Lookout Brook Hydro Plant Refurbishment (Clustered), p. 4 of 96, $2,155,000

Q. In the report provided in Tab 1.2 Lookout Brook Hydro Plant Refurbishment, page 7, NP mentions "arc flash zone of influence". If NP has investigated the extent of arc flash exposure in its facilities please provide the report that has been prepared. If not, please provide reasons why this investigation has not been undertaken.

A. Newfoundland Power has not prepared a formal report on arc flash exposure for all of its facilities.

Newfoundland Power has investigated the extent of arc flash exposure and completed arc flash hazard studies for all of its substation and hydro plant high voltage switchgear. Such studies are completed to current industry standards under the supervision of qualified professional engineers.

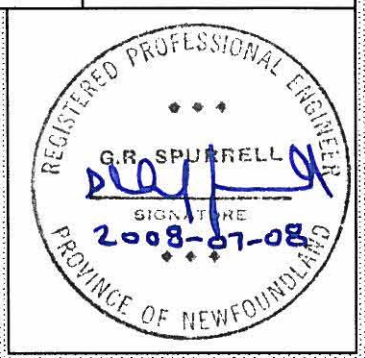
Attachment A provides the arc flash study for Lookout Brook Plant. The *arc flash zone of influence* for the switchgear at Lookout Brook Plant is 633 inches or 16 metres.

Lookout Brook
Arc Flash Hazard Study

ELECTRICAL ENGINEERING

ARC FLASH HAZARD STUDY

Company Area:	Stephenville	
Switchgear Included:	LBK 2.4kV	
Prepared by:	D. Jones	**Date:**

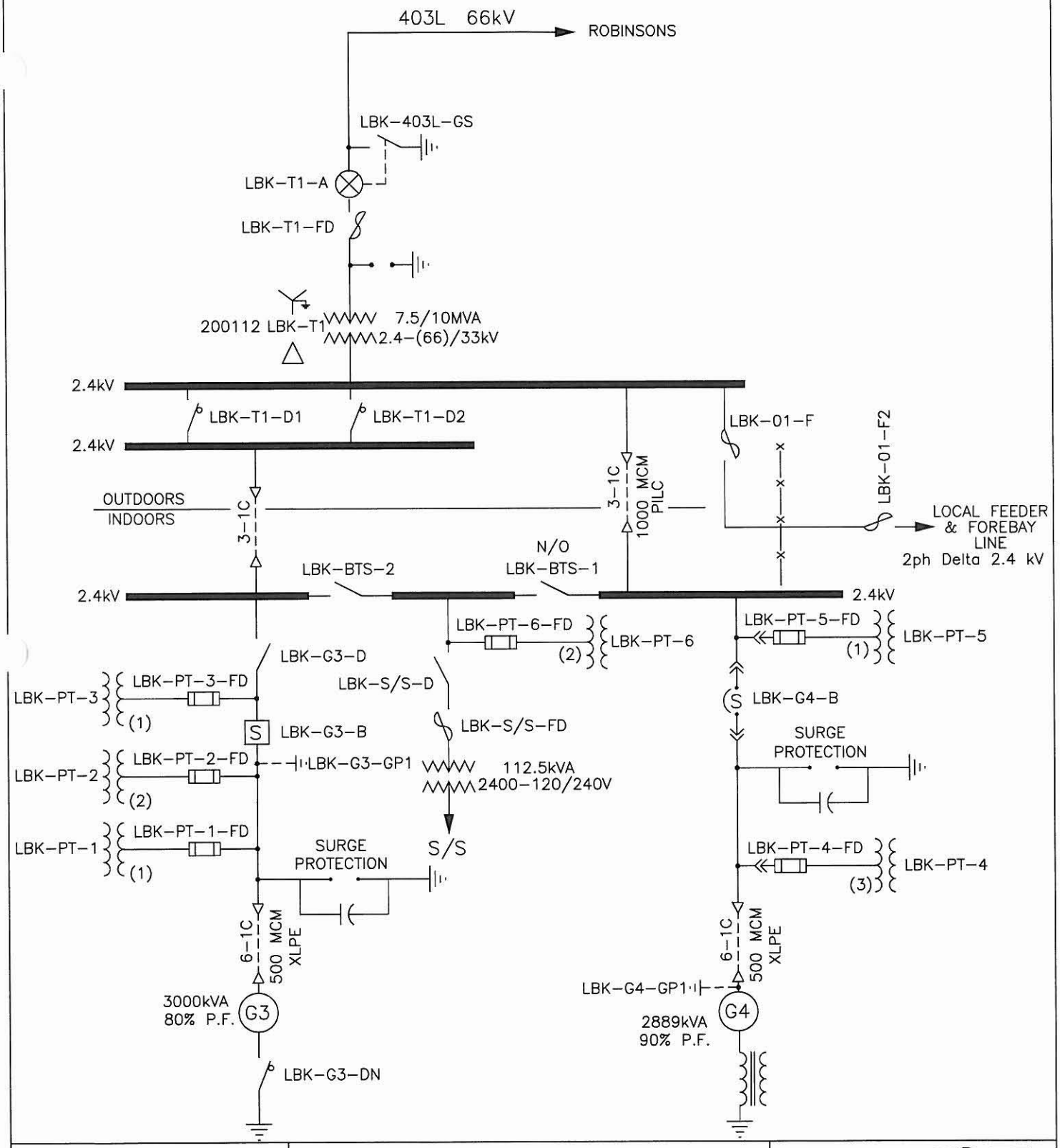


REASON FOR ARC FLASH HAZARD STUDY

Arc Flash Hazard calculations to be done for all Metal Clad Switrchgear.
Study revisited after 403L conversion from 33kV to 66kV.

POINTS TO NOTE

1. PPE level class >4 at 16 inches (working inside switchgear).
2. PPE level class 3 at 36 inches (racking out breaker).



REGISTERED PROFESSIONAL ENGINEER
PROVINCE OF NEWFOUNDLAND
Lorne W. Thompson
SIGNATURE
2009-03-18
DATE

SINGLE LINE DIAGRAM

NEWFOUNDLAND POWER
A FORTIS COMPANY

PROVINCE OF NEWFOUNDLAND
PERMIT HOLDER
This Permit Allows
NEWFOUNDLAND POWER INC.
To practice Professional Engineering in Newfoundland and Labrador. Permit No. as issued by APEGN N0124 which is valid for the year 2009

LOOKOUT BROOK

Date: 2009-03-18	Page 1 Of 1
App:	SLD No. 8-913

Rev 1.0

3/5/2008

Recheck of LBK-T1 fuse size;

Steps to select power transformer fuse:

1. Select voltage rating.
2. Check interrupting rating.
3. Select ampere rating and speed.
4. Check co-ordination with loadside device.
5. Check co-ordination with source side device.

Fuse Voltage Rating Selection \\

HV system voltage (kV)	66.00

Voltage rating selected should always be in excess of the system phase-to-phase voltage.
Recall that in all likelihood one of any two fuses carrying fault current will melt before the other. Thus a full phase-to-phase recovery voltage will appear across the blown fuse.

Fuse manufacturer	S & C
Select holder type	
Select voltage rating	66.00

Fuse interrupting rating //

LLL maximum fault level at fuse	171.00
Angle 3-phase.	-65.70
X/R ratio for above.	-2.21
Assymetry factor based on X/R ratio (See graph window)	1.2
Assymetrical L3 fault level	205.2
Phase-to-ground maximum fault level at fuse location.	124.00
Angle- phase-to-ground.	-71.2

X/R ratio for above.	-2.94
Assymetry factor based on X/R ratio	1.3
Assymetrical LG fault level	161.2
S & C 66.00 kV asymmetrical interrupting rating (MVA)	1673.00
S & C 66.00 kV symmetrical interrupting rating (MVA)	1046.00

(If the rating is higher than the fault levels above, the selected fuse can interrupt these faults. A lower X/R ratio for the fault levels above will allow a higher safety margin.)

Determine fusing ratio //

Fusing ratio = Fuse rating / Xfmr self-cooled MVA rating

Transformer self-cooled MVA rating	7.50
Full load amps at 66.00 kV	65.6
Transformer MVA rating with full cooling	10.00
Full load amps at 66.00 kV	87.5
Select a fuse size	80
Fuse letter code	E
Fusing ratio with above	1.22
Corresponding rating (MVA)	18.29
Simple overload capacity (Transformer FL / 2 x fuse rating)	183%

(A fuse will normally carry approximately 2X its current rating before it will start to melt.)

Impedance limited secondary faults may reduce the short circuit current to the order of 500-1000 % of the transformer rated full-load current. Overcurrents of this magnitude definitely accelerate transformer aging and should be cleared promptly. This basically requires a low fusing ratio. S&C recommends that fusing ratios should be less than 1.5 and no greater than 2.0.

LOCATION ----------	Lookout Brook	
Device	LBK-T1-FD	
Fuse Manufacturer	S&C	
Manufacturer's designation	SMD-1A	
kV rating	69	
Size	80E	
Fuse speed rating	Standard	
Holder type	SMD-1A	
Manufacturer's catalog number		
Curve numbers	153-1, 153-1-6-1	

COMMENTS:

LOCATION ----------	Lookout Brook	
Relay type	MCGG22	
System kV	66.00	
CT Ratio:1	20	(100:5)
CT connection	Y	
Rated current of the CT secondary (In)	5	
DEVICE --->	LBK-T1-51N	
Relay range (increments of 0.05)	0.05-2.4	
Range in secondary amps (Is) (relay range x In)	0.25-12	
Pickup setting (Is/In)	---------->	0.2
Pickup setting, sec. amps (Is) (pickup x In)	1.00	
Time multiplier (0.025-1)(increments of 0.025)	---------->	0.30
MVA setting	2.29	
Operating Curve	---------->	Very Inverse
DEVICE --->	LBK-T1-50NLV	
Relay range (increments of 1)	1-31	
Range in secondary amps (relay range x Is)	(5-155) x Is	
Pickup setting	---------->	N/A
Pickup setting, sec. amps (pickup x Is)	0.00	
MVA setting	0.00	

COMMENTS //////////////////////

Change the Pickup setting from 0.4 (2.3 MVA @ 33KV) to 0..2 (2.3 MVA @ 66 KV).

Convert 403L to 66 KV

STG-403L-P143

Phase Settings

I>1 Function	**IEC E Inverse**
I>1 Direction	**Non-Directional**
I>1 Current	**Set 111.0 A**
I>1 TMS	**100.0e-3**
I>1 tRESET	**0 s**
I>2 Function	**Disabled**
I>3 Status	**Enabled**
I>3 Direction	**Non-Directional**
I>3 Current Set	**795.0 A**
I>3 Time Delay	~~**0 s**~~ 300 ms cgs
I>4 Status	**Disabled**
I> Blocking	**001111**
I> Char Angle	**45.00 deg**
V CONTROLLED	**O/C**
VCO Status	**Disabled**

1. Change I>1 Function from IEC v Inverse to IEC E Inverse.
2. Change I>1 TMS from 0.350 to 0.100
3. Change I>1 Current from 201 amps to 111 amps.
4. Change I>3 Current set from 1359 amps to 795 amps.

FROM APPROVED 403L CONVERSION COORDINATION STUDY.

Maximum Generation Fault LBK 2.4 kV

Faulted Bus -> (I) report

Faulted Bus	Bus Id	Type	Prefault kV	Fault type	Fault S [MVA]	Ia [A]	Ia [deg]	Ib [A]	Ib [deg]	Ic [A]	Ic [deg]	In [A]	In [deg]
LBK 02	LBK 02		2.4	LLL	100	23994.75	-82.9135	23994.75	157.0865	23994.75	37.0865	0	0
First Ring Contributions													
LBK 02	LBK G1	Generator	2.4	LLL	34	8191.156	-90	8191.156	150	8191.156	30	0	0
LBK 02	LBK T1	Xmer	2.4	LLL	66	15898.69	-79.2697	15898.69	160.7303	15898.69	40.7303	0	0

Global Current Report

Faulted Bus	Branch id	Type	Fault type	Branch Side	Ia [A]	Ia [deg]	Ib [A]	Ib [deg]	Ic [A]	Ic [deg]	In [A]	In [deg]
LBK 02	403L(B)	Line	LLL	ROB 403L-D3	578	130.7353	578	10.7353	578	-109.265	0	0
LBK 02	403L(B)	Line	LLL	LBK T1-A	578	-49.2647	578	-169.265	578	70.7353	0	0

Minimum Generation Fault LBK 2.4 kV. LBK plant on.

Faulted Bus -> (I) report

Faulted Bus	Bus Id	Type	Prefault kV	Fault type	Fault S [MVA]	Ia [A]	Ia [deg]	Ib [A]	Ib [deg]	Ic [A]	Ic [deg]	In [A]	In [deg]
LBK 02	LBK 02		2.4	LLL	92	22066.52	-83.7537	22066.52	156.2463	22066.52	36.2463	0	0
First Ring Contributions													
LBK 02	LBK T1	Xmer	2.4	LLL	58	13952.89	-80.092	13952.89	159.908	13952.89	39.908	0	0
LBK 02	LBK G1	Generator	2.4	LLL	34	8191.156	-90	8191.156	150	8191.156	30	0	0

Global Current Report

Faulted Bus	Branch id	Type	Fault type	Branch Side	Ia [A]	Ia [deg]	Ib [A]	Ib [deg]	Ic [A]	Ic [deg]	In [A]	In [deg]
LBK 02	403L(B)	Line	LLL	ROB 403L-D3	507.2	129.913	507.2	9.913	507.2	-110.087	0	0
LBK 02	403L(B)	Line	LLL	LBK T1-A	507.2	-50.087	507.2	-170.087	507.2	69.913	0	0

MVA: x 1 at 66 kV

7-Fuse S&C SMD1A STD 69KV
Rating: 80E [A]
66.00 [kV]

Fmin:507 [A]

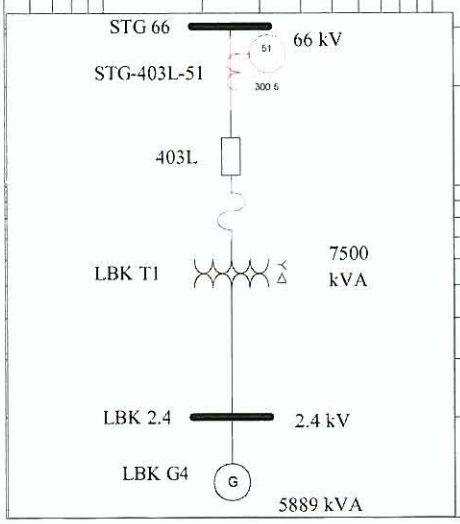
6-Relay ALSTOM MICOM IEC E I
Tap Range:[0.5 / 11.2] Tap:1.85
Pick Up:111.00 [A] TD:0.100
CT:300:5 at 66.00 [kV]
Inst. Option: OFF
ST Option: OFF

0.963 sec. at 4.000 pu / 414.900 amps

Time in Seconds

1000
100
10
1
0.1
0.01

0.5 1 10 100 1000 10000



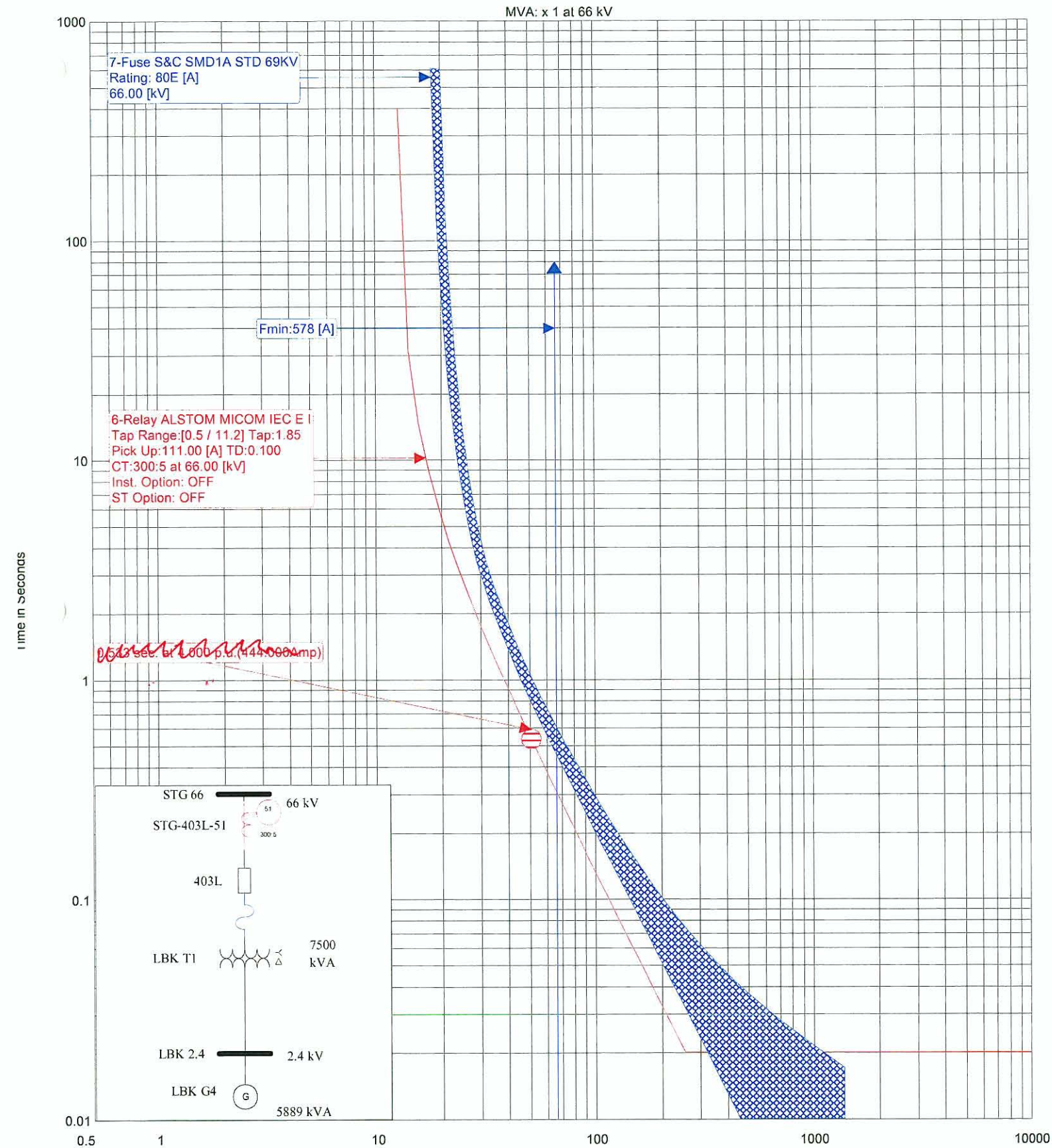
Breaker clearing time 0.3064 Max Gen
Breaker clearing time 0.4028 Min Gen
Fuse clearing time 0.6040 Max Gen.
Fuse clearing time 0.7809 Min Gen.

PLOTTING VOLTAGE:66 kV
BY: D. Jones
Plot shows miscoordination between Breaker and Fuse.

LBK – 2.4kV FAULT

NO.
DATE: 7-24-2009

Study: X:\COMM\Arc Flash\Plants\LBK\LBK 2009 Review\LBK Min Gen.tcc



Breaker clearing time 0.3064 Max Gen	PLOTTING VOLTAGE:66 kV
Breaker clearing time 0.4028 Min Gen	BY: D. Jones
Fuse clearing time 0.6040 Max Gen.	Plot shows miscoordination between Breaker and Fuse.
Fuse clearing time 0.7809 Min Gen.	DATE: 7-24-2009

LBK - 2.4 KV FAULT

Study: X:\COMM\Arc Flash\Plants\LBK\LBK 2009 Review\LBK Max Gen Icc

Arc Flash Hazard LBK 2.4 kV with 80E fuses installed on LBK-T1 transformer. 403L converted to 66 kV
IEEE standard

Faulted Bus	Generation	Fault	Fault Current	CT	CT Plus Fuses	Working Distance	Flash Hazard Boundry	cal / cm2	PPE Level	L.A.B.	R.A.B.	P.A.B.
LBK 2.4	Max	LLL	23995	0.6040	0.6040	16"	533	37.24	4	60"	26"	7"
LBK 2.4	Min	LLL	22067	0.7809	0.7809	16"	633	44.06	>4	60"	26"	7"

Faulted Bus	Generation	Fault	Fault Current	CT	CT Plus Fuses	Working Distance	Flash Hazard Boundry	cal / cm2	PPE Level	L.A.B.	R.A.B.	P.A.B.
LBK 2.4	Max	LLL	23995	0.6040	0.6040	36"	533	16.91	3	60"	26"	7"
LBK 2.4	Min	LLL	22067	0.7809	0.7809	36"	633	20.00	3	60"	26"	7"

***Arc Flash Calculated for Switchgear and fixed conductor.**
Software won't supply Arc Flash results for clearing times over one second.

L.A.B. Limited Approach Boundry
R.A.B. Restricted Approach Boundry
P.A.B. Prohibited Approach Boundry

Miscoordination between STG-403L-B and LBK-T1 fuses for 2.4 kV bus fault.
Used fuse Clearing Time for Arc Flash Study as this would be worst case.

IEEE 1584 Based Arc Flash Calculator and Warning Label Creator

Equipment Class: Switchgear

Gap between Conductors: 104 mm.

Grounding Type: Grounded

Working Distance: 406.4 mm.

Available 3 Phase Bolted Current: 23.995 kA

System Voltage: 2400 Volt

☑ I agree to be bound with Terms & Conditions of this website.

Calculate Boundaries

Equipment Type: Switchgear

Typical Gap bw. Electrodes: 104mm.

Grounding: Grounded

Work Distance: 406.4 mm.

Arc Duration @ Predicted Arcing Current: 0.6040 sec.

Arc Duration @ 15% Reduced Arc Current : 0.6040 sec.

Available 3Ø Bolted Current: 23.995 kA

Predicted 3Ø Arcing Current: 22940 A

System Voltage L-L: 2400 Volt

Calculation Mode	Incident Energy Exposure (cal/cm²)	Flash Protection Boundary (inches)	Level of PPE
@ 100% Arcing Current	**37.24**	**533**	**4**
@ 85% Arcing Current	31.24	445	4

IEEE 1584 Based Arc Flash Calculator and Warning Label Creator

Equipment Class: Switchgear

Gap between Conductors: 104 mm.

Grounding Type: Grounded

Working Distance: 406.4 mm.

Available 3 Phase Bolted Current: 22.067 kA

System Voltage: 2400 Volt

☑ I agree to be bound with Terms & Conditions of this website.

Calculate Boundaries

Equipment Type: Switchgear

Typical Gap bw. Electrodes: 104mm.

Grounding: Grounded

Work Distance: 406.4 mm.

Arc Duration @ Predicted Arcing Current: 0.7809 sec.

Arc Duration @ 15% Reduced Arc Current : 0.7809 sec.

Available 3Ø Bolted Current: 22.067 kA

Predicted 3Ø Arcing Current: 21130 A

System Voltage L-L: 2400 Volt

Calculation Mode	Incident Energy Exposure (cal/cm²)	Flash Protection Boundary (inches)	Level of PPE
@ 100% Arcing Current	**44.06**	**633**	**N/A**
@ 85% Arcing Current	36.96	528	4

633 inches / 39.54 inches = 16. meters

IEEE 1584 Based Arc Flash Calculator and Warning Label Creator

Equipment Class: Switchgear

Gap between Conductors: 104 mm.

Grounding Type: Grounded

Working Distance: 914.4 mm.

Available 3 Phase Bolted Current: 23.995 kA

System Voltage: 2400 Volt

☑ I agree to be bound with Terms & Conditions of this website.

Calculate Boundaries

Equipment Type: Switchgear

Typical Gap bw. Electrodes: 104mm.

Grounding: Grounded

Work Distance: 914.4 mm.

Arc Duration @ Predicted Arcing Current: 0.6040 sec.

Arc Duration @ 15% Reduced Arc Current : 0.6040 sec.

Available 3Ø Bolted Current: 23.995 kA

Predicted 3Ø Arcing Current: 22940 A

System Voltage L-L: 2400 Volt

Calculation Mode	Incident Energy Exposure (cal/cm²)	Flash Protection Boundary (inches)	Level of PPE
@ 100% Arcing Current	**16.91**	**533**	**3**
@ 85% Arcing Current	14.19	445	3

IEEE 1584 Based Arc Flash Calculator and Warning Label Creator

Equipment Class: Switchgear

Gap between Conductors: 104 mm.

Grounding Type: Grounded

Working Distance: 914.4 mm.

Available 3 Phase Bolted Current: 22.067 kA

System Voltage: 2400 Volt

☑ I agree to be bound with Terms & Conditions of this website.

Calculate Boundaries

Equipment Type: Switchgear

Typical Gap bw. Electrodes: 104mm.

Grounding: Grounded

Work Distance: 914.4 mm.

Arc Duration @ Predicted Arcing Current: 0.7809 sec.

Arc Duration @ 15% Reduced Arc Current : 0.7809 sec.

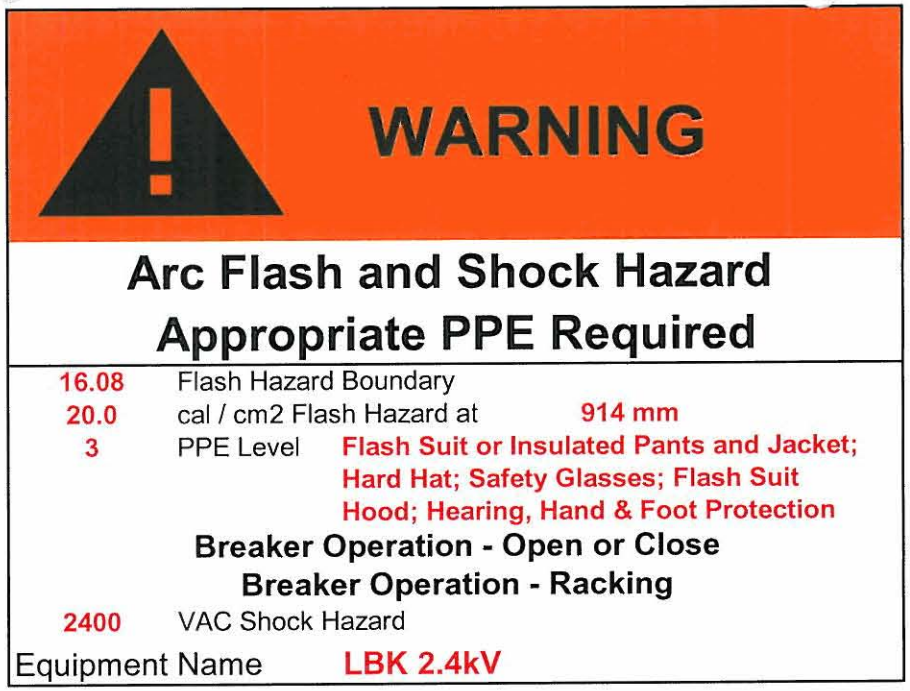
Available 3Ø Bolted Current: 22.067 kA

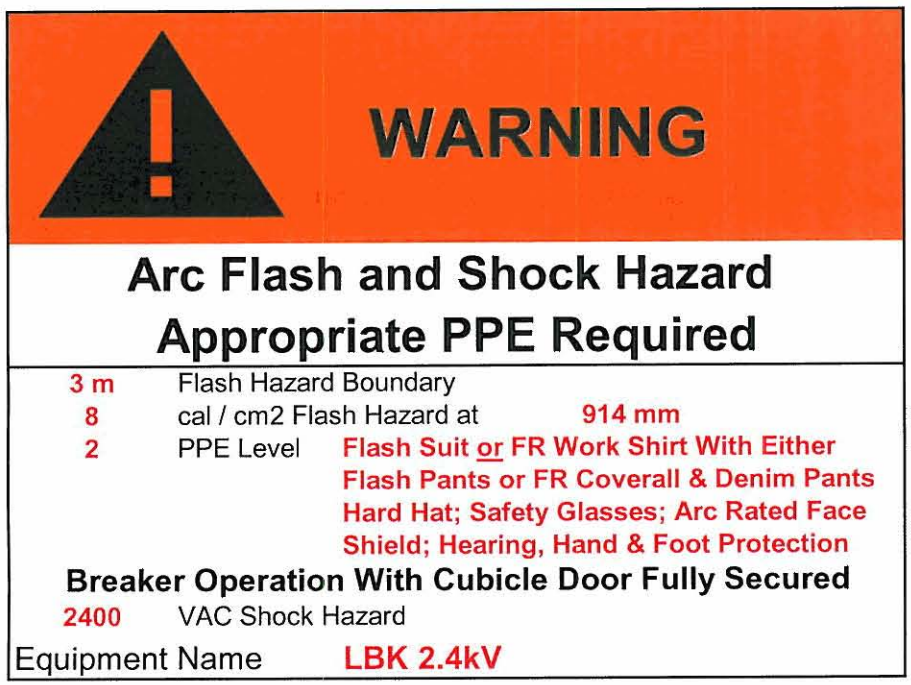
Predicted 3Ø Arcing Current: 21130 A

System Voltage L-L: 2400 Volt

Calculation Mode	Incident Energy Exposure (cal/cm ^{2})	Flash Protection Boundary (inches)	Level of PPE
@ 100% Arcing Current	**20.00**	**633**	**3**
@ 85% Arcing Current	16.78	528	3


WARNING
Arc Flash and Shock Hazard
Appropriate PPE Required
16.08 Flash Hazard Boundary
44.1 cal / cm2 Flash Hazard at 406 mm
>4 PPE Level De-energize Switchgear or Change Protection Settings to Reduce Hazard Category
Inside Any Switchgear Cubicle Compartment
2400 VAC Shock Hazard
Equipment Name LBK 2.4kV


WARNING
Arc Flash and Shock Hazard
Appropriate PPE Required
16.08 Flash Hazard Boundary
20.0 cal / cm2 Flash Hazard at 914 mm
3 PPE Level Flash Suit or Insulated Pants and Jacket; Hard Hat; Safety Glasses; Flash Suit Hood; Hearing, Hand & Foot Protection
Breaker Operation - Open or Close
Breaker Operation - Racking
2400 VAC Shock Hazard
Equipment Name LBK 2.4kV


WARNING
Arc Flash and Shock Hazard
Appropriate PPE Required
3 m Flash Hazard Boundary
8 cal / cm2 Flash Hazard at 914 mm
2 PPE Level Flash Suit or FR Work Shirt With Either Flash Pants or FR Coverall & Denim Pants Hard Hat; Safety Glasses; Arc Rated Face Shield; Hearing, Hand & Foot Protection
Breaker Operation With Cubicle Door Fully Secured
2400 VAC Shock Hazard
Equipment Name LBK 2.4kV