



ATS EPSS Clearing Time Testing Report

ATS Report Number: 006.8-22.3

Authors and Contributors:

[Redacted]

Andrew Abranches

Reviewer

03/29/2022

Date

[Redacted]

Approver

03/31/2022

Date

cc: Mark Quinlan
Sumeet Singh

[Redacted]

PG&E Enhanced Powerline Safety Settings

Clearing Time Optimization Testing Report

Authors and Contributors: [REDACTED], [REDACTED], [REDACTED], [REDACTED], [REDACTED]

Executive Summary

PG&E's Distribution Asset Planning Department requested Applied Technology Services (ATS) to perform overhead fault testing in support of the Enhanced Powerline Safety Settings (EPSS) initiative to help reduce wildfire risk by adjusting the sensitivity of protective devices. Circuits currently enabled with EPSS are configured to clear bolted fault conditions at 100ms; however, increasing the clearing time can improve the coordination margin between devices, thus reducing the patrol zone. The purpose of this test is to provide empirical data describing ignition risk as a function of fault clearing times for distribution protection equipment if the 100ms fault duration time were extended.

Line-to-ground fault testing was performed at three fault current magnitudes, 300A, 1500A, and 3000A, at various clearing times ranging from 100ms to 2s by dropping #4 ACSR conductor on three different types of fuel beds. The fuel beds chosen from most to least conservative for testing were undried sod, dried sod, and an erosion control mat per Cal-Fire standards. Line-to-line fault testing was also performed at the same fault current magnitudes and clearing times ranging from 100ms to 2s by creating conductor to conductor faults. In addition, a line-to-line fault was created with vegetation and cleared at 500ms to demonstrate what occurs. Testing was recorded on one high-speed camera, one high-speed thermal camera, and several go-pro cameras to capture the particles emitted from the conductor during an arcing event.

Testing was performed at the ATS High Current Test Yard from January-February 2022. A total of 174 tests were performed.

The testing results indicate the following:

- The probability of ignition is higher on dried sod compared to other natural fuel media with higher moisture content.
- As the fault current increases, the probability of sustained ignition increases.
- As the clearing time increases, the probability of sustained ignition increases for all the fault current magnitudes used for testing.

Based on the test results, the reduction in clearing time (fast relaying) for all faults will help reduce the ignition risk and is aligned with enhanced safety practices by other utilities and industry research. Faster relaying will also help limit the movement of faults/traveling arcs on circuits and flashover/arc to adjacent phases.

It was observed that for faster clearing times below 100ms, the risk of sustained ignition was minimal compared to conventional relay settings. Increasing EPSS relay clearing times beyond 100ms is not recommended at this time, as it may increase the ignition risk.

Test Setup

ATS High Current Yard

The ATS High Current Yard was configured to deliver a maximum line-to-line voltage of 12kV or a line-to-ground voltage of 7kV. Reactors were connected in the impedance bay, which provided the fault duties of approximately 300 A, 1500 A, and 3000 A. Downstream of the impedance, a G&W line recloser with a Beckwith M7679 controller, was used as the source side protective device to clear the faulted condition. A single line of the high current yard is shown below in Figure 1.

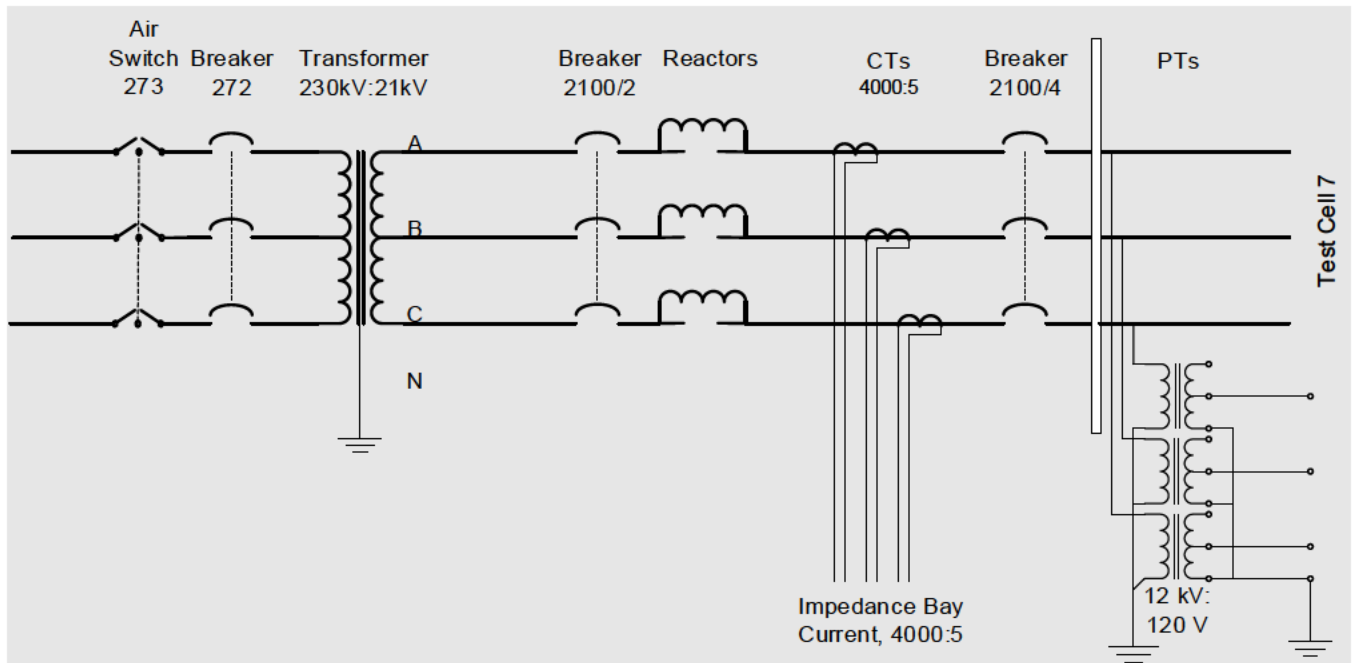


Figure 1: Diagram of ATS High Current Yard test circuit

Line-to-Ground Fault Test Setup

This test apparatus was constructed to simulate a conductor falling to the ground, creating a line-to-ground fault. The line-to-ground fault test apparatus consisted of a 2' x 4' copper plate on an insulated stand. The copper plate was connected to the station ground, and the fuel bed was placed on top. A trap door mechanism held the #4 ACSR conductor above the fuel bed until it was ready to release. A switch in the control room controlled the release. The source-side protective device consisted of a G&W line recloser with a Beckwith M7679 controller. Fig. 2 below shows the test setup



Figure 2: Line-to-ground test apparatus

Line-to-line test setup

The line-to-line fault test apparatus consisted of two 50' fiberglass poles with #4 ACSR conductors strung in-between, creating a short span. The conductors were set at 22.5' above ground, the minimum height per CPUC GO 95 for distribution. A mechanism mounted above the conductors on the source side pole was used to release the shorting conductor (or tree) on the span, initiating a line-to-line fault for some of the tests. The dropping of the shorting conductor caused substantial damage to the main conductors when making contact which required the whole span to be replaced after each test. Due to this issue, another method was developed that used sacrificial conductors and a fuse wire to initiate the fault. Fig. 3 below shows the test setup.



Figure 3: Line-to-line test apparatus

Fault current magnitude and clearing times

Fault Current

The three fault current magnitudes chosen for this testing are based on the following:

- Fuse fault data and line section fault data from PG&E HFTDs
- Phase-to-phase and phase-to-ground fault duties from EPSS-enabled circuits in 2021

The data sets' line-to-line and line-to-ground fault duties ranged from 316A to 3488A.

Table 1 below shows the three targeted fault duty magnitudes and the actual fault duties measured utilizing the available impedances in the test yard.

Table 1: Targeted Test Fault vs. Actual Fault Duties

Targeted fault duties	Actual fault duty measured		Percentile Expected Fault Current in Field
	L-G	L-L	
300A	333A	373A	10%
1500A	1694A	1415A	50%
3000A	3331A	2728A	90%

Clearing Time

The clearing time of the faults ranged from 100ms to 500ms with a 2s "control group" to simulate legacy settings employed in the field with low fault current.

Conductor Types

#4 ACSR (Aluminum Conductor Steel Reinforced) conductor was chosen for these tests because it was the most common in the High Fire Threat Districts (HFTD) at a length of approximately 11k miles.

Test plan and summarized test results

Test Plan

A total of 174 tests were performed, including 134 line-to-ground tests and 40 line-to-line tests. The test combinations and the number of tests for the line-to-ground and line-to-line faults performed are summarized in the tree diagrams in Attachment 1, Figures 6 to 11. The test plan documenting all test results is available in Attachment 2.

Summarized Test Results

Ignition Media:

Undried Sod

- All line-to-ground and line-to-line faults tests below 3000 Amps did not produce ignition.
- Some line-to-ground faults at 3000 amps resulted in minimum ignition that quickly self-extinguished.

Dried Sod

- Ignition occurred on all line-to-ground tests at all clearing times

Erosion Control Mat

- Severe and immediate ignition occurred on all tests. Further testing of this ignition media was abandoned.

Fault Comparison:

Line-to-Line Faults

Wind speed was quite variable during testing. Testing during windy conditions resulted in significantly fewer ignitions. Due to the uncontrolled variable of the wind, this data set is less valuable than the line-to-line faults and was not used to draw any conclusions.

Line-to-Ground Faults

Ignition occurred at all test currents and all clearing times for faults on erosion control mat material and dried SOD. The time of sustained ignition during the fault typically increased with clearing time and fault current.

Ignition Severity	
1	No fire or flame, smoldering only/Wet Sod
2	Fire observed, one fire spot, self extinguish < 10s
3	fire observed, self-extinguish between 10s-20s, or only one fire spot, If no fire but lots of particles
4	fire observed, self-extinguish between 20s-30s or multiple fire spots
5	Fire did not extinguish, or self extinguish more than 30s

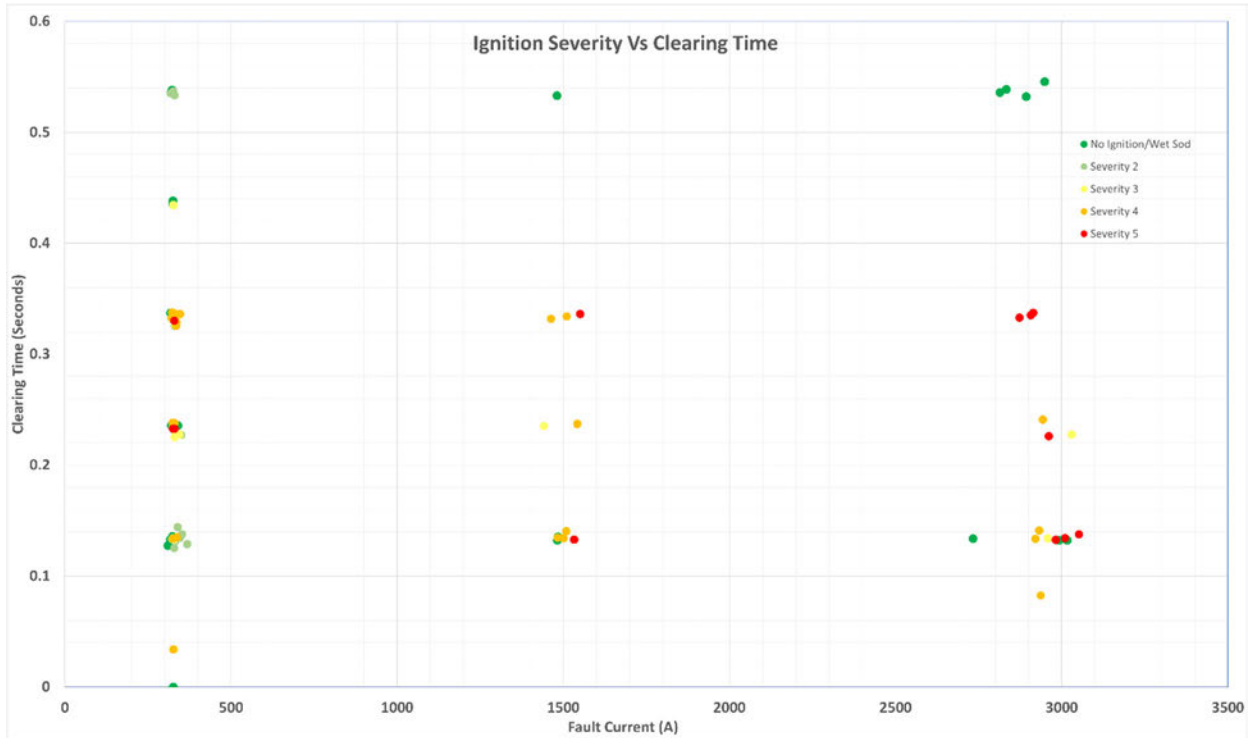


Figure 4: Ignition severity for line-to-ground faults on dry and wet sod

Attachment 1: Test Tree Diagrams

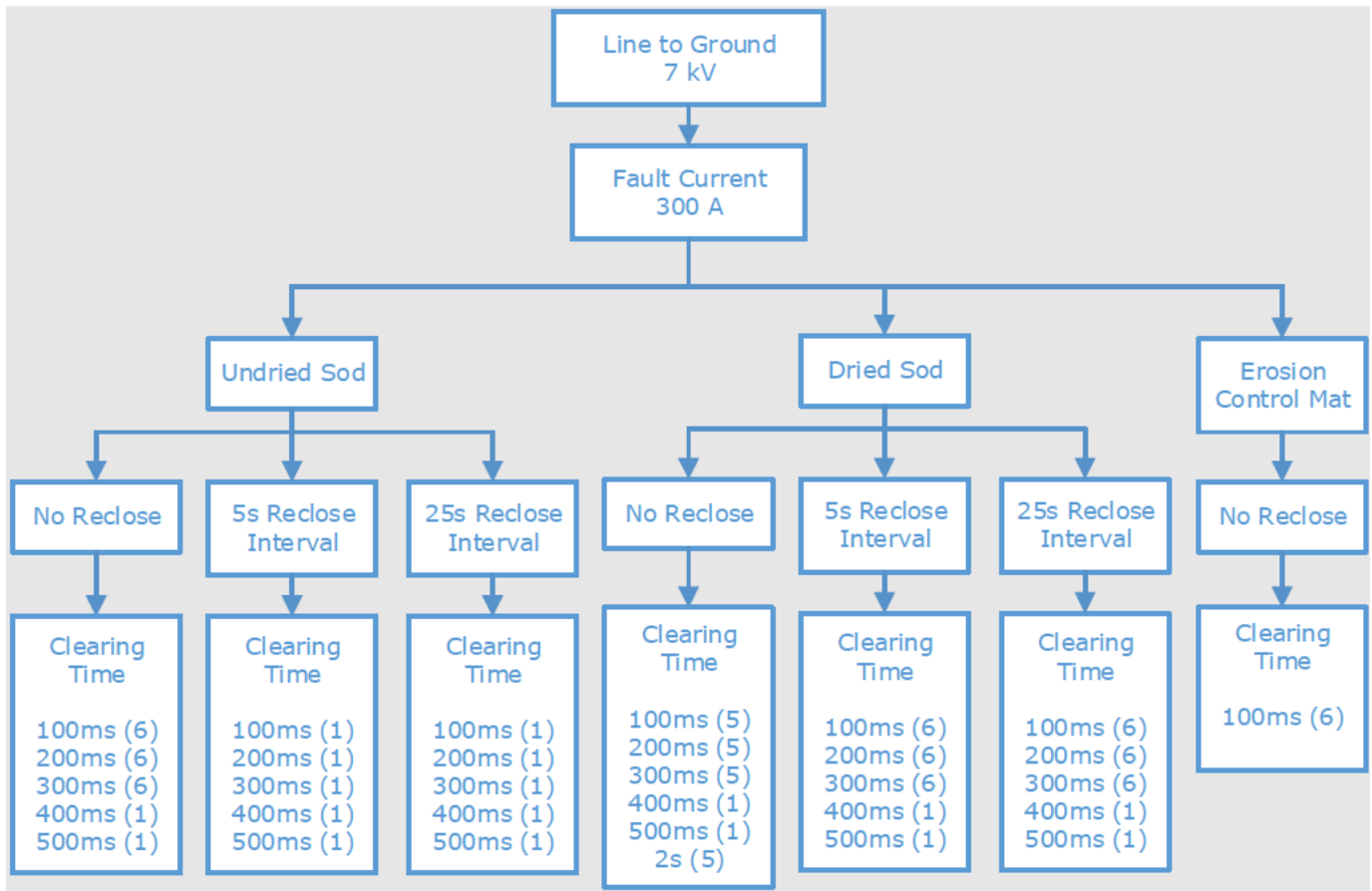


Figure 5: Line-to-ground fault @ 300A Test Tree Diagram

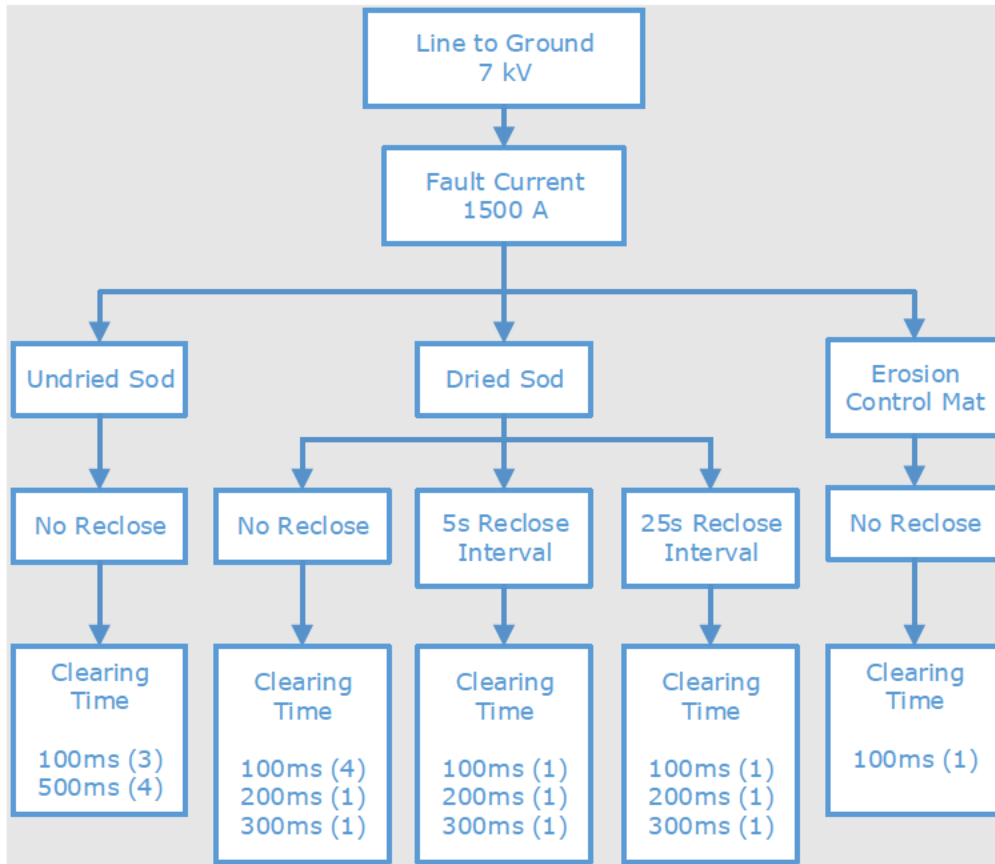


Figure 6: Line-to-ground fault @ 1500A Test Tree Diagram

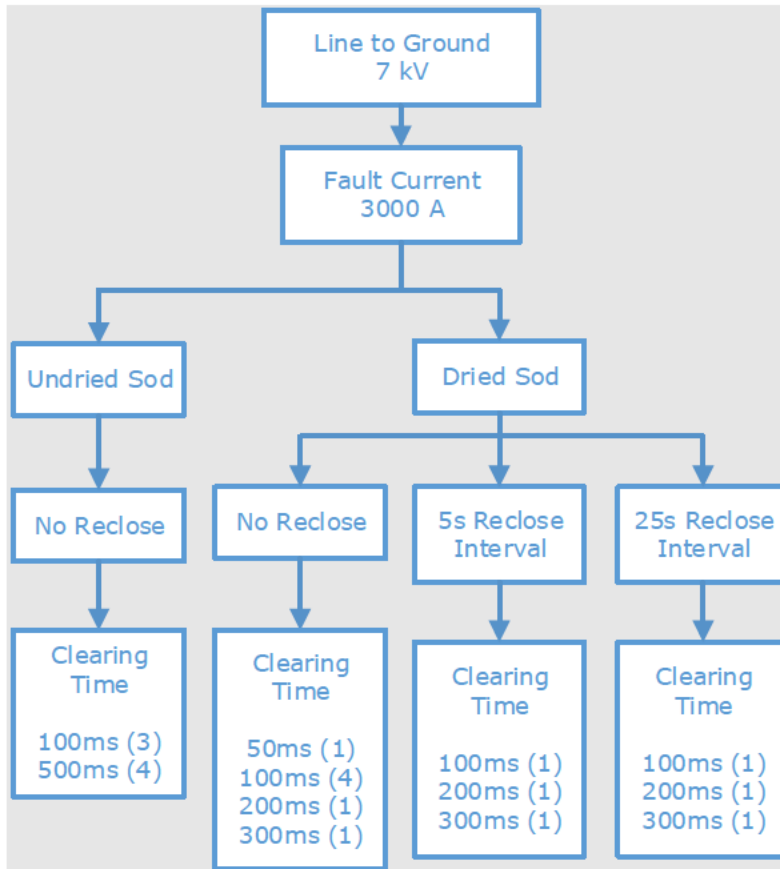


Figure 7: Line-to-ground fault @ 3000A Test Tree Diagram

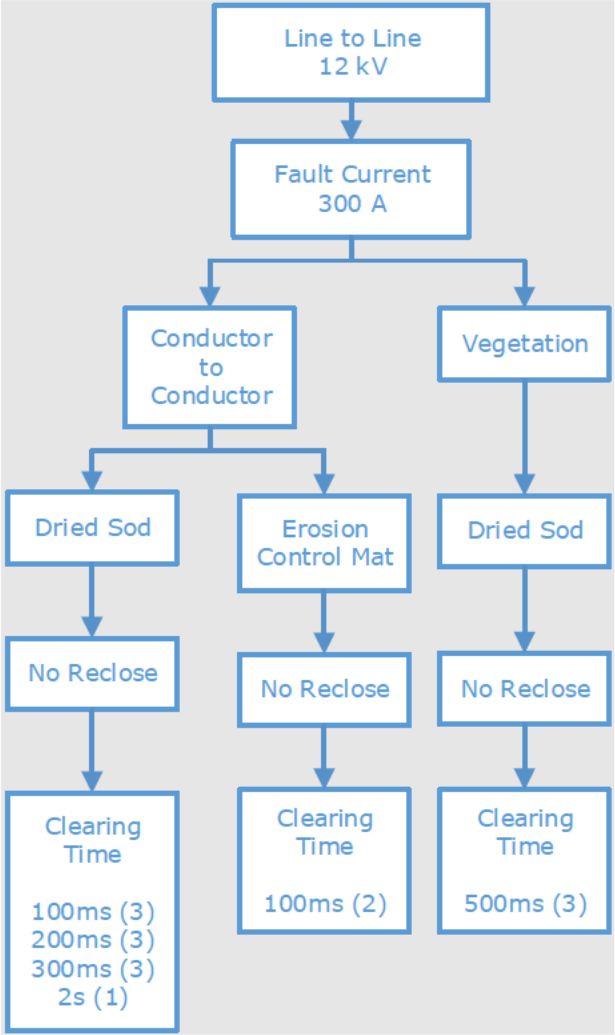


Figure 8: Line to line fault @ 300A Test Tree Diagram

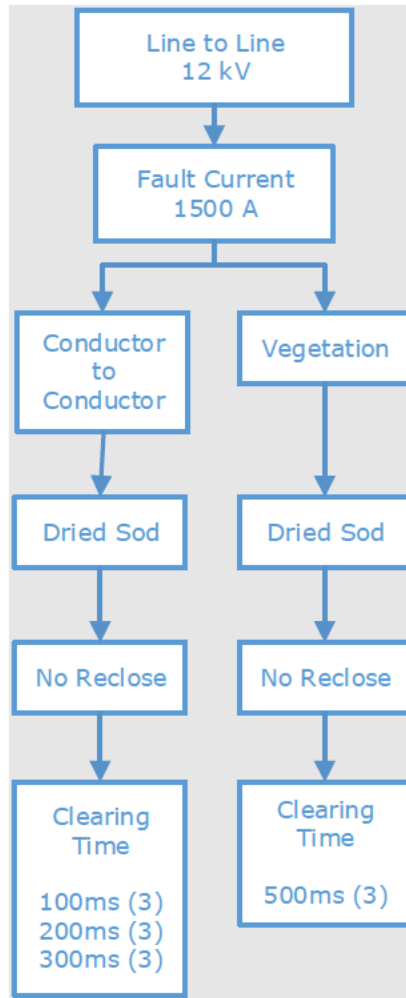


Figure 9: Line to line fault @ 1500A Test Tree Diagram

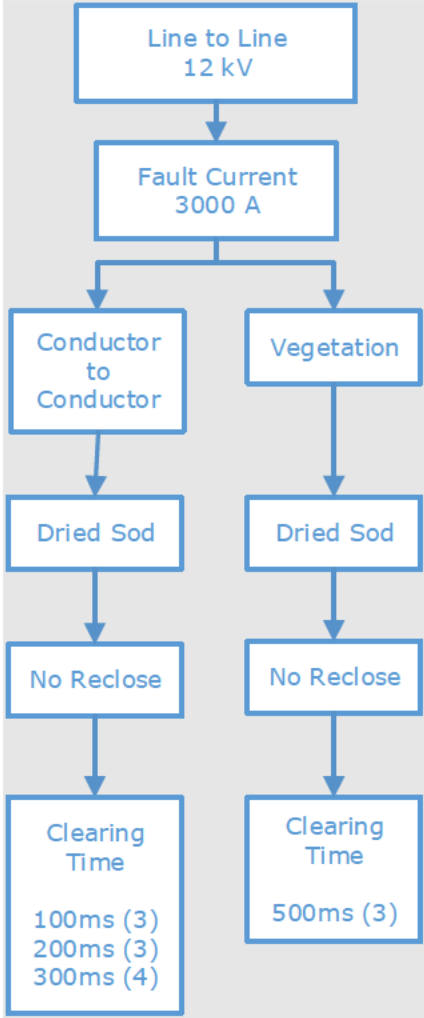


Figure 10: Line to line fault @ 3000A Test Tree Diagram

Attachment 2: Test Data

Test ID	Fault Type	Fault Current	Reclose	Faut Duration	Soil Type	1 st Fault Current (RMS)			Reclose interval (sec)	2nd Fault Current (RMS)		Post Test Comment	Fire Severity	Ignition Rank
						Full Fault Length (cycle)	B Phase (A)	C Phase (A)		Full Fault Length (cycle)	B Phase (A)			
300A L-G														
24	BG	300A	No Reclose	100ms	Dried SOD	8.02	325					Fire observed. 1 fire spot ignited and self-extinguish after ~20sec	3	2
52	BG	300A	No Reclose	100ms	Dried SOD	8.1	337					Fire observed. 2 fire spots ignited and self-extinguish after ~10sec	4	2
54	BG	300A	No Reclose	100ms	Dried SOD	7.9	332					Fire observed. 1 fire spot ignited and self-extinguish after ~10sec	2	2
55	BG	300A	No Reclose	100ms	Dried SOD	8.05	325					Fire observed. 1 fire spot ignited and self-extinguish after ~10sec	2	2
57	BG	300A	No Reclose	100ms	Dried SOD	7.76	366					Fire observed. 2 fire spots ignited and did not self-extinguish.	5	3
58	BG	300A	No Reclose	100ms	Dried SOD	8.00	323					Fire observed. 1 fire spot ignited and self-extinguish after ~5sec	2	2
41	BG	300A	No Reclose	100ms	Erosion Mat	7.65	360					Fire observed. 1 fire spot ignited and did not self-extinguish	5	3
43	BG	300A	No Reclose	100ms	Erosion Mat	7.69	364					Fire observed. 1 fire spot ignited and did not self-extinguish	5	3
44	BG	300A	No Reclose	100ms	Erosion Mat	7.69	338					Fire observed. 2 fire spots ignited. Did not self-extinguish	5	3
48	BG	300A	No Reclose	100ms	Erosion Mat	8.11	334					Fire observed. 2 fire spots ignited. Did not self-extinguish	5	3
49	BG	300A	No Reclose	100ms	Erosion Mat	7.73	351					Fire observed. 1 fire spot ignited and did not self-extinguish	5	3
50	BG	300A	No Reclose	100ms	Erosion Mat	7.94	332					Fire observed. 2 fire spots ignited. Did not self-extinguish	5	3
3	BG	300A	No Reclose	100ms	Undried SOD	8.06	326					No fire observed.	1	1
193	BG	300A	No Reclose	100ms	Undried SOD		326					No Fire observed. Wire drop was after the recording, so no data	1	1
194	BG	300A	No Reclose	100ms	Undried SOD	7.97	323					No Fire observed.	1	1
195	BG	300A	No Reclose	100ms	Undried SOD	7.93	324					No Fire observed.	1	1
196	BG	300A	No Reclose	100ms	Undried SOD	8.15	320					No Fire observed.	1	1
28	BG	300A	No Reclose	200ms	Dried SOD	13.91	331					Fire observed. 1 fire spot ignited and self-extinguish after ~2sec	2	2

Internal

Test ID	Fault Type	Fault Current	Reclose	Faut Duration	Soil Type	1 st Fault Current (RMS)			Reclose interval (sec)	2nd Fault Current (RMS)		Post Test Comment	Fire Severity	Ignition Rank
						Full Fault Length (cycle)	B Phase (A)	C Phase (A)		Full Fault Length (cycle)	B Phase (A)			
71	BG	300A	No Reclose	200ms	Dried SOD	14.30	325					Fire observed. 2 fire spots ignited and self-extinguish after ~30sec	4	2
72	BG	300A	No Reclose	200ms	Dried SOD	13.64	346					Fire observed. 1 fire spot ignited and self-extinguish after ~20sec	3	2
74	BG	300A	No Reclose	200ms	Dried SOD	14.27	330					Fire observed. multiple fire spots ignited and self-extinguish after ~10sec	4	2
75	BG	300A	No Reclose	200ms	Dried SOD	13.52	330					Fire observed. 1 fire spot ignited, appear to almost extinguish in 10s but the flame gets bigger again. Finally self-extinguish after ~20sec	3	3
76	BG	300A	No Reclose	200ms	Dried SOD	14.11	327					Fire observed. 3 fire spots ignited and self-extinguish after ~15sec	4	3
8	BG	300A	No Reclose	200ms	Undried SOD	14.14	318					No fire observed.	1	1
106	BG	300A	No Reclose	2s	Dried SOD	2.0352s	326					Fire observed. 1 fire spot ignited and self-extinguish after ~50sec	5	3
108	BG	300A	No Reclose	2s	Dried SOD	2.03	325					Fire observed. 1 fire spot ignited and self-extinguish after ~25sec. The fire spot is very big	5	3
109	BG	300A	No Reclose	2s	Dried SOD	2.03	321					Fire observed. 1 fire spot ignited and self-extinguish after ~35sec	5	3
110	BG	300A	No Reclose	2s	Dried SOD	2.03	326					Fire observed. 1 fire spot ignited and self-extinguish after ~25sec	4	2
111	BG	300A	No Reclose	2s	Dried SOD	2.03	329					Fire observed. 1 fire spot ignited and self-extinguish after ~15sec	3	2
31	BG	300A	No Reclose	300ms	Dried SOD	19.96	320					Fire observed. 2 fire spots ignited.1st one extinguishes in 7s, 3rd one self-extinguish after ~15sec	4	2
88	BG	300A	No Reclose	300ms	Dried SOD	20.23	328					Fire observed. 2 fire spots ignited and self-extinguish after ~30sec	4	2
89	BG	300A	No Reclose	300ms	Dried SOD	19.75	336					Fire observed. 1 fire spot ignited and self-extinguish after ~20sec	4	2
90	BG	300A	No Reclose	300ms	Dried SOD	19.54	330					Fire observed. 2 fire spots ignited and self-extinguish after ~15sec	2	2
91	BG	300A	No Reclose	300ms	Dried SOD	20.18	347					Fire observed. 1 fire spot ignited and self-extinguish after ~25sec	4	2

Test ID	Fault Type	Fault Current	Reclose	Faut Duration	Soil Type	1 st Fault Current (RMS)			Reclose interval (sec)	2nd Fault Current (RMS)		Post Test Comment	Fire Severity	Ignition Rank
						Full Fault Length (cycle)	B Phase (A)	C Phase (A)		Full Fault Length (cycle)	B Phase (A)			
92	BG	300A	No Reclose	300ms	Dried SOD	20.12	326					Fire observed. 1 fire spot ignited and self-extinguish after ~20sec	3	2
11	BG	300A	No Reclose	300ms	Undried SOD	20.23	325					No fire observed.	1	1
34	BG	300A	No Reclose	400ms	Dried SOD	26.08	326					Fire observed. 1 fire spot ignited and self-extinguish after ~20sec	3	2
14	BG	300A	No Reclose	400ms	Undried SOD	26.29	322					No fire observed.	1	1
37	BG	300A	No Reclose	500ms	Dried SOD	32.01	330					Fire observed. 1 fire spot ignited and self-extinguish after ~5sec	2	2
18	BG	300A	No Reclose	500ms	Undried SOD	32.11	318					Few fire spots observed but extinguish immediately	2	2
198	BG	300A	No Reclose	500ms	Undried SOD	32.13	323					No Fire observed.	1	1
199	BG	300A	No Reclose	500ms	Undried SOD	32.29	319					No Fire observed.	1	1
200	BG	300A	No Reclose	500ms	Undried SOD	32.15	322					No Fire observed.	1	1
201	BG	300A	No Reclose	500ms	Undried SOD	32.26	310					No Fire observed.	1	1
25	BG	300A	2 shot 5 sec	100ms	Dried SOD	7.99	329		5.02	9.47	329	Fire observed on 1st shot, did not completely extinguish before 2nd shot. Fire observed on 2nd shot, self-extinguish ~15s after fault clear	3	2
59	BG	300A	2 shot 5 sec	100ms	Dried SOD	8.26	353			8.26	353	fire observed on 1st shot, self-extinguish in ~5s after fault clear. Fire observed on 2nd shot, self-extinguish in 5s after fault clear	2	2
62	BG	300A	2 shot 5 sec	100ms	Dried SOD	8.07	331		5.02	8.56	325	Fire observed on 1st shot, did not self-extinguish before 2nd shot. Fire observed on 2nd shot, self-extinguish in ~2s after fault clear	2	2
63	BG	300A	2 shot 5 sec	100ms	Dried SOD	7.73	368		5.03	12.03	322	Fire observed on 1st shot, did not self-extinguish before 2nd shot. Fire observed on 2nd shot, self-extinguish in ~10s after fault clear	2	2
64	BG	300A	2 shot 5 sec	100ms	Dried SOD	8.02	326		5.02	8.48	327	Fire observed on 1st shot, did not self-extinguish before 2nd shot. Fire observed on 2nd shot, self-extinguish in ~10s after fault clear	2	2

Test ID	Fault Type	Fault Current	Reclose	Faut Duration	Soil Type	1 st Fault Current (RMS)			2nd Fault Current (RMS)			Post Test Comment	Fire Severity	Ignition Rank
						Full Fault Length (cycle)	B Phase (A)	C Phase (A)	Reclose interval (sec)	Full Fault Length (cycle)	B Phase (A)			
65	BG	300A	2 shot 5 sec	100ms	Dried SOD	8.65	340		5.02	8.07	332	Fire observed on 1st shot, did not self-extinguish before 2nd shot. Fire observed on 2nd shot, self-extinguish in ~5s after fault clear.	2	2
6	BG	300A	2 shot 5 sec	100ms	Undried SOD	7.65	340		5.02	8.49	326	No fire observed.	1	1
29	BG	300A	2 shot 5 sec	200ms	Dried SOD	13.97	325		5.05	14.03	328	Fire observed on 1st shot, did not extinguish before 2nd shot. fire observed on 2nd shot, self-extinguish ~5s after fault cleared	2	2
77	BG	300A	2 shot 5 sec	200ms	Dried SOD	13.97	328		6.16	14.06	326	Fire observed on 1st shot, self-extinguish in ~5s. Fire observed on 2nd shot, self-extinguish in ~25s after fault clear	3	2
78	BG	300A	2 shot 5 sec	200ms	Dried SOD	13.66	345		5.02	15.17	336	Fire observed on 1st shot, did not self-extinguish before 2nd shot. Fire observed on 2nd shot, self-extinguish in ~15s after fault clear	3	2
79	BG	300A	2 shot 5 sec	200ms	Dried SOD	13.72	335		5.02	21.69	330	Fire observed on 1st shot, did not self-extinguish before 2nd shot. Fire observed on 2nd shot, self-extinguish in ~20s after fault clear	3	2
80	BG	300A	2 shot 5 sec	200ms	Dried SOD	14.03	324		5.01	14.27	342	Fire observed on 1st shot, did not self-extinguish before 2nd shot. Fire observed on 2nd shot, self-extinguish in ~10s after fault clear	2	2
81	BG	300A	2 shot 5 sec	200ms	Dried SOD	13.63	351		5.02	14.62	327	Fire observed on 1st shot, did not self-extinguish before 2nd shot. Fire observed on 2nd shot, self-extinguish in ~10s after fault clear	2	2
9	BG	300A	2 shot 5 sec	200ms	Undried SOD	14.14	326		5.02	14.55	332	No fire observed.	1	1
32	BG	300A	2 shot 5 sec	300ms	Dried SOD	20.05	324		5.01	20.62	324	Fire observed on 1st shot, did not self-extinguish before 2nd shot. 2nd shots create bigger flame and burn area, fire self-extinguish in 5s.	2	2

Test ID	Fault Type	Fault Current	Reclose	Faut Duration	Soil Type	1 st Fault Current (RMS)			2 nd Fault Current (RMS)			Post Test Comment	Fire Severity	Ignition Rank
						Full Fault Length (cycle)	B Phase (A)	C Phase (A)	Reclose interval (sec)	Full Fault Length (cycle)	B Phase (A)			
93	BG	300A	2 shot 5 sec	300ms	Dried SOD	20.26	323		5.01	20.12	332	Fire observed on 1st shot, did not self-extinguish before 2nd shot. Fire observed on 2nd shot, self-extinguish in ~25s after fault clear	4	2
94	BG	300A	2 shot 5 sec	300ms	Dried SOD	20.02	328		5.02	20.25	346	Fire observed on 1st shot, did not self-extinguish before 2nd shot. Fire observed on 2nd shot, self-extinguish in ~10s after fault clear	2	2
97	BG	300A	2 shot 5 sec	300ms	Dried SOD	19.89	327		5.02	20.33	339	Fire observed on 1st shot, did not self-extinguish before 2nd shot. Fire observed on 2nd shot, self-extinguish in ~5s after fault clear	2	2
98	BG	300A	2 shot 5 sec	300ms	Dried SOD	19.81	329		5.02	20.27	339	Fire observed on 1st shot, did not self-extinguish before 2nd shot. Fire observed on 2nd shot, self-extinguish in ~50s after fault clear	5	3
99	BG	300A	2 shot 5 sec	300ms	Dried SOD	19.79	334		5.02	36.53	329	Fire observed on 1st shot, did not self-extinguish before 2nd shot. Fire observed on 2nd shot, self-extinguish in ~20s after fault clear	3	2
12	BG	300A	2 shot 5 sec	300ms	Undried SOD	20.15	325		5.02	20.18	330	No fire observed.	1	1
35	BG	300A	2 shot 5 sec	400ms	Dried SOD	26.06	327		5.02	26.69	339	Fire observed on 1st shot, did not self-extinguish before 2nd shot. Fire observed on 2nd shot, self-extinguish in ~20s after fault cleared	3	2
15	BG	300A	2 shot 5 sec	400ms	Undried SOD	26.29	317		5.01	26.93	326	No fire observed.	1	1
38	BG	300A	2 shot 5 sec	500ms	Dried SOD	32.22	326		5.01	33.76	326	Fire observed on 1st shot, did not self-extinguish before 2nd shot. Fire observed on 2nd shot, self-extinguish in 10s after fault cleared	2	2
19	BG	300A	2 shot 5 sec	500ms	Undried SOD	32.11	324		5.02	33.10	331	Fire observed on 2nd shot but self-extinguish in ~10sec after the fault cleared	2	2
27	BG	300A	2 shot 25 sec	100ms	Dried SOD	8.03	326		25.01	8.66	350	Fire observed on 1st and 2nd shot. both self-extinguish in 3 sec after fault clear	2	2

Test ID	Fault Type	Fault Current	Reclose	Faut Duration	Soil Type	1 st Fault Current (RMS)			Reclose interval (sec)	2nd Fault Current (RMS)		Post Test Comment	Fire Severity	Ignition Rank
						Full Fault Length (cycle)	B Phase (A)	C Phase (A)		Full Fault Length (cycle)	B Phase (A)			
66	BG	300A	2 shot 25 sec	100ms	Dried SOD	7.52	329		25.02	8.63	357	Fire observed on 1st shot, self-extinguish in ~5s after fault clear. Fire observed on 2nd shot, self-extinguish in ~5s after fault clear	2	2
67	BG	300A	2 shot 25 sec	100ms	Dried SOD	8.07	346		25.01	8.48	335	fire observed on 1st shot, self-extinguish in ~2s after fault clear. Fire observed on 2nd shot, self-extinguish in 5s after fault clear	2	2
68	BG	300A	2 shot 25 sec	100ms	Dried SOD	8.02	326		25.02	8.18	353	fire observed on 1st shot, self-extinguish in ~8s after fault clear. Fire observed on 2nd shot, self-extinguish in ~5s after fault clear	2	2
69	BG	300A	2 shot 25 sec	100ms	Dried SOD	8.06	327		25.02	14.50	331	fire observed on 1st shot, self-extinguish in ~5s after fault clear. Fire observed on 2nd shot, self-extinguish in 10s after fault clear	2	2
70	BG	300A	2 shot 25 sec	100ms	Dried SOD	8.04	338		25.01	8.59	360	fire observed on 1st shot, self-extinguish in ~10s after fault clear. Fire observed on 2nd shot, self-extinguish in ~5s after fault clear	2	2
7	BG	300A	2 shot 25 sec	100ms	Undried SOD	7.97	331		25.02	8.67	336	No fire observed.	1	1
30	BG	300A	2 shot 25 sec	200ms	Dried SOD	14.02	324		26.08	14.06	327	smoldering observed prior, small flame observed after 1st shot. self-extinguish after 1s. fire observed on 2nd shot, self-extinguish in 5s after fault clear	2	2
83	BG	300A	2 shot 25 sec	200ms	Dried SOD	13.99	327		25.01	14.76	354	Fire observed on 1st shot, self-extinguish Fire observed on 2nd shot, self-extinguish in. 272 Breaker did not open. Manual Open is required.	2	2
84	BG	300A	2 shot 25 sec	200ms	Dried SOD	13.98	328		25.02	14.48	326	Fire observed on 1st shot, did not self-extinguish before 2nd shot. Fire observed on 2nd shot, self-extinguish in ~20s after fault clear	3	2

Test ID	Fault Type	Fault Current	Reclose	Faut Duration	Soil Type	1 st Fault Current (RMS)			2nd Fault Current (RMS)			Post Test Comment	Fire Severity	Ignition Rank
						Full Fault Length (cycle)	B Phase (A)	C Phase (A)	Reclose interval (sec)	Full Fault Length (cycle)	B Phase (A)			
85	BG	300A	2 shot 25 sec	200ms	Dried SOD	13.97	330		25.02	14.05	324	Fire observed on 1st shot, self-extinguish in ~15s. Fire observed on 2nd shot, self-extinguish in ~1min after fault clear	5	3
86	BG	300A	2 shot 25 sec	200ms	Dried SOD	13.97	326		25.02	22.05	325	Fire observed on 1st shot, self-extinguish in ~15s. Fire observed on 2nd shot, self-extinguish in ~35s after fault clear	5	3
87	BG	300A	2 shot 25 sec	200ms	Dried SOD	13.69	333		25.02	14.08	354	Fire observed on 1st shot, did not self-extinguish before 2nd shot. Fire observed on 2nd shot, self-extinguish in ~15s after fault clear	3	2
10	BG	300A	2 shot 25 sec	200ms	Undried SOD	14.03	327		25.02	14.32	339	Small fire observed but self-extinguish about ~2-4s after 2nd shot has cleared.	2	2
33	BG	300A	2 shot 25 sec	300ms	Dried SOD	19.95	325					Fire observed on 1st shot, self-extinguish in 10s after fault clear. fire observed on 2nd shot, self-extinguish in 10s	2	2
100	BG	300A	2 shot 25 sec	300ms	Dried SOD	19.55	333		25.34	20.09	347	Fire observed on 1st shot, self-extinguish in ~10s. Fire observed on 2nd shot, self-extinguish in ~20s after fault clear	3	2
101	BG	300A	2 shot 25 sec	300ms	Dried SOD	20.11	328		25.01	20.18	342	Fire observed on 1st shot, self-extinguish in ~10s. Fire observed on 2nd shot, self-extinguish in ~15s after fault clear	3	2
102	BG	300A	2 shot 25 sec	300ms	Dried SOD	19.54	335		25.04	20.56	326	Fire observed on 1st shot, self-extinguish in ~15s. Fire observed on 2nd shot, self-extinguish in ~30s after fault clear	4	2
103	BG	300A	2 shot 25 sec	300ms	Dried SOD	19.94	328		25.01	39.19	329	Fire observed on 1st shot, self-extinguish in ~10s. Fire observed on 2nd shot, self-extinguish in ~15s after fault clear	3	2

Test ID	Fault Type	Fault Current	Reclose	Faut Duration	Soil Type	1 st Fault Current (RMS)			Reclose interval (sec)	2nd Fault Current (RMS)		Post Test Comment	Fire Severity	Ignition Rank
						Full Fault Length (cycle)	B Phase (A)	C Phase (A)		Full Fault Length (cycle)	B Phase (A)			
104	BG	300A	2 shot 25 sec	300ms	Dried SOD	19.94	326		25.01	36.99	331	Fire observed on 1st shot, did not self-extinguish before 2nd shot. Fire observed on 2nd shot, self-extinguish in ~30s after fault clear	4	2
13	BG	300A	2 shot 25 sec	300ms	Undried SOD	20.03	325		25.02	20.20	337	No fire observed. Smoldering observed but self-extinguish	1	1
36	BG	300A	2 shot 25 sec	400ms	Dried SOD	25.85	320		25.30	26.44	333	Fire observed on 1st shot, self-extinguish in 5s after fault clear. fire observed on 2nd shot, self-extinguish in ~5sec after fault clear	2	2
17	BG	300A	2 shot 25 sec	400ms	Undried SOD	26.12	323		25.01	26.89	336	No fire observed. Lots of particles dropped on the floor on 1st shot	1	1
39	BG	300A	2 shot 25 sec	500ms	Dried SOD	32.18	328		25.02	31.91	336	Fire observed on 1st shot, self-extinguish in ~5s after fault clear. Fire observed on 2nd shot, self-extinguish in 10s after fault clear	2	2
21	BG	300A	2 shot 25 sec	500ms	Undried SOD	32.11	331		5.02	32.30	332	Fire observed on 1st shot but extinguish about 3-5 sec. Multiple fire spots observed on 2nd shot but self-extinguish abbot 2-5sec after fault cleared	2	2
1500A L-G														
113	BG	1500A	No Reclose	100ms	Dried SOD	8.43	1509					Fire observed. 1 fire spot ignited and self-extinguish after ~25sec. Lots of particles	4	2
208	BG	1500A	No Reclose	100ms	Dried SOD	8.05	1501					Fire observed. 1 fire spot ignited and self-extinguish after ~15 sec	3	2
209	BG	1500A	No Reclose	100ms	Dried SOD	8.08	1483					Fire observed. 1 large fire spot ignited and self-extinguish after ~30 sec	4	2
210	BG	1500A	No Reclose	100ms	Dried SOD	8.05	1501					Fire observed. 3 fire spots ignited and self-extinguish after ~15 sec	4	2
126	BG	1500A	No Reclose	100ms	Erosion Mat	7.97	1533					Fuel bed ignited. Multiple fire spot ignited. Did not self-extinguish	5	3
202	BG	1500A	No Reclose	100ms	Undried SOD	8.03	1482					No Fire observed.	1	1
203	BG	1500A	No Reclose	100ms	Undried SOD	7.93	1484					No Fire observed.	1	1
204	BG	1500A	No Reclose	100ms	Undried SOD	8.12	1481					No Fire observed.	1	1

Test ID	Fault Type	Fault Current	Reclose	Faut Duration	Soil Type	1 st Fault Current (RMS)			2nd Fault Current (RMS)			Post Test Comment	Fire Severity	Ignition Rank
						Full Fault Length (cycle)	B Phase (A)	C Phase (A)	Reclose interval (sec)	Full Fault Length (cycle)	B Phase (A)			
116	BG	1500A	No Reclose	200ms	Dried SOD	14.23	1542					Fire observed. 2 fire spots ignited and self-extinguish after ~20sec. Lots of particles	4	2
119	BG	1500A	No Reclose	300ms	Dried SOD	20.05	1510					Fire observed. 3 fire spots ignited and self-extinguish after ~25sec. Lots of particles	4	2
125	BG	1500A	No Reclose	500ms	Undried SOD	31.99	1425					No Fire observed but lot of hot particles landed on the SOD. some smoldering observed	1	1
205	BG	1500A	No Reclose	500ms	Undried SOD	31.99	1476					No Fire observed.	1	1
206	BG	1500A	No Reclose	500ms	Undried SOD	32.26	1442					No Fire observed.	1	1
207	BG	1500A	No Reclose	500ms	Undried SOD	32.24	1428					No Fire observed.	1	1
114	BG	1500A	2 shot 5 sec	100ms	Dried SOD	7.73	1464		5.08	7.98	1487	Fire observed on 1st shot, did not self-extinguish before 2nd shot. Fire observed on 2nd shot, self-extinguish in ~10s after fault clear. The fault blows a hole on the copper plate. lot of particles	2	2
117	BG	1500A	2 shot 5 sec	200ms	Dried SOD	14.06	1517		5.02	14.11	1545	Fire observed on 1st shot, did not self-extinguish before 2nd shot. Fire observed on 2nd shot, self-extinguish in ~15s after fault clear. lot of particles	2	2
120	BG	1500A	2 shot 5 sec	300ms	Dried SOD	19.91	1463		5.02	21.02	1472	Fire observed on 1st shot, did not self-extinguish before 2nd shot. Fire observed on 2nd shot, self-extinguish in ~25s after fault clear. lot of particles	4	2
115	BG	1500A	2 shot 25 sec	100ms	Dried SOD	7.72	1646		25.04	7.99	1489	Fire observed on 1st shot, self-extinguish in ~5s. Fire observed on 2nd shot, self-extinguish in ~10s after fault clear. lot of particles	2	2
118	BG	1500A	2 shot 25 sec	200ms	Dried SOD	14.12	1442		25.02	14.25	1527	Fire observed on 1st shot, self-extinguish in ~20s. Fire observed on 2nd shot, self-extinguish in ~10s after fault clear	3	2

Test ID	Fault Type	Fault Current	Reclose	Faut Duration	Soil Type	1 st Fault Current (RMS)			Reclose interval (sec)	2nd Fault Current (RMS)		Post Test Comment	Fire Severity	Ignition Rank
						Full Fault Length (cycle)	B Phase (A)	C Phase (A)		Full Fault Length (cycle)	B Phase (A)			
123	BG	1500A	2 shot 25 sec	300ms	Dried SOD	20.18	1551		25.01	20.32	1510	Fire observed on 1st shot, did not self-extinguish before 2nd shot. Fire observed on 2nd shot, self-extinguish in ~35s after fault clear. lot of particles	5	3
3000A L-G														
131	BG	3000A	No Reclose	100ms	Dried SOD	7.96	2982					Fuel bed ignited. 2 big fire spots ignited. Did not self-extinguish	5	3
217	BG	3000A	No Reclose	100ms	Dried SOD	8.26	3052					Fire observed. 1 big fire spot ignited and self-extinguish after ~1 min. Recloser reclosed when it shouldn't	5	3
219	BG	3000A	No Reclose	100ms	Dried SOD	8.01	2921					Fire observed. 1 big fire spot ignited and self-extinguish after ~20 sec	4	2
220	BG	3000A	No Reclose	100ms	Dried SOD	8.47	2932					Fire observed. Multiple fire spot ignited and self-extinguish after ~35 sec	4	3
211	BG	3000A	No Reclose	100ms	Undried SOD	7.97	2993					No Fire observed.	1	1
212	BG	3000A	No Reclose	100ms	Undried SOD	7.94	3017					No Fire observed.	1	1
213	BG	3000A	No Reclose	100ms	Undried SOD	7.94	2949					No Fire observed.	1	1
137	BG	3000A	No Reclose	200ms	Dried SOD	14.46	2943					Fire observed. 1 large fire spot ignited and self-extinguish after ~30sec. Lots of particles	4	2
141	BG	3000A	No Reclose	300ms	Dried SOD	19.98	2873					Fire observed. Multiple fire spot ignited. Did not self-extinguish. Lots of particles landed outside the SOD	5	3
214	BG	3000A	No Reclose	500ms	Undried SOD	32.74	2833					No fire., the arc is escaping thru the cooper plate	1	1
215	BG	3000A	No Reclose	500ms	Undried SOD	32.32	2814					Fire observed	1	2
216	BG	3000A	No Reclose	500ms	Undried SOD	32.15	2893					No Fire observed on SOD	1	1
144	BG	3000A	No Reclose	500ms	Undried SOD	31.93	2733					No Fire observed.	1	
145	BG	3000A	No Reclose	50ms	Dried SOD	4.95	2937					Fire observed. 2 fire spots ignited and self-extinguish after ~25sec.	4	
134	BG	3000A	2 shot 5 sec	100ms	Dried SOD	8.04	2958		5.2743	8.58	2942	Fire observed on 1st shot, self-extinguish in ~4s before 2nd shot. Fire observed on 2nd shot, self-extinguish in ~15s.	3	2

Test ID	Fault Type	Fault Current	Reclose	Faut Duration	Soil Type	1 st Fault Current (RMS)			2nd Fault Current (RMS)			Post Test Comment	Fire Severity	Ignition Rank
						Full Fault Length (cycle)	B Phase (A)	C Phase (A)	Reclose interval (sec)	Full Fault Length (cycle)	B Phase (A)			
139	BG	3000A	2 shot 5 sec	200ms	Dried SOD	13.57	2961		5.0185	44.02	2616	Fire observed on 1st shot, did not self-extinguish before 2nd shot. Fire observed on 2nd shot, did not self-extinguish. The 2nd shot duration is longer that it should.	5	3
142	BG	3000A	2 shot 5 sec	300ms	Dried SOD	20.11	2907		5.0147	20.17	2902	Fire observed on 1st, did not self-extinguish before 2nd shot. Fire observed on 2nd shot, did not self-extinguish.	5	3
136	BG	3000A	2 shot 25 sec	100ms	Dried SOD	8.05	3010		25.012	8.57	2913	Fire observed on 1st shot, the flame disappeared in ~20s but it appears to be still smoldering before 2nd shot. Fire observed on 2nd shot, self-extinguish in ~45s	5	3
140	BG	3000A	2 shot 25 sec	200ms	Dried SOD	13.66	3030		25.0491	14.56	2920	Fire observed on 1st shot, the flame disappeared but still smoldering before 2nd shot. Fire observed on 2nd shot, self-extinguish in ~15s	3	2
143	BG	3000A	2 shot 25 sec	300ms	Dried SOD	20.24	2914		25.1091	20.37	2554	Fire observed on 1st, did not self-extinguish before 2nd shot. Fire observed on 2nd shot, did not self-extinguish.	5	3
300A L-L														
149	BC	300A	No Reclose	100ms	Erosion Mat	7.58	376	378				Minimal Sparks observed. The conductor welded on one phase	1	1
150	BC	300A	No Reclose	100ms	Erosion Mat	7.69	428	435				Sparks and fire observed. 1 fire spot ignited. Did not self-extinguish.	5	3
151	BC	300A	No Reclose	100ms	Dried SOD	8.01	363	363				Sparks observed. No Fire observed. Particles appear to be landed on the concrete floor	1	1
152	BC	300A	No Reclose	100ms	Dried SOD	7.73	455	444				Sparks observed. No Fire observed.	1	1
153	BC	300A	No Reclose	100ms	Dried SOD	7.69	408	403				Spark observed. No Fire. Observed particles landed on concrete. Not captured on IR	1	1
154	BC	300A	No Reclose	200ms	Dried SOD	13.87	397	396				Sparks observed. No Fire.	1	1
155	BC	300A	No Reclose	200ms	Dried SOD	200ms	383	425				Fire observed, 2 fire spots ignited and self-extinguish after ~10s	2	2

Internal

Test ID	Fault Type	Fault Current	Reclose	Faut Duration	Soil Type	1 st Fault Current (RMS)			Reclose interval (sec)	2nd Fault Current (RMS)		Post Test Comment	Fire Severity	Ignition Rank
						Full Fault Length (cycle)	B Phase (A)	C Phase (A)		Full Fault Length (cycle)	B Phase (A)			
156	BC	300A	No Reclose	200ms	Dried SOD	13.8	564	437				Fire observed, 1 fire spots ignited and self-extinguish after ~10s	2	2
157	BC	300A	No Reclose	300ms	Dried SOD	19.67	390	392				Fire observed, 1 fire spots ignited and self-extinguish after ~10s	2	2
158	BC	300A	No Reclose	300ms	Dried SOD	20.61	366	367				Fire observed, 1 fire spots ignited and self-extinguish after ~5s	2	2
159	BC	300A	No Reclose	300ms	Dried SOD	20.73	406	400				Sparks observed. No Fire observed	1	1
160	BC	300A	No Reclose	2s	Dried SOD	2.04s	365	365				Fire observed, multiple fire spots ignited and self-extinguish after ~15s	4	2
161	BC	300A	No Reclose	500ms	Dried SOD	30.76	341	340				Particles and smoldering Observed. No fire observed.	1	1
162	BC	300A	No Reclose	500ms	Dried SOD	32.22	355	354				Particles observed. No Fire observed	1	1
163	BC	300A	No Reclose	500ms	Dried SOD	32.06	353	352				No Fire observed.	1	1
1500A L-L														
168	BC	1500A	No Reclose	500ms	Dried SOD	32.46	1241	1238				No Fire observed.	1	1
169	BC	1500A	No Reclose	500ms	Dried SOD	32.21	1239	1236				No fire observed. Observed multiple hot particles and smoldering. Measure about 18A on B, 8.601 A on C prior to fault	1	1
170	BC	1500A	No Reclose	500ms	Dried SOD	31.97	1239	1236				Particles observed but no fire. Measure about 6.9A prior to fault	1	1
171	BC	1500A	No Reclose	100ms	Dried SOD	8.95	1281	1278				Fire observed, multiple fire spots ignited. Did not self-extinguish. Lots of particles landed on SOD	5	3
172	BC	1500A	No Reclose	100ms	Dried SOD	8.96	1279	1276				Fire observed, 1 fire spots ignited and self-extinguish after ~5s. Lots of particles landed on SOD	2	2
173	BC	1500A	No Reclose	100ms	Dried SOD	8.98	1296	1293				Fire observed, 1 fire spots ignited and self-extinguish after ~5s. Lots of particles landed on SOD	2	2
174	BC	1500A	No Reclose	200ms	Dried SOD	17.8	1361	1360				Fire observed, 1 fire spots ignited and self-extinguish after ~20s. Lots of particles landed on SOD	3	2
175	BC	1500A	No Reclose	200ms	Dried SOD	15.06	1288	1286				Fire observed, 1 fire spots ignited and self-extinguish after ~5s. Lots of particles landed on SOD	2	2

Test ID	Fault Type	Fault Current	Reclose	Faut Duration	Soil Type	1 st Fault Current (RMS)			Reclose interval (sec)	2nd Fault Current (RMS)		Post Test Comment	Fire Severity	Ignition Rank
						Full Fault Length (cycle)	B Phase (A)	C Phase (A)		Full Fault Length (cycle)	B Phase (A)			
176	BC	1500A	No Reclose	200ms	Dried SOD	17.81	1367	1373				Fire observed, 2 fire spots ignited. Did not self-extinguish. Lots of particles landed on SOD	5	3
177	BC	1500A	No Reclose	300ms	Dried SOD	21.1	1272	1270				Fire observed, multiple fire spots ignited and self-extinguish after ~20s. Lots of particles landed on SOD	4	2
178	BC	1500A	No Reclose	300ms	Dried SOD	21.25	1297	1296				No fire observed. Lots of particles observed. Some are blowing away from SOD	1	1
179	BC	1500A	No Reclose	300ms	Dried SOD	21.02	1298	1296				Sparks and fire observed, self-extinguish in ~20s	4	2
3000A L-L														
180	BC	3000A	No Reclose	100ms	Dried SOD	8.96	2525	2520				Sparks observed. SOD ignited, did not self-extinguish	5	3
181	BC	3000A	No Reclose	100ms	Dried SOD	12.71	2765	2759				Sparks observed, no fire observed. Lot of particles were landed on the concrete	1	1
182	BC	3000A	No Reclose	100ms	Dried SOD	11.63	2793	2786				Sparks observed, no fire observed. Lot of particles were landed on the concrete	1	1
183	BC	3000A	No Reclose	200ms	Dried SOD	14.84	2670	2664				Sparks observed, no fire observed. Lot of particles were landed on the concrete	1	1
184	BC	3000A	No Reclose	200ms	Dried SOD	18.28	2694	2688				Sparks observed. SOD ignited, did not self-extinguish	5	3
185	BC	3000A	No Reclose	200ms	Dried SOD	17.87	2624	2629				Sparks observed. SOD ignited, did not self-extinguish	5	3
186	BC	3000A	No Reclose	300ms	Dried SOD	24.19	2581	2605				Sparks observed, smoldering observed. Lot of particles were landed on the concrete	1	1
187	BC	3000A	No Reclose	300ms	Dried SOD	21.18	2598	2592				Sparks observed. SOD ignited, did not self-extinguish	5	3
188	BC	3000A	No Reclose	300ms	Dried SOD	21.15	2575	2569				Sparks observed, smoldering observed. Lot of particles were landed on the concrete	1	1

Test ID	Fault Type	Fault Current	Reclose	Faut Duration	Soil Type	1 st Fault Current (RMS)			Reclose interval (sec)	2nd Fault Current (RMS)		Post Test Comment	Fire Severity	Ignition Rank
						Full Fault Length (cycle)	B Phase (A)	C Phase (A)		Full Fault Length (cycle)	B Phase (A)			
192	BC	3000A	No Reclose	300ms	Dried SOD	24.2	2628	2622				Particles observed. No Fire observed. Wind blows all the particles away	1	1
189	BC	3000A	No Reclose	500ms	Dried SOD	32.14	2511	2506				Particles observed. No Fire observed	1	1
190	BC	3000A	No Reclose	500ms	Dried SOD	32.24	2527	2521				Particles observed. No Fire observed	1	1
191	BC	3000A	No Reclose	500ms	Dried SOD	32.61	2504	2498				Particles observed. No Fire observed	1	1