



**DEPARTMENT OF VETERANS AFFAIRS  
VA MEDICAL CENTER – ERIE, PA**

Contract No. V244-P-1779  
TWN Project No. 2113994

August 2011

Fault Current Study and Arc Flash Analysis

SECTION 2

**SHORT CIRCUIT ANALYSIS**

## 2.0 SHORT CIRCUIT ANALYSIS

### 2.1 Introduction to Short Circuit Analysis

A power system Short Circuit Study is used to calculate system fault current duties which can be compared with the short circuit current ratings of circuit-interrupting devices, such as circuit breakers and fuses, and guide the selection and rating or setting of short circuit protective devices such as direct-acting, trips, fuses, and relays.

### 2.2 Short Circuit Analysis Procedures (General)

The Short Circuit Study begins with the representation of the electric power distribution system in matrix form in a digital computer. Each of the power system components (utility sources, generators, motors, transformers, cables, etc.) is represented by an impedance value (resistance and reactance or reactance alone). The computer program places an assumed three-phase fault at each bus location in the system, and a set of short circuit currents is calculated which could be compared with the published short circuit ratings of the power system equipment including interrupting devices.

Interrupting devices must be able to withstand and interrupt the most severe short circuit currents realizable in the actual system. Three-phase bolted faults at maximum load, maximum utility short circuit MVA available, and maximum local generation are usually considered most severe. Under some conditions tie breakers in the distribution system are assumed to be closed to produce the highest possible short circuit currents.

The calculation techniques used are in accordance with the American National Standards C37.13-1990 for low-voltage circuit breakers, C37.010-1999 and C37.50-1989 (R2000) for medium-voltage and high-voltage circuit breakers.

ANSI Code provides an easy way to enter ANSI Standard impedances and interrupting duty multipliers for motors. Code numbers are chosen according to the motor types, sizes and modeling method. Regardless of the code chosen, ANSI Standard interrupting value multipliers are used.

Using the ANSI Code field is the recommended method to enter motor impedances to assure that the proper interrupting duty impedance multiplier is used for ANSI Standard calculations.

TABLE 1: IMPEDANCE MULTIPLIERS FOR ANSI STANDARD SHORT CIRCUIT CALCULATIONS			
CODE	MOTOR	MOMENTARY DUTY FIRST- CYCLE	INTERRUPTING DUTY 1.5-4 CYCLES
1.	Synchronous	$1.0 X''_{dv}$	$1.5 X''_{dv}$
2.	Induction Motor > 1000 HP or > 250 HP @ 3600 RPM	$1.0 X''_{dv}$	$1.0 X''_{dv}$
3.	Induction Motor Group > 50 HP	$1.2 X''_{dv}$	$3.0 X''_{dv}$
4.	Induction Motor Group < 50 HP	$1.67 X''_{dv}$	Infinite $X''_{dv}$
5.	Lumped Induction Motor Group	$1.0 X''_{dv}$ (X=25%)	$3.0 X''_{dv}$
Note: $X''$ for induction motor groups three (3) and four (4) are typically assumed equal to 16.7%. This corresponds to an equivalent motor contribution of 3.6 to 4.8 times the full load current.			

All system connected motors and generators are assumed to be operating unless noted otherwise. This assumption produces the highest calculated short circuit currents since the rotating machine contributions are maximized.

The results of the short circuit analysis are shown in Section 2.6. By comparing the calculated short circuit current magnitudes to the specific electrical protective equipment interrupting ratings, any equipment adequately or inadequately rated from a short circuit standpoint can be quickly detected. All device ratings and data are taken from the Model computer program database. This information follows manufacturing, ANSI, NEMA, and NEC standards.

### **2.3 Specific Short Circuit Analysis Procedures (See Appendix VII)**

### **2.4 Short Circuit Analysis Single Lines and Naming**

The Model<sup>®</sup> short circuit single-line diagram, included in electronic format on a CD and in the Appendix V, is explained in Section 5.1 of this report. This single-line represents electrical power distribution system. All tables and text contained in the study are referenced to the diagrams. Being the foundation of the study, the diagrams include only the data and system parameters pertinent to the study.

The single-line diagrams can be a valuable aid for maintaining, trouble-shooting and planning expansion of the electrical distribution system. It is important, however, that the diagrams be periodically updated to show any system changes. Thus, future system analyses or additions can be easily made since the basic database has been established and can be continually updated.

To facilitate the making and reading of the Model's single line diagrams, some basic rules were used in identifying the system components. The description for numbering the different electrical components is listed below. The Model's short circuit model sets many of the default letters for the basic identification of the electrical components, such as PNL for a panel.

The abbreviations for each electrical device used are as follows:

ABBREVIATION	DESCRIPTION	ABBREVIATION	DESCRIPTION
UTL	Utility source	MTR	Motor
GEN	Generator	C	Cable
BUS	Electrical bus	X	Transmission line
BWY	Busway	MCC	Motor control center
CLR	Current-limiting reactor	SH	Shunt reactor
CAP	Capacitor	FL	Filter
XFM	2-winding transformer	TW	3-winding transformer
BL	Low-voltage breaker	TZ	Zigzag transformer
BH	High-voltage breaker	MET	Meter
FSW	Fused switch	PNL	Panel
SWI	Switch	CT	Current transformer
LD	Load	R	relay

Once the above abbreviations are established, a numbering system was needed to identify each individual electrical component. No two (2) devices can have the same name. If two (2) components were defined identically, the computer program would reject the second component and would not allow that component to be entered on the single line diagram. The maximum alphanumeric character allowed to identify a component is sixteen (16). The larger the alphanumeric name, the more difficult it is to fit on the single line diagram. This is especially true when the Model single line diagram is illustrated with short circuit, load flow, or Arc Flash numbers.

The bus connections are the key elements on every short circuit single-line diagram. A bus defines the connection point for two or more pieces of equipment. Each piece of equipment, i.e. cable or breaker; must be connected to a bus. The computer program does not allow a cable to be connected to a transformer. A bus must be established and identified before this connection can be made.

Therefore, in identifying the buses on the Model short circuit computer single-line diagram, the Electrical single-line diagrams were used as a basis for the layout and identification.

Special attention was given to the adoption of established naming conventions for devices and busses. This was done in recognition of prior studies and equipment designation. Where possible, prior naming conventions were adopted.

To identify buses not identified on the single-line diagrams but required by the Model computer program, a system of alphanumeric numbers was generated in sequence by the computer program. A bus established to connect a piece of equipment is generally named in accordance with the equipment which the bus is connected to.

## 2.5 Short Circuit Evaluation Table(s) (see Following Tables)

Bus Evaluation Comprehensive Fault Report (1 of 3)						
Bus Name	Status	EquipCategory	Calc Isc kA	Dev Isc kA	Isc Rating%	
003A SWGR-1A	Pass	Switchgear	4.20	40.00	10.51	
003B SWGR-1B	Pass	Switchgear	4.20	40.00	10.51	
007 SWBD-1A	Marginal	LV Switchboard	64.89	65.00	99.83	
007 SWBD-1B	Fail	LV Switchboard	65.08	65.00	100.12	
009 SWBD-2B	Pass	LV Switchboard	36.82	65.00	56.65	
014 ATS-1	Marginal	LV Panelboard	9.65	10.00	96.46	
028 PP1	Pass	LV Panelboard	5.65	10.00	56.54	
029 SWBD-2A	Pass	LV Switchboard	30.21	65.00	46.48	
032A MDP-1	Pass	LV Switchboard	52.56	65.00	80.86	
032B MDP-2	Pass	LV Switchboard	50.84	65.00	78.21	
033 RTU 2-FLR	Pass	LV Panelboard	4.80	10.00	47.95	
034 PP68-E-B9	Pass	LV Panelboard	13.01	22.00	59.13	
038 AHU WH-209	Pass	LV Panelboard	17.23	100.00	17.23	
039 FAN WH-209	Pass	LV Panelboard	5.51	100.00	5.51	
040 CHILLER BUS	Pass	LV Panelboard	31.87	100.00	31.87	
041 P-4 (PP-4A)	Pass	LV Panelboard	11.02	65.00	16.95	
043 AIR C.C. BUS0	Pass	LV Panelboard	2.82	10.00	28.23	
044 A-EE-200	Marginal	LV Panelboard	21.96	22.00	99.81	
045 M-P/S	Fail	LV Panelboard	25.34	22.00	115.17	
046 LP-P/S	Pass	LV Panelboard	12.15	22.00	55.25	
047 AC NURSING	Pass	LV Panelboard	17.24	65.00	26.52	
048 B-EE-200	Fail	LV Panelboard	23.38	22.00	106.28	
050 HEAT RECOVERY BU	Pass	LV Panelboard	10.54	65.00	16.22	
052 LS-PL	Pass	LV Panelboard	14.48	65.00	22.27	
053 LS-3E	Marginal	LV Panelboard	9.41	10.00	94.07	
056 KPS	Pass	LV Panelboard	8.74	22.00	39.75	
058 AC LAB	Pass	LV Panelboard	25.94	65.00	39.90	
059 OUTPATIENT	Fail	LV Panelboard	55.95	10.00	559.47	
062 PP9	Pass	LV Panelboard	7.05	22.00	32.02	
BUS-0005	Unknown	0	0.00	0.00	0.00	
BUS-0605	Pass	LV Panelboard	45.21	65.00	69.55	
BUS-0606	Pass	LV Panelboard	33.69	100.00	33.69	
BUS-0607	Pass	LV Panelboard	19.00	65.00	29.24	
BUS-B1 Dental Unit	Pass	LV Panelboard	4.38	10.00	43.78	
BUS: 75T CH CP	Fail	LV Panelboard	10.34	10.00	103.40	
BUS: ACCU-1	Marginal	LV Panelboard	9.31	10.00	93.05	
PNL: B1 1BWA	Fail	LV Panelboard	11.90	10.00	118.96	
PNL: B1 A (laundry)	Pass	LV Panelboard	1.77	35.00	5.05	
PNL: B1 A (on ATS-EL)	Fail	LV Panelboard	14.41	10.00	144.06	
PNL: B1 A1	Pass	LV Panelboard	3.30	22.00	14.98	
PNL: B1 AA	Pass	LV Panelboard	8.77	30.00	29.23	
PNL: B1 BB	Pass	LV Panelboard	8.52	18.00	47.34	
PNL: B1 C	Pass	LV Panelboard	5.99	22.00	27.22	
PNL: B1 C-WH100	Pass	LV Panelboard	5.25	10.00	52.50	
PNL: B1 C2	Pass	LV Panelboard	6.80	22.00	30.93	
PNL: B1 CA	Pass	LV Panelboard	8.55	22.00	38.88	
PNL: B1 CC-1N-ER	Pass	LV Panelboard	13.06	22.00	59.35	
PNL: B1 CC-2W-ER	Pass	LV Panelboard	14.25	22.00	64.79	
PNL: B1 CC-2WERA	Pass	LV Panelboard	12.35	22.00	56.14	
PNL: B1 CC-3E	Pass	LV Panelboard	11.64	18.00	64.65	
PNL: B1 CC-E1-7W	Pass	LV Panelboard	4.69	10.00	46.85	
PNL: B1 CC-E1-7W-A	Pass	LV Panelboard	5.23	10.00	52.30	
PNL: B1 CC-E1-DWB	Fail	LV Panelboard	10.77	10.00	107.67	
PNL: B1 CC-W1	Pass	LV Panelboard	7.00	22.00	31.82	

### Bus Evaluation Comprehensive Fault Report (2 of 3)

Bus Name	Status	EquipCategory	Calc Isc kA	Dev Isc kA	Isc Rating%
PNL: B1 CC-W2	Pass	LV Panelboard	6.70	22.00	30.43
PNL: B1 CC1-2LW	Pass	LV Panelboard	12.03	22.00	54.67
PNL: B1 CC1-3E2	Pass	LV Panelboard	16.15	22.00	73.43
PNL: B1 CC1-4E2	Pass	LV Panelboard	15.01	22.00	68.23
PNL: B1 CC1-4LW	Marginal	LV Panelboard	9.39	10.00	93.88
PNL: B1 CC1-5EA	Pass	LV Panelboard	14.02	22.00	63.72
PNL: B1 CC1-5LW	Pass	LV Panelboard	8.98	10.00	89.80
PNL: B1 CC1-6EA	Pass	LV Panelboard	13.63	22.00	61.98
PNL: B1 CC1-EA	Pass	LV Panelboard	12.68	22.00	57.62
PNL: B1 CC2-BW	Pass	LV Panelboard	12.84	22.00	58.37
PNL: B1 CC3-N	Pass	LV Panelboard	13.86	22.00	62.99
PNL: B1 CC3-NB	Pass	LV Panelboard	11.12	18.00	61.77
PNL: B1 CC3-NC	Pass	LV Panelboard	13.08	22.00	59.44
PNL: B1 CCA	Pass	LV Panelboard	9.87	22.00	44.84
PNL: B1 CCA-1	Pass	LV Panelboard	9.51	22.00	43.23
PNL: B1 CCB	Pass	LV Panelboard	10.60	22.00	48.18
PNL: B1 CT Scan Rm	Marginal	LV Panelboard	9.29	10.00	92.92
PNL: B1 DENTAL PUMP	Pass	LV Panelboard	0.54	65.00	0.83
PNL: B1 DP-BE	Pass	LV Panelboard	13.05	42.00	31.08
PNL: B1 DP-CC-E	Fail	LV Panelboard	27.05	22.00	122.94
PNL: B1 DP-CC-E1	Fail	LV Panelboard	29.86	22.00	135.74
PNL: B1 DP-ES-E	Fail	LV Panelboard	30.60	22.00	139.08
PNL: B1 DP-ES-E1	Pass	LV Panelboard	16.00	22.00	72.74
PNL: B1 DP-ES-R1	Pass	LV Panelboard	5.66	10.00	56.64
PNL: B1 DP-LS-E	Marginal	LV Panelboard	21.59	22.00	98.14
PNL: B1 EM-1	Pass	LV Panelboard	14.90	22.00	67.75
PNL: B1 EM-DP	Pass	LV Switchboard	11.03	85.00	12.98
PNL: B1 EM-LR	Pass	LV Panelboard	11.31	25.00	45.25
PNL: B1 ES-2E	Marginal	LV Panelboard	21.43	22.00	97.42
PNL: B1 ES-8N	Pass	LV Panelboard	4.80	22.00	21.81
PNL: B1 ES-BE	Pass	LV Panelboard	13.34	18.00	74.08
PNL: B1 ES-BN	Pass	LV Panelboard	7.44	22.00	33.80
PNL: B1 ES-BW	Pass	LV Panelboard	6.63	18.00	36.85
PNL: B1 ES-PH	Pass	LV Panelboard	19.38	22.00	88.09
PNL: B1 ES-PH2	Pass	LV Panelboard	12.63	22.00	57.40
PNL: B1 ES-SB	Pass	LV Panelboard	5.41	10.00	54.06
PNL: B1 ES-SPD	Pass	LV Panelboard	19.38	22.00	88.09
PNL: B1 ES1	Pass	LV Panelboard	5.81	10.00	58.07
PNL: B1 ES1- BW	Pass	LV Panelboard	4.49	10.00	44.89
PNL: B1 ES1-1	Pass	LV Panelboard	7.95	22.00	36.13
PNL: B1 ES1-2WA	Pass	LV Panelboard	7.20	10.00	72.00
PNL: B1 ES1-BW	Marginal	LV Panelboard	9.15	10.00	91.53
PNL: B1 ES1-CNA	Pass	LV Panelboard	8.72	10.00	87.24
PNL: B1 ES1-CNB	Pass	LV Panelboard	8.34	22.00	37.90
PNL: B1 ES1-CNC	Pass	LV Panelboard	8.44	22.00	38.34
PNL: B1 ES1-WA	Pass	LV Panelboard	5.60	10.00	55.98
PNL: B1 ES2-BN	Pass	LV Panelboard	6.71	10.00	67.10
PNL: B1 ESE-1	Fail	LV Panelboard	10.33	10.00	103.25
PNL: B1 ESE-1-K-3	Pass	LV Panelboard	9.57	22.00	43.50
PNL: B1 ESE-1-K-3A	Pass	LV Panelboard	8.78	22.00	39.90
PNL: B1 ESE-1-K1	Pass	LV Panelboard	7.33	22.00	33.34
PNL: B1 ESE-1-K2	Pass	LV Panelboard	5.51	22.00	25.03
PNL: B1 ESE-16W	Pass	LV Panelboard	8.62	10.00	86.20
PNL: B1 KP2	Pass	LV Panelboard	6.42	10.00	64.19
PNL: B1 LE-1C	Pass	LV Panelboard	6.67	18.00	37.05
PNL: B1 LE-1D	Pass	LV Panelboard	6.39	22.00	29.05
PNL: B1 LP-7	Pass	LV Panelboard	5.09	10.00	50.94
PNL: B1 LP-7E	Pass	LV Panelboard	7.57	22.00	34.42
PNL: B1 LS-2N	Pass	LV Panelboard	2.28	10.00	22.83
PNL: B1 LS-3E	Pass	LV Panelboard	4.88	10.00	48.85
PNL: B1 LS-3W	Pass	LV Panelboard	3.51	18.00	19.51



### Bus Evaluation Comprehensive Fault Report (3 of 3)

Bus Name	Status	EquipCategory	Calc Isc kA	Dev Isc kA	Isc Rating%
PNL: B1 LS-6E	Pass	LV Panelboard	3.47	22.00	15.77
PNL: B1 LS-8N	Pass	LV Panelboard	1.37	10.00	13.69
PNL: B1 LS-BE	Pass	LV Panelboard	8.23	65.00	12.66
PNL: B1 LS-BN	Pass	LV Panelboard	4.07	10.00	40.69
PNL: B1 LS-BW	Pass	LV Panelboard	3.84	18.00	21.33
PNL: B1 LS1-2EB	Pass	LV Panelboard	15.44	22.00	70.19
PNL: B1 LS1-BEA	Pass	LV Panelboard	10.08	22.00	45.82
PNL: B1 LS1-EA	Pass	LV Panelboard	17.13	22.00	77.88
PNL: B1 LS1A	Pass	LV Panelboard	3.87	22.00	17.61
PNL: B1 LS2-BE	Pass	LV Panelboard	13.78	22.00	62.63
PNL: B1 LSGR	Pass	LV Panelboard	12.15	18.00	67.53
PNL: B1 MCC-EA	Pass	LV MCC	9.28	42.00	22.09
PNL: B1 N-4E	Pass	LV Panelboard	5.09	22.00	23.11
PNL: B1 N-5E	Pass	LV Panelboard	4.83	22.00	21.95
PNL: B1 N-6E	Pass	LV Panelboard	4.60	22.00	20.90
PNL: B1 N1A	Pass	LV Panelboard	1.62	22.00	7.36
PNL: B1 N1B	Pass	LV Panelboard	4.21	10.00	42.13
PNL: B1 N2A-1	Pass	LV Panelboard	4.24	22.00	19.26
PNL: B1 N2A-2	Pass	LV Panelboard	4.20	22.00	19.10
PNL: B1 N2B	Pass	LV Panelboard	4.20	22.00	19.10
PNL: B1 N3W	Pass	LV Panelboard	2.71	18.00	15.06
PNL: B1 N4W	Pass	LV Panelboard	4.24	10.00	42.44
PNL: B1 N5W	Pass	LV Panelboard	4.12	10.00	41.20
PNL: B1 N6W	Pass	LV Panelboard	4.09	10.00	40.88
PNL: B1 OP	Pass	LV Panelboard	6.47	10.00	64.68
PNL: B1 P2M	Pass	LV Panelboard	4.38	10.00	43.76
PNL: B1 PP	Pass	LV Panelboard	13.80	25.00	55.19
PNL: B1 PP-1	Pass	LV Panelboard	6.17	10.00	61.66
PNL: B1 PP-10	Pass	LV Panelboard	2.84	10.00	28.43
PNL: B1 PP-11	Fail	LV Panelboard	10.59	10.00	105.91
PNL: B1 PP-2	Pass	LV Panelboard	6.71	10.00	67.05
PNL: B1 PP-4B	Pass	LV Panelboard	6.03	10.00	60.34
PNL: B1 PP-4C	Pass	LV Panelboard	4.78	22.00	21.74
PNL: B1 PP-8	Pass	LV Panelboard	3.58	10.00	35.76
PNL: B1 SUB-PANEL	Pass	LV Panelboard	10.37	18.00	57.59
PNL: B1 Tosh Rm	Marginal	LV Panelboard	9.29	10.00	92.92
PNL: B1 UPS	Pass	LV Panelboard	6.64	10.00	66.37
PNL: B1 W1-72	Fail	LV Panelboard	14.56	10.00	145.64
PNL: B1 WB-H	Pass	LV Panelboard	6.93	22.00	31.48
PNL: B1 WH-207	Pass	LV Panelboard	19.06	22.00	86.63
PNL: B1 XRAY 208	Pass	LV Panelboard	24.74	100.00	24.74
PNL: B1 XRAY 480	Pass	LV Panelboard	10.17	30.00	33.89
PNL: B10 GEN	Pass	LV Panelboard	4.93	10.00	49.32
PNL: B10A DIST PNL	Pass	LV Panelboard	7.02	10.00	70.22
PNL: B2 1ST FL	Pass	LV Panelboard	2.02	10.00	20.16
PNL: B2 2ND FL	Pass	LV Panelboard	2.07	10.00	20.74
PNL: B2 BASEMENT	Pass	LV Panelboard	2.73	10.00	27.32
PNL: B2 DIST	Pass	LV Panelboard	2.80	10.00	28.01
PNL: B3 DIST	Pass	LV Panelboard	3.91	10.00	39.10
PNL: B3A L-1F	Pass	LV Panelboard	3.56	10.00	35.62
PNL: B3A L-2F	Pass	LV Panelboard	3.31	10.00	33.06
PNL: B3B R-1F	Pass	LV Panelboard	3.50	10.00	34.98
PNL: B3B R-2F	Pass	LV Panelboard	3.25	10.00	32.49
PNL: B4 BSMT	Pass	LV Panelboard	4.06	10.00	40.62
PNL: B4 L-1F	Pass	LV Panelboard	4.07	10.00	40.74
PNL: B4 L-1F0	Pass	LV Panelboard	4.07	10.00	40.74
PNL: B4 L-2F	Pass	LV Panelboard	3.75	10.00	37.55
PNL: B4 L-2F0	Pass	LV Panelboard	3.75	10.00	37.55
PNL: B5 BSMT	Pass	LV Panelboard	3.87	10.00	38.75
PNL: B5 DIST	Pass	LV Panelboard	4.12	10.00	41.22
PNL: B5 MH1	Pass	LV Panelboard	3.39	10.00	33.95
PNL: B5 MH3-1	Pass	LV Panelboard	3.33	22.00	15.16
PNL: B5 PAUVILION	Pass	LV Panelboard	2.76	10.00	27.63
PNL: B6 "C" in Hallway	Pass	LV Panelboard	1.48	10.00	14.82
PNL: B6 A	Pass	LV Panelboard	2.08	10.00	20.82
PNL: B6 Bsmnt SubPnl	Pass	LV Panelboard	1.58	10.00	15.76
PNL: B7 NE1	Pass	LV Panelboard	4.99	22.00	22.68
PNL: CB	Pass	LV Panelboard	7.20	22.00	32.73

Summarized Devices for Consideration										
Device Evaluation - Comprehensive Bus Report										
Connected Bus	DevName	Bus Voltage	Frame Voltage	Frame/Trip	Status	Calc Int kA	Dev Int kA	Int Rating %	Series Rating	
007 SWBD-1A	008-2 SWBD-2A LSI	480	480	2,500	Marginal	64.891	65	0	65	
	008-3 DPG-1 LSI	480	480	400	Marginal	64.891	65	0	65	
	008-4 SPARE LSI	480	480	400	Marginal	64.891	65	0	65	
	008-5 SPARE LSI	480	480	400	Marginal	64.891	65	0	65	
	008-6 SPARE LSI	480	480	1,200 / 800	Marginal	64.891	65	0	65	
007 SWBD-1B	007-2 SWBD-2B LSI	480	480	2,500	Fail	65.076	65	0	65	
	007-3 DPG-2 LSI	480	480	400	Fail	65.076	65	0	65	
	007-4 SPARE LSI	480	480	400	Fail	65.076	65	0	0	
	007-5 SPARE LSI	480	480	400	Fail	65.076	65	0	65	
	007-6 SPARE LSI	480	480	1,200 / 800	Fail	65.076	65	0	65	
015 DP-BP-2	015-2 Mech Shops	208	240	200	Marginal	9.5205	10	0	0	
	015-4 H	208	240	200	Marginal	9.5205	10	0	0	
024 MP1	024-2	480	480	20	Fail	40.274	18	0	0	
029 SWBD-2A	029-5 SPARE	480	600	250	Fail	30.211	25	0	0	
041 P-4 (PP-4A)	CB: B1 PNL PP-4B	208	240	225 / 125	Fail	11.33	10	0	0	
	CB: B1 PNL PP-4C	208	240	225 / 125	Fail	11.33	10	0	0	
	CB: B1 RTU1	208	240	225 / 150	Fail	11.33	10	0	0	
044 A-EE-200	CB: B1 PNL A Main	208	240	225 / 125	Marginal	21.959	22	0	0	
045 M-P/S	CB: COND PUMP-1	208	240	15	Fail	25.338	22	0	0	
	CB: CW PUMP-1	208	240	30	Fail	25.338	22	0	0	
	CB: CW PUMP-2	208	240	30	Fail	25.338	22	0	0	
	CB: HW-PUMP-1	208	240	20	Fail	25.338	22	0	0	
048 B-EE-200	CB: B1 PNL B Main	208	240	225	Fail	23.382	22	0	0	
BUS: Laundry 12kV	FU: XF LAUNDRY	12470	15500	50	Fail	4.0863	2.5	0	0	
BUS: XRAY 12kV Tap	FU: XF XRAY_208V	12470	15500	50	Fail	4.0356	2.5	0	0	
PNL: B1 1BWA	CB: B1 AC COMP RM	208	240	100	Fail	11.896	10	0	0	
PNL: B1 CC1-2LW	CB: B1 CC1-2LW-MAIN	208	240	225	Fail	12.113	10	0	0	
PNL: B1 CC1-4LW	CB: B1 CC1-4LW-MAIN	208	240	225	Marginal	9.3879	0	0	10	
PNL: B1 CC1-5EA	CB: B1 CC1-5EA-MAIN	208	240	225 / 200	Fail	14.197	10	0	0	
PNL: B1 CC3-N	CB: B1 CC3-NB	208	240	100 / 60	Marginal	13.857	14	0	0	

Note: Information only shown for devices NOT resulting in "PASS"



Summarized Devices for Consideration										
Device Evaluation - Comprehensive Bus Report										
Connected Bus	DevName	Bus Voltage	Frame Voltage	Frame/Trip	Status	Calc Int kA	Dev Int kA	Int Rating	Series Rating	
	CB: B1 CC3-NC	208	240	225 / 200	Fail	14.305	0	0	10	
PNL: B1 CCA-1	CB: B1 HTR	208	240	50 / 40	Marginal	9.5112	10	0	0	
PNL: B1 DP-CC-E	CB: B1 CC-2W-ER, 2WER6	208	240	400	Fail	27.047	22	0	0	
	CB: B1 CC3E	208	240	225 / 175	Fail	27.047	22	0	0	
	CB: B1 CC3-N, NB, NC	208	240	400	Fail	27.047	22	0	0	
	CB: B1 CCA	208	240	400 / 250	Fail	27.047	22	0	0	
PNL: B1 DP-CC-E	CB: B1 CCB	208	240	225 / 200	Fail	27.047	22	0	0	
	CB: B1 CC-W1, W2	208	240	225 / 150	Fail	27.047	22	0	0	
	CB: B1 LS1-EA, 2EB, LS2-E	208	240	400	Fail	27.047	22	0	0	
PNL: B1 DP-CC-E1	CB: B1 CC1-2LW, 4LW, 5LW	208	240	400	Fail	29.863	22	0	0	
	CB: B1 CC1-3E2, 4E2, 5EA, 6E	208	240	400	Fail	29.863	22	0	0	
	CB: B1 CC1-EA	208	240	225 / 150	Fail	29.863	22	0	0	
	CB: B1 WH-207	208	240	225	Fail	29.863	22	0	0	
PNL: B1 DP-ES-E	CB: B1 ES-2	208	240	400	Fail	30.598	22	0	0	
	CB: B1 ES-BE	208	240	225	Fail	30.598	22	0	0	
	CB: B1 ES-BN	208	240	225 / 200	Fail	30.598	22	0	0	
	CB: B1 ES-BW	208	240	225	Fail	30.598	22	0	0	
	CB: B1 ES-PH	208	240	225	Fail	30.598	22	0	0	
	CB: B1 ES-SPD	208	240	225	Fail	30.598	22	0	0	
	CB: B1 MCC-EA	208	240	400	Fail	30.598	22	0	0	
PNL: B1 DP-LS-E	CB: B1 3E, 6E, 8N, LS-BE	208	240	225 / 150	Marginal	21.591	22	0	0	
	CB: B1 ESE-1-K-3	208	240	225	Marginal	21.591	22	0	0	
	CB: B1 LS-BW, 3W	208	240	225 / 125	Marginal	21.591	22	0	0	
	CB: B1 LSGR, LE-1C, SUB	208	240	225 / 150	Marginal	21.591	22	0	0	
PNL: B1 ES-2E	CB: B1 AC	208	240	50 / 40	Fail	22.938	10	0	0	
PNL: B1 ES-2E	CB: B1 ES-2-MAIN	208	240	400	Marginal	21.433	22	0	0	
	CB: B1 GRILL	208	240	50	Fail	22.938	10	0	0	
	CB: B1 OVEN	208	240	100 / 70	Fail	22.938	10	0	0	
PNL: B1 ESE-1	CB: B1 ESE-1-MAIN	208	240	225	Fail	10.325	0	0	10	
PNL: B1 ES-PH	CB: B1 ES-PH2	208	240	100 / 60	Fail	19.38	10	0	0	
PNL: B1 LS2-BE	CB: B1 LS1-BEA	208	240	100 / 60	Fail	13.779	10	0	0	
PNL: B1 LS-3W	CB: B1 LS-3W	208	240	60	Fail	3.5111	0	0	0	
PNL: B1 LSGR	CB: B1 LSGR-MAIN	208	240	225	Fail	12.155	0	0	10	
	CB: B1 SUB-PNL	208	240	225 / 125	Fail	12.155	0	0	0	
PNL: B1 P2M	CB: B1 P2M-MAIN	208	240	225	Fail	4.3761	0	0	0	
PNL: B1 PP-11	CB: B1 ACC 2	208	240	30	Fail	10.563	10	0	0	
PNL: B1 XRAY 208	CB: B1 1N	208	240	200	Marginal	24.737	25	0	0	
	CB: B1 PNL 1BWA	208	240	200	Marginal	24.737	25	0	0	
	CB: B1 PNL PP	208	240	200	Marginal	24.737	25	0	0	

Note: Information only shown for devices NOT resulting in "PASS"

## Information Used in the Calculations (Input Data)

### 2.5.1 Power Company Data

In attempting to gather the appropriate Power Company Information, it was identified that Mike Dzuricky is the Penelec Account Manager in Customer Support/Erie.

On August 2, 2011, TEAMWORKnet requested utility data from Mr. Dzuricky for the power system study including Arc Flash Labeling for VAMC – Erie, PA. From this conversation, TEAWORKnet was informed that this request will need to come from either Tony or Doug Pollock at VAMC.

Subsequently Doug Pollock requested the Utility information from T&D with a request to send it back to Doug Pollock at VAMC. Specifically, requested was:

Information for French Rd. and Glenwood feeds to the facility in order to update our study appropriately:

1. System impedance
2. 3 phase fault current
3. Phase-to-ground fault current

Additionally, it was understood that the information was provided 3-years ago for both Glenwood and French Rd.

Name:	UTIL: GLENWOOD		<input checked="" type="checkbox"/> In Service	Incomplete	U
Initial Operating Conditions					
Voltage:	1.000	pu	Angle:	0.00	Degrees
<input checked="" type="radio"/> Enter MVA/kVA/Amps <input type="radio"/> Enter Per Unit <input data-bbox="711 1291 824 1323" type="button" value="Update..."/>					
Utility Contribution					
Three Phase:	2955.1	Amps	X/R:	2.560	
Line to Ground:	2403.8	Amps		2.120	
Per Unit Contribution					
Base/Rated MVA:	100.0	Positive	R	0.570064	X
Base/Rated Voltage (L-L):	12470	Zero		1.324978	2.307297

Name:	UTIL: FRENCH RD.		<input checked="" type="checkbox"/> In Service	Incomplete	U
Initial Operating Conditions					
Voltage:	0.970	pu	Angle:	0.00	Degrees
<input checked="" type="radio"/> Enter MVA/kVA/Amps <input type="radio"/> Enter Per Unit <input data-bbox="1360 1291 1474 1323" type="button" value="Update..."/>					
Utility Contribution					
Three Phase:	4140.0	Amps	X/R:	4.410	
Line to Ground:	3531.9	Amps		3.250	
Per Unit Contribution					
Base/Rated MVA:	100.0	Positive	R	0.247313	X
Base/Rated Voltage (L-L):	12470	Zero		0.661913	1.577452

TEAMWORKnet was informed by Doug Pollock that it may take a while for Penelec to get back to him and VAMC did not want the delay, keep things moving, and the importance of getting the panels labeled.

To the extent that this information is not obtained, the 3 year old information could be converted. Ideally, the Base/Rated MVA and Base/Rated Voltage along with three phase and Line to Ground current contribution and X/R ratio for each are needed.

The model was based on the existing data (2008 / 2009) and can be summarized as follows:

The facility medium voltage switchgear is served by two utility feeders. The utility, PENELEC, has advised that the "FRENCH" or East feeder is capable of delivering a maximum available three-phase short-circuit current of 4140A at 12,470V with an X/R ratio of 4.41. The "GLENWOOD" West feeder is capable of delivering a maximum available three-phase shortcircuit current of 2947A at 12,470V with an X/R ratio of 2.56. These values determined the starting point for the analysis.

#### **2.5.2 Cable Data**

The "Feeder Schedule" model list the conductor (cable and/or busway) data used for each circuit segment. Included are lengths, number per phase, size, conductor material, cable insulation type, conduit material and resistance and reactance values. Also, conductor lengths, number per phase, and size and conductor material are recorded on the one-line diagrams. (See Appendix V)

Resistance values are based on 25 degrees Celsius (room temperature) rather than the full load temperature usually shown in descriptive literature since short-circuits can occur when the circuit is initially energized or lightly loaded as well as when fully loaded. The resistance and reactance values are typical values obtained from a study of data from various conductor manufactures.

Values are tabulated according to whether several single conductors or one multiple conductor is used and whether the conduit is steel, aluminum or plastic.

#### **2.5.3 Transformer Data**

Nameplate transformer percent impedance and typical X/R ratio values were used for all transformers. The exact R and X component values used are shown on the "Transformer Schedule". (See Appendix V)

#### **2.5.4 Motor Contribution to Short-Circuit Current**

Motor contribution to the short-circuit current is taken into account in this short-circuit analysis. During the first few cycles of a fault, running motors

act as generators and produce a current which will combine with the source short-circuit current flowing to the fault as illustrated in Figure 1. Sources may be, but are not limited to, the Power Company, local generators, or both.

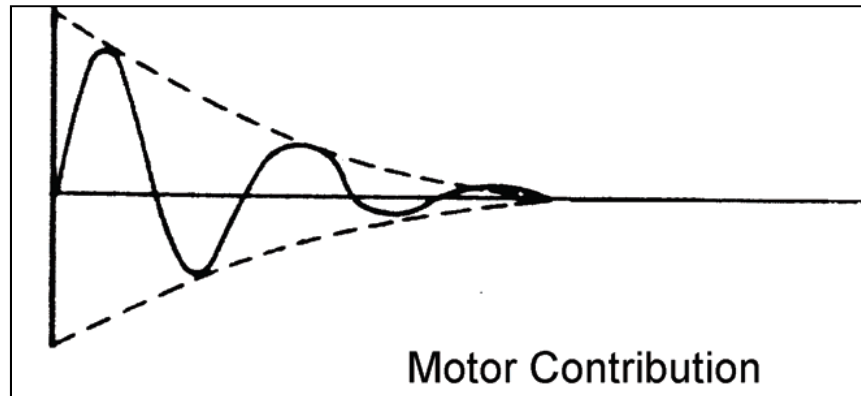


Figure 1:

Example motor contribution. Connected motors shown on the study one-line were assumed to be running at the time of the fault. Motors fed by adjustable speed drives equipped with bypass contactors were considered to contribute to system fault currents as well. However, motors fed by drives without bypass contactors were not considered since they do not contribute to fault current. Redundant motors shown on the study one-line were also assumed to be running at the time of the fault unless operating controls prohibit these conditions.

A motor's contribution to a fault at its terminals is equal to the full-load ampere (FLA) rating of the motor divided by its per-unit subtransient reactance, similar to the contribution from a generator. However, at the upstream switchboard, panelboard, or motor-control center, the fault contribution from the individual motors is reduced by the impedance of the motor branch circuit conductors. Since data on motor subtransient reactances and branch-circuit conductor lengths is often difficult to obtain, assumptions regarding the motors' subtransient reactances are typically made when the system model is built.

For calculation of low-voltage fault duty, the contribution from induction motors and synchronous motors in the system are considered. For small induction motors (less than 50 hp) where the impedance of the installation (i.e., motor and conductor) is not known, an equivalent subtransient reactance of 0.25 pu, resulting in a fault contribution of 4 times rated current, is assumed. Larger motors (50 hp and above) have an assumed subtransient reactance of 0.2 pu, resulting in a fault contribution of 5 times rated current. This is consistent with recommendations in IEEE Std. 141, IEEE Recommended Practice for Electric Power Distribution for Industrial Plants (the IEEE Red Book).

The motor short-circuit contribution is determined and included in the computer short-circuit analysis so that the results should represent the highest short-circuit current to which the equipment might be subjected.

Unless otherwise indicated in the "Short Circuit Contribution Table" computer printouts, some motor loads are modeled as lumped induction motors connected directly to the low voltage buses using the recommended subtransient reactance values from C37.010, C37.13, and IEEE Std. 141. These modeled values appear on the "Short Circuit Contribution Table" (See Appendix V) and the "Bus Evaluation Comprehensive Fault Report" (See Appendix II).

## **2.6    Short Circuit Analysis Report (See APPENDIX II)**