00	
	[REDACTED]	08/14/2018	08/14/2018	06:00	14:00	Y	08:00	00:00	

Attachment 2 page 1 of 3



Washington Metropolitan Area Transit Authority
Maintenance and Material Management System
Work Order Details

Page 2 of 3
MX76PROD

Work Order #: 14463137
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Status: CLOSE
08/24/2018 13:09

Work Description: C99 TP POWER EQUIPMENT CAUGHT ON FIRE
Job Plan Description:

Actual Labor									
Task ID	Labor	Start Date	End Date	Start Time	End Time	Approved?	Regular Hours	Premium Hours	Line Cost
		08/14/2018	08/14/2018	06:00	14:00	Y	08:00	00:00	
		08/15/2018	08/15/2018	06:00	14:00	Y	08:00	00:00	
		08/18/2018	08/18/2018	06:00	14:00	Y	08:00	00:00	
		08/14/2018	08/14/2018	06:00	14:00	Y	08:00	00:00	
		08/14/2018	08/14/2018	06:00	14:00	Y	08:00	00:00	
		08/15/2018	08/15/2018	06:00	14:00	Y	08:00	00:00	
		08/16/2018	08/16/2018	06:00	14:00	Y	08:00	00:00	
		08/25/2018	08/25/2018	06:00	14:00	Y	08:00	00:00	
		08/21/2018	08/21/2018	06:00	14:00	Y	08:00	00:00	
		08/22/2018	08/22/2018	06:00	14:00	Y	08:00	00:00	
		08/24/2018	08/24/2018	06:00	14:00	Y	08:00	00:00	
		08/14/2018	08/15/2018	23:00	05:00	Y	00:00	06:00	
		08/20/2018	08/20/2018	06:00	14:00	Y	08:00	00:00	
		08/20/2018	08/20/2018	06:00	14:00	Y	08:00	00:00	
		08/14/2018	08/14/2018	15:00	23:00	Y	08:00	00:00	
		08/15/2018	08/16/2018	23:00	05:00	Y	00:00	06:00	
		08/14/2018	08/15/2018	23:00	05:00	Y	00:00	06:00	
		08/14/2018	08/14/2018	16:00	22:00	Y	06:00	00:00	
		08/15/2018	08/16/2018	23:00	05:00	Y	00:00	06:00	
		08/14/2018	08/14/2018	07:00	10:00	Y	03:00	00:00	
		08/14/2018	08/14/2018	07:00	10:00	Y	03:00	00:00	
Total Actual Hour/Labor:							200:00	24:00	
Actual Materials									
Task ID	Item	Assetnum	Description	Storeroom	Trans Date	Issue Unit	Quantity	Unit Cost	Line Cost
	R59830103		FAN: ELECTRICAL RATING: 120VAC/60HZ, TYPE: FLOOR	300	08/14/2018	EA	2		
	067000209		DUST-MIST, DISPOSABLE:	300	08/14/2018	EA	40		
	067000258		COMPOUND, CONCRETE, SWEEPING:	300	08/14/2018	BX	3		
	R54400004		LADDER, STEP: 8 FT, WOOD	300	08/14/2018	EA	2		
Total Actual									

Attachment 2 page 2 of 3



Washington Metropolitan Area Transit Authority
Maintenance and Material Management System
Work Order Details

Page 3 of 3
MX76PROD

Work Order #: 14463137
Type: CM



Status: CLOSE
08/24/2018 13:09

Work Description: C99 TP POWER EQUIPMENT CAUGHT ON FIRE
Job Plan Description:

Related Incidents				
Ticket	Description	Class	Status	Relationship
8348100	Late dispatch. See Max # 8347958	SR	RESOLVED	RELATED
8348095	Late dispatch. See MAX # 8347958	SR	RESOLVED	RELATED
8347958	REPORT OF SMOKE IN C99 TRACTION POWER SUB-STATION.	SR	INPROG	RELATED
Failure Reporting				
Cause	Remedy		Supervisor	Remark Date
2334	MAJOR EQUIPMENT PROBLEM	3444 NONE		
Remarks:				

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Date: 8/14/2018 Time: 01:45 hrs.
Final Report – Fire/Smoke Event
E18345

Drafted By: SAFE 705 – 06/04/2019
Reviewed By: SAFE 701 – 07/08/2019
Approved By: SAFE 70 – 08/29/2019

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"C99 TPS FIRE INCIDENT"
"AUGUST 14, 2018"
"ALEXANDRIA YARD SUBSTATION"

**MAINTENANCE OF WAY ENGINEERING (MOWE)
POWER**

Revision: 0

Submitted By: _____
Sr. Traction Power Engineer

Reviewed By: _____
Chief Engineer – MOWE-Power

Attachment 3 – Fire Incident Report provided by MOWE page 1 of 7

INTRODUCTION

On Tuesday morning, August 14, 2018 around 1:50AM, a fire incident occurred at Alexandria Yard Traction Power Substation (C99 TPS), on one section of the DC Feeder Breakers Line-up. As a result, the Blue Line service was suspended, and the Yellow Line was operating with 15 to 20 minutes delay, until around 7:00 AM.

At C99 TPS, the fire completely burned two cubicles with their breakers, and also caused sever damages on three additional cubicles on the same section of the positive bus-bar.

The two completely damaged cubicles, (C99-22 and C99-50), are the "Cathode Breaker #22" and the "Positive to Positive Bus Tie Breaker #50" and their corresponding breakers, see *Picture-2*.

At C99 TPS, the Positive Bus-bar has two sections (see Figure-1),

The following breakers are connected to the first section of the Positive Bus-bar:

- DC Feeder Breaker #35 which feed YCR #19
- DC Feeder Breaker #32 which feed YCR #2
- DC Feeder Breaker #33 which feed YCR #3
- DC Feeder Breaker #31 which feed YCR #1
- DC Feeder Breaker #38 which used to feed Maintenance Shop (Currently abandoned)
- DC Cathode Breaker #21
- Common Cabinet to which common protective devices are instrumented
- DC Cathode Breaker #24

The following breakers are connected to second section Positive Bus-bar:

- DC Feeder Breaker #34 which feed YCR #23
- DC Feeder Breaker #37 which feed YCR #43
- DC Feeder Breaker #36 which feed YCR #26
- DC Cathode Breaker #22

Between these two sections of the Positive Bus-bar there is:

1. DC Bus Tie Breaker, Breaker #50 which has a Normally Closed configuration, &
2. A Bus Transition Cubicle, no breaker inside this cabinet

It appears that the fire started inside the Bus Tie breaker #50 cubicle and spread to the adjacent cubicles and breakers which are also connected to the second section of the positive bus bar as shown on *Figure-1*. Thus, DC cathode breaker, Breaker #22 cubicle is more damaged than the adjacent DC Feeder breaker #36 and its cubicle. The severity is less on DC Feeder Breaker #34 and its cubicle than DC Feeder Breaker #37 and its

cubicle. In general, all the dc breakers cubicles connected to the second section the positive bus bar and four breakers were damaged beyond repair, (Picture 1-8).

The fire also damages control cables on the cable tray right above the burned switchgears, and there is also a visible smoke on the 4" conduit that runs from the Transformer feeder breaker #12 AC switchgear to Transformer #2 (Picture 9 & 10).



Figure-1, C99 TPS DC Switchgear Lineup

Other than the above-mentioned equipment's and cable raceways, preliminary visual surveys indicate that there is no visible damage occurred on the Rectifiers, the Positive Bus-bar and on the Track Feeder Cables.

PRELIMINARY FINDINGS

Alexandria Yard TPS has a capacity of 8 megawatts out of which 6 megawatts are supplied to energize the Yard Contact Rails (YCR) and 2 megawatts is dedicated to the S&I Shop.

The DC Switchgear Line-up at this substation is comprised of 15 separate switchgears. This includes one 6kA Cathode breaker, which is manufactured by CPC in 1990, and the rest 14 switchgears are manufactured by Whipp and Bourne (W&B) in the late 1970's. The three cathode breakers and the tie breakers are all rated 6kA while the feeder breakers are rated 4kA.

Like all other high-speed dc breakers in WMAT's system, the DC breakers at C99 TPS are also assembled with an arc chute. It is one of the most critical parts of the breaker to extinguish the arc created, when the breaker contacts are partially opened, during manual & automatic switching, and during an automatic tripping.

The arc chute is comprised of vertical steel plates arranged around, and over the arc runners in such a way that the arc is drawn into the stack of steel plates, and split into a number of small arcs which are cooled and extinguished as they move rapidly towards the top of the plates. The breaker is also equipped with an air puffer, mounted between the top and bottom main contacts and operated by the breaker mechanism.

Thus, the arc chute stretches, cools and contains the arc created when the breaker contacts are partially opened. In doing so, the arc creates an ionized air, which is conductive, and burns in an ionized metal vapor which continually leaves the contact area and condenses on the surrounding metal shields. It is not possible to service the arc chutes or to replace parts, apart from cleaning as recommended by the manufacturer and on the PMI.

It appeared that DC Bus Tie Breaker, breaker #50 arc chute was completely burned by the fire created due to excessive arcing during the arc interruption in the arc chute, (Picture 3&4). The fire may be ignited by flammable dust and ionized metal particles in the presence of an ionized air, inside a 40-year-old arc chute.

Before Breaker #50 arc chute was completely burned, the fire and the extreme heat it created was puffed out of its chimney vent and spread to the adjacent cathode breaker #22. The heat and flames also damaged the above cable tray containing control wires (Picture 9). It also appears that the fire inside wiring compartment of these cubicles, which enclosed breaker #50 and #22, was ignited and totally burned by the intense heat on the back of the metal enclosed control wiring compartment, which first started by melting the control wire insulation and then caught fire.

Any defect in the arc chutes could cause a restrike- a condition in which small arcs linger on the main arcing contacts and re-establish themselves.

Attachment 3 – Fire Incident Report provided by MOWE page 4 of 7

CONCLUSION

Considering the intensity of the damage on the dc switchgear, while the positive bus bar, the track feeder cables and the rectifier remain intact, shows that the fire wasn't caused by a fault current or a short circuit current inside the switchgear, which usually accompanied with a mechanical damage on the switchgear assembly. Then, the possible cause of the fire was the intense heat created inside the arc chutes of the bus tie breaker #50, when it was partially opened, before tripping for unknown reason.

As mentioned previously, the Bus Tie breaker arc chute of this breaker was completely burned by the fire created due to excessive arcing, during arc interruption in the arc chute. The fire may be ignited by flammable dust and ionized metal particles in the presence of an ionized air, inside a 40-year-old arc chute. Here, age is the main factor and it appears that behind the scenes all the circuit breakers could be on the brink of failure.

With age, circuit breakers and its arc chutes gather dirt, moisture and ionized metals described previously. This compromises the insulation, dielectric strength and the thermal performances of vital components of the breaker. The primary insulation of these components tends to degrade with time, moisture would penetrate into it, heat created during arc interruption can also weaken the insulation.

It appeared that all or part of these factors could exist inside Breaker #50 switchgear assembly when that fire incident happened on August 14, 2018.

Temporary Yard Power Configuration

Due to this emergency situation, currently the Yard power system is configured as described below.

1. The yard is tied to the main line.
This is accomplished by closing the following Normally Opened (N.O.) Disconnect Switches. These are:
 - a. AY-DS1P
 - b. AY-DS2N
 - c. AY-DS3P
 - d. AY-DS4N
2. The DC Switchgear Line-up is now configured as a "TBS" and works only in Manual mode. Thus, the Yard Tower has no control on the YCR power system. The YCR are energized via J01 TBS feeder breaker #83 & #84 and opening these two breakers will de-energized the whole YCR.
 - a. Breaker #31/YCR-1 CLOSED and Feeds both YCR-1 & YCR-26
 - b. Breaker #32/YCR-2 CLOSED and Feeds both YCR-2 & YCR-23
 - c. Breaker #33/YCR-3 CLOSED and Feeds both YCR-3 & YCR-43
 - d. Breaker #35/ YCR-19 is CLOSED

3. I/C Line AC Breaker #1 & Rect-Transformer AC Breaker #11 are CLOSED to energized Transformer #3 which feed the S&I shop via C99-23 (Cathode Breaker #23)

NOTE:

To achieve the configuration described in 2, YCR feeder cables are reduced from 4 to 3 to consolidate with the existing four feeder cables on the load side cable termination bus. Meanwhile, MOWE will continue to monitor the current through these three YCR feeder cables. MOWE also recommends that the Yard shouldn't store more than its capacity

Attachments:

C99 Yard Contact Rail Schematic (CRS-E-15)

Picture-1: C99 DC Switchgear Line-up

Picture-2: C99 DC Breaker #50 & #22 Switchgears

Picture-3: C99 DC Breaker #50 Switchgear control Cable Compartment

Picture-4: C99 DC Breaker #50

Picture-5: C99 DC Breaker #22 Switchgear Control Cable Compartment

Picture-6: C99 DC Breaker #22

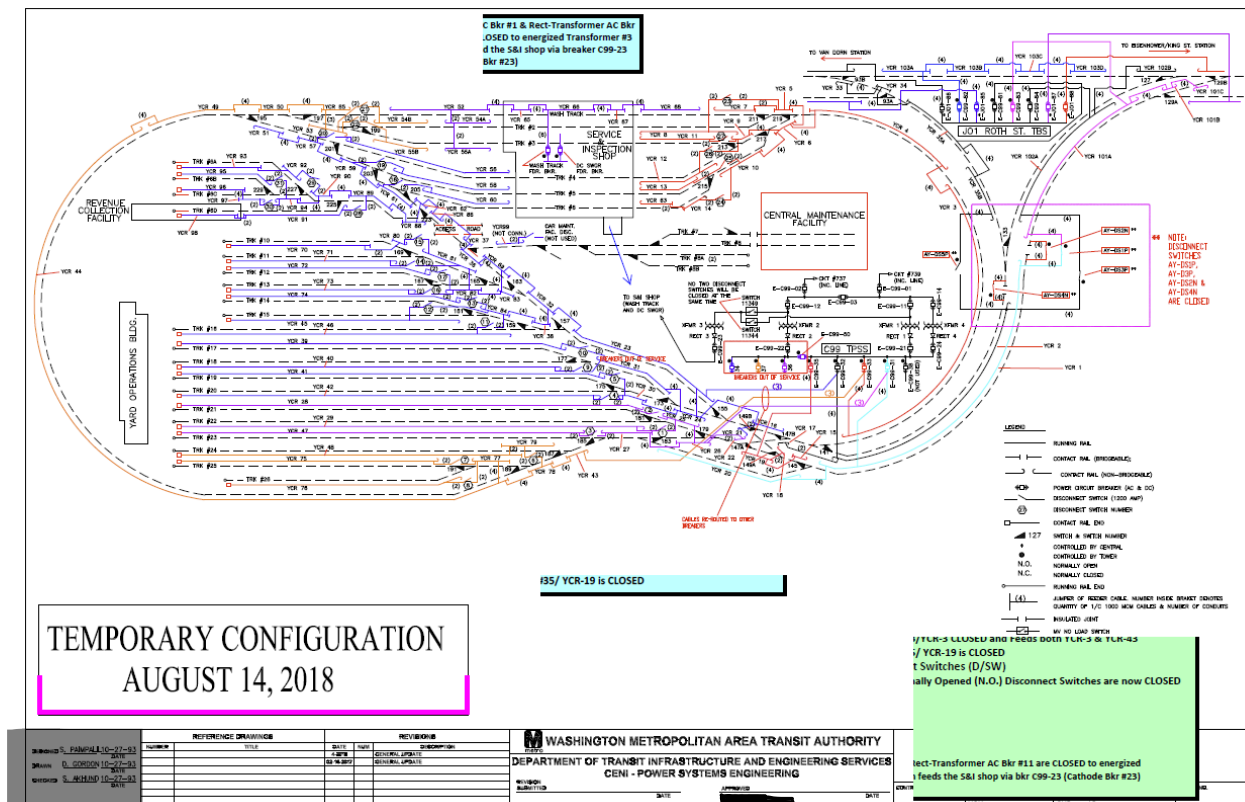
Picture-7: C99 DC Breaker #26

Picture-8: C99 DC Breaker #43

Picture-9: C99 DC Switchgear Control Cables & Cable Tray

Picture-10: C99 Transformer #2 Feeder Cable Conduit

Attachment 3 – Fire Incident Report provided by MOWE page 6 of 7



Attachment 3 – Fire Incident Report provided by MOWE page 7 of 7

Photos



Picture 1 - C99 DC Switchgear Line-up



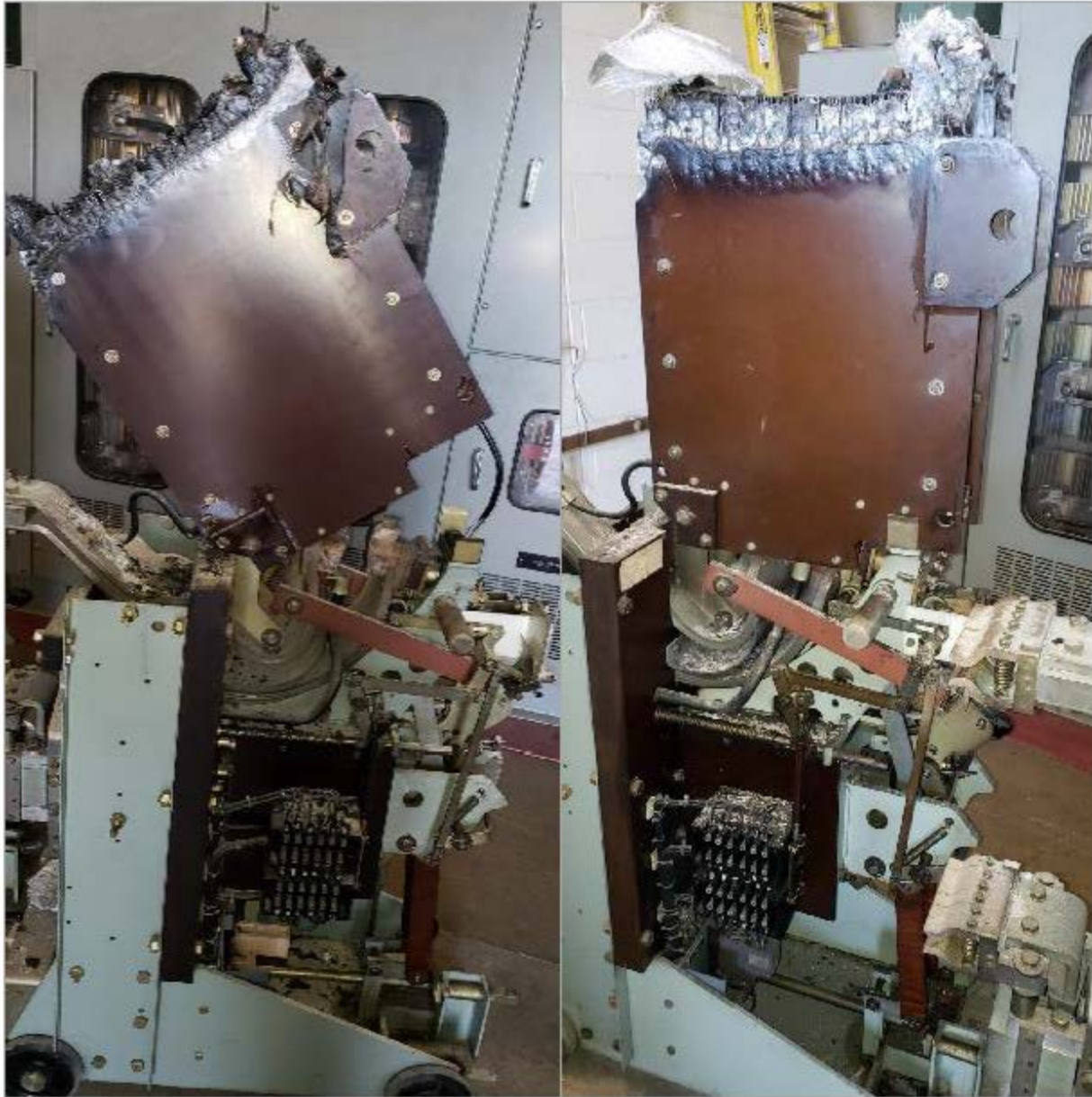
Picture 2 - C99 DC Breaker 50 and 22 Switchgears



Picture 3 - C99 DC Breaker 50 Switchgear Cable Compartment and Breaker



Picture 4 - C99 DC Breaker 22 Switchgear Cable Compartment and Breaker



Picture 5 - C99 DC Feeder Breaker 26 and 43



Picture 6 - C99 DC Switchgear Control Cables & Cable Tray



Picture 7 - C99 Transformer 2 Feeder Cable Conduit