ARC FLASH
ARK BLAST

WBA Regional Broadcasters 2025 Clinic

An **arc flash** is the light and heat produced as part of an **arc fault** (sometimes referred to as an **electrical flashover**), a type of electrical explosion or discharge that results from a connection through air to ground or another voltage phase in an electrical system.

Arc flash is different from the **arc blast**, which is the supersonic shockwave produced when the conductors and surrounding air are heated by the arc, becoming a rapidly expanding plasma. Both are part of the same arc fault and are often referred to as simply an arc flash, but from a safety standpoint they are often treated separately. For example, (PPE) can be used to effectively shield a worker from the radiation of an arc flash, but that same PPE (40Cal) may likely be ineffective against the flying objects, molten metal, and violent concussion that the arc blast can produce. Note the over 40 Cal arc flash label. An arc flash-blast occurs when the circuit is connected to a lower impedance fault that results in an instantaneous excessive current flow. Depending on how fast the overcurrent device can interrupt the current flow results in the flash-arc blast energy. PPE Category 4 (167.5J/cm^2) requires a 40Cal rated clothing. 40 Calories is the maximum protection available. The energy released over 40 calories is life threatening.

Arc flash temperatures can reach or exceed 35,000 °F (19,400 °C) at the arc terminals.[3] The massive energy released in the fault rapidly vaporizes the metal conductors involved, blasting molten metal and expanding plasma outward with extraordinary force.[3]

The rule of thumb is that arc flash is typically not an issue when the fault current of a system is below 10,000 AIC which stands for Ampere Interrupting Capacity. Arc flash calculations are done by calculating the clearing time of the overcurrent device with a (calculated short circuit current value) which will decrease with increasing distance from the source along with a factor for the dimensions of the enclosure. The calculation is further complicated with the fact that the clearing time curve for a circuit breaker increases with a reduction of current flow. In some cases, a panel closer to the source will have a lower arc flash rating due to the faster clearing time of the circuit breaker than one further away. The result of the arc flash calculations is label placed on a given device that displays the incident energy in calories. I attached a typical label

For a 125KVA transformer with a % impedance of .03% operating a 208/120 VAC the fault current calculation is: 125000/208/1.73/.03= 11579 amperes with 10 feet of conduit and conductor between the source and the equipment you are just above the 1.2 Cal/CM^2. There is also a shock hazard that is applicable as noted on the label along with PPE requirements.

A 500 KVA transformer with a % impedance of .048% operating at 480/277VAC the fault current calculation is: 500,000/480/1.73/.048=12,544 amperes with 10 feet of conduit and conductor between the source and the equipment the fault current. Phase to phase and phase to neutral.

A 500 KVA transformer with a % impedance of .03% operating at 480/277VAC the fault current calculation is: 500000/480/1.73/.048=20,700 amperes with 10 feet of conduit and conductor between the source and the equipment the fault current. phase to phase and phase to neutral. Due to the need to coordinate with the maximum trip time is 2 seconds.

Insert Arc Flash Video

ARC FLASH LABEL REQUIREMENTS

NFPA 70E 2024

NFPA 70E includes tables that give estimations for arc flash boundaries in specific situations.

Arc flash labels are described in section 130.5(H), "Electrical Equipment...maintenance while energized shall be marked with a label containing all the following information":

Requirements

1. **Nominal System Voltage** – The nominal system voltage, offers a quick way to assess the potential shock hazard and general degree of danger represented by a system. It can be measured in VAC (volts, alternating current) or VDC (volts, direct current). Common values are 120, 208, 220, and 480.
2. **Arc Flash Boundary** – The arc flash boundary, is the distance from the equipment at which an unprotected person would receive second-degree burns in the event of an arc flash. The distance is calculated in a variety of ways, and the calculation method must be documented. It does not need to appear on the label.
3. **Protective Equipment** – At a minimum choose one of the following

   a. Incident energy and corresponding working distance, or the arc flash PPE category.

   b. Minimum arc rating of clothing

   c. Site-specific level of PPE

Other Label Elements

A. **Warning/Danger Header** – These labels warn of a hazard that could result in serious injury or death. An ANSI Z535-compliant header should be used. The header can be either an orange band with the word "WARNING" in black, or a red band with the word "DANGER" in white. "Danger" should be used for more serious threats. In either case, the "alert" symbol should be included to the left of the header text.

B. **Shock Boundaries** – Electrical equipment that poses an arc flash hazard also presents a shock hazard. The Limited Approach Boundary is a distance from the equipment that should only be crossed by qualified workers, or workers properly equipped and accompanied by a qualified worker. The Restricted Approach Boundary, should only be crossed by qualified workers with a written and approved plan of action.

C. **Date of Risk Assessment** – All arc flash labels should include a Date of Risk Assessment. NFPA 70E requires the analysis to be reviewed at least once every five years, and labels must be updated whenever the relevant information has changed. CSA Z462 (the Canadian standard to NFPA 70E) requires this date appears on the label.

WBA 2025 Confernece

Available Fault Current Calculation

by:John Sokolik Ver. 2021

jmp1ids@comcast.net

Utility Fault Current _____ amperes

kVA = 500

E = 208

$I = \frac{kVA \times 1000}{E \times 1.732}$ = trans. FLA

trans. FLA = 1388

$I_{sca} = \frac{\text{trans. FLA} \times 100 \times PF}{\text{transformer } Z}$ =

PF = 100%

Z = 4.80%

I_{sca} = ampere short-circuit current RMS symmetrical.

I_{sca} = 28,915 amperes

Point to Point Method

Three Phase 208/120

Length (distance) FEET — L = 10 — Copper in Nonmetallic Raceway

(ASC) — I_{sca} = 28,915

$'f' \text{ factor} = \frac{1.732 \times L \times I}{N \times C \times E_{L-N}}$

conductors per Ø — N = 1

Ø conductor constant — C = 13,453 — **Phase Conductor** 4/0 AWG

$'Z' = \text{SQRT}((XL \times XL)+(Rac \times Rac))$ — Voltage L-L — E_{L-L} = 208 Volt

'C' = 1/(Z/1000) — f = 0.179

Neutral conductor constant — C = 13,453 — **Neutral Conductor** 4/0 AWG

Multiplier — Voltage L-N — E_{L-N} = 120 Volt

f = 0.310

$M = \frac{1}{1+f}$

Line to Line — M = 0.848

Line to Neutral — M = 0.763

Fault Current at Service Equipment

I_{sca} x M = fault current at terminals of main disconnect L- L = ⟶ 24,525 amperes

I_{sca} x M = fault current at terminals of main disconnect L- N = ⟶ 22,069 amperes

WBA 2025 Confernece

Available Fault Current Calculation

by:John Sokolik Ver. 2021

jmp1ids@comcast.net

Utility Fault Current _____ amperes

kVA = 500

E = 480

$I = \frac{kVA \times 1000}{E \times 1.732}$ = trans. FLA

trans. FLA = 601

$I_{sca} = \frac{\text{trans. FLA} \times 100 \times PF}{\text{transformer } Z}$ =

PF = 100%

Z = 4.80%

I_{sca} = ampere short-circuit current RMS symmetrical.

I_{sca} = 12,530 amperes

Point to Point Method

Three Phase 480/277

Length (distance) FEET — L = 10 — Copper in Nonmetallic Raceway

(ASC) — I_{sca} = 12,530

$'f' \text{ factor} = \frac{1.732 \times L \times I}{N \times C \times E_{L-N}}$

conductors per Ø — N = 2

Ø conductor constant — C = 21,082 — **Phase Conductor** 500 kcmil

$'Z' = \text{SQRT}((XL \times XL)+(Rac \times Rac))$ — Voltage L-L — E_{L-L} = 480 Volt

'C' = 1/(Z/1000) — f = 0.011

Neutral conductor constant — C = 21,082 — **Neutral Conductor** 500 kcmil

Multiplier — Voltage L-N — E_{L-N} = 277 Volt

f = 0.019

$M = \frac{1}{1+f}$

Line to Line — M = 0.989

Line to Neutral — M = 0.982

Fault Current at Service Equipment

I_{sca} x M = fault current at terminals of main disconnect L- L = ⟶ 12,397 amperes

I_{sca} x M = fault current at terminals of main disconnect L- N = ⟶ 12,301 amperes

DANGER

Arc Flash and Shock Risk Hazards
Appropriate PPE Required
Failure to Comply Can Result in Death or Injury!

317 in Flash Hazard Boundry
117.6 cal/cm^2 Incident Energy at 18 in

DO NOT WORK ON LIVE!

480 VAC Shock Hazard
00 Glove Class
42 in Limited Approach
12 in Restricted Approach

SWITCHGEAR Supply & Distribution

920-234-2500
January 22, 2024

Location: PNL-MPDP-1-MAIN
Protection: MaxTripTime @2.0s

NOTE: Changes in equipment settings, configuration, or lack of maintenance will invalidate the calculated values and PPE requirements.

WARNING

Arc Flash and Shock Risk Hazards
Appropriate PPE Required
Failure to Comply Can Result in Death or Injury!

90 in Flash Hazard Boundry
15.7 cal/cm^2 Incident Energy at 18 in

AR flash suit jacket, pants, hood, gloves, safety glasses, hard hat, and hearing protection

240 VAC Shock Hazard
00 Glove Class
42 in Limited Approach
12 in Restricted Approach

SWITCHGEAR Supply & Distribution

920-234-2500
January 22, 2024

Location: PNL-MPDP-2-MAIN
Protection: MPDP-1 - T-2 CB

NOTE: Changes in equipment settings, configuration, or lack of maintenance will invalidate the calculated values and PPE requirements.

WARNING

Arc Flash and Shock Risk Hazards
Appropriate PPE Required
Failure to Comply Can Result in Death or Injury!

78 in Flash Hazard Boundry
12.4 cal/cm^2 Incident Energy at 18 in

AR flash suit jacket, pants, hood, gloves, safety glasses, hard hat, and hearing protection

480 VAC Shock Hazard
00 Glove Class
42 in Limited Approach
12 in Restricted Approach

SWITCHGEAR Supply & Distribution

920-234-2500
January 22, 2024

Location: ATS EMERGENCY
Protection: GEN - ATS CB

NOTE: Changes in equipment settings, configuration, or lack of maintenance will invalidate the calculated values and PPE requirements.

WARNING

Arc Flash and Shock Risk Hazards
Appropriate PPE Required
Failure to Comply Can Result in Death or Injury!

57 in Flash Hazard Boundry
7.63 cal/cm^2 Incident Energy at 18 in

AR shirt, pants, face shield, balaclava, safety glasses, hard hat, hearing protection, and gloves

240 VAC Shock Hazard
00 Glove Class
42 in Limited Approach
12 in Restricted Approach

SWITCHGEAR Supply & Distribution

920-234-2500
January 22, 2024

Location: MCC-2
Protection: MPDP-2 - MCC-2 CB

NOTE: Changes in equipment settings, configuration, or lack of maintenance will invalidate the calculated values and PPE requirements.

WARNING

Arc Flash and Shock Risk Hazards
Appropriate PPE Required
Failure to Comply Can Result in Death or Injury!

90 in Flash Hazard Boundry
15.7 cal/cm^2 Incident Energy at 18 in

AR flash suit jacket, pants, hood, gloves, safety glasses, hard hat, and hearing protection

240 VAC Shock Hazard
00 Glove Class
42 in Limited Approach
12 in Restricted Approach

SWITCHGEAR Supply & Distribution

920-234-2500
January 22, 2024

Location: PNL-MPDP-2
Protection: PNL-MPDP-2-MCB

NOTE: Changes in equipment settings, configuration, or lack of maintenance will invalidate the calculated values and PPE requirements.

WARNING

Arc Flash and Shock Risk Hazards
Appropriate PPE Required
Failure to Comply Can Result in Death or Injury!

11 in Flash Hazard Boundry
0.54 cal/cm^2 Incident Energy at 18 in

AR shirt, pants, face shield, safety glasses, hard hat, hearing protection, and gloves

480 VAC Shock Hazard
00 Glove Class
42 in Limited Approach
12 in Restricted Approach

SWITCHGEAR Supply & Distribution

920-234-2500
January 22, 2024

Location: SPD-1
Protection: MPDP-1 - SPD-1 CB

NOTE: Changes in equipment settings, configuration, or lack of maintenance will invalidate the calculated values and PPE requirements.

WARNING

Arc Flash and Shock Risk Hazards
Appropriate PPE Required
Failure to Comply Can Result in Death or Injury!

57 in Flash Hazard Boundry
7.63 cal/cm^2 Incident Energy at 18 in

AR shirt, pants, face shield, balaclava, safety glasses, hard hat, hearing protection, and gloves

240 VAC Shock Hazard
00 Glove Class
42 in Limited Approach
12 in Restricted Approach

SWITCHGEAR Supply & Distribution

920-234-2500
January 22, 2024

Location: MCC-1
Protection: MPDP-2 - MCC-1 CB

NOTE: Changes in equipment settings, configuration, or lack of maintenance will invalidate the calculated values and PPE requirements.

WARNING

Arc Flash and Shock Risk Hazards
Appropriate PPE Required
Failure to Comply Can Result in Death or Injury!

75 in Flash Hazard Boundry
11.8 cal/cm^2 Incident Energy at 18 in

AR flash suit jacket, pants, hood, gloves, safety glasses, hard hat, and hearing protection

480 VAC Shock Hazard
00 Glove Class
42 in Limited Approach
12 in Restricted Approach

SWITCHGEAR Supply & Distribution

920-234-2500
January 22, 2024

Location: MCC-3
Protection: MPDP-1 - MCC-3 CB

NOTE: Changes in equipment settings, configuration, or lack of maintenance will invalidate the calculated values and PPE requirements.

ARC FLASH PPE CATEGORIES

NFPA 70E 2024

The National Fire Protection Association (NFPA) uses four Arc Flash PPE Categories to classify ranges of arc flash hazards, and the corresponding acceptable combinations of Personal Protective Equipment (PPE). These categories inform workers about the protection they need while working on energized equipment.

PPE CATEGORY 1

Minimum Arc Rating of
16.75 J/cm²

Arc Rated Clothing:

- AR long-sleeve shirt and pants, or AR coverall
- AR face shield, or AR flash suit hood
- AR jacket, parka, high-visibility apparel, rain wear, or hard hat liner (as needed)

Protective Equipment:

- Hard hat
- Safety glasses or safety goggles
- Hearing protection (with inserts)
- Heavy-duty leather gloves, AR gloves, or rubber insulating gloves with leather protectors
- Leather footwear (as needed)

PPE CATEGORY 2

Minimum Arc Rating of
33.5 J/cm²

Arc Rated Clothing:

- AR long-sleeve shirt and pants, or AR coverall
- AR flash suit hood, or AR face shield and AR balaclava
- AR jacket, parka, high-visibility apparel, rain wear, or hard hat liner (as needed)

Protective Equipment:

- Hard hat
- Safety glasses or safety goggles
- Hearing protection (with inserts)
- Heavy-duty leather gloves, AR gloves, or rubber insulating gloves with leather protectors
- Leather footwear

PPE CATEGORY 3

Minimum Arc Rating of
104.7 J/cm²

Arc Rated Clothing:

- As required: AR long-sleeve shirt, AR pants, AR coverall, AR flash suit jacket, and AR flash suit pants
- AR flash suit hood
- AR gloves or rubber insulating gloves with leather protectors
- AR jacket, parka, high-visibility apparel, rain wear, or hard hat liner (as needed)

Protective Equipment:

- Hard hat
- Safety glasses or safety goggles
- Hearing protection (with inserts)
- Leather footwear

PPE CATEGORY 4

Minimum Arc Rating of
167.5 J/cm²

Arc Rated Clothing:

- As required: AR long-sleeve shirt, AR pants, AR coverall, AR flash suit jacket, and AR flash suit pants
- AR flash suit hood
- AR gloves or rubber insulating gloves with leather protectors
- AR jacket, parka, high-visibility apparel, rain wear, or hard hat liner (as needed)

Protective Equipment:

- Hard hat
- Safety glasses or safety goggles
- Hearing protection (with inserts)
- Leather footwear

Each category includes a minimum Arc Rating (AR) value for the required PPE. This value is determined by the PPE manufacturer to indicate the amount of heat energy (in cal/cm²) that the clothing can absorb or block before the wearer is burned. (Second-degree burns are expected when skin is exposed to 1.2 cal/cm² of incident energy.)

Category 1 and 2 requirements can be met with a single layer of arc-rated PPE. To meet category 3 or 4 requirements, multiple layers of PPE may be required. These layers need to be tested together to receive a complete system arc rating.

With regards to operating circuit breakers and disconnects: When the cover in place with all the screws in place there is not an issue operating a circuit breaker or disconnect switch of UL listed equipment that is in operatable condition. That said if you ever get into a situation where a Disconnect Switch or circuit breaker seems to be jammed or otherwise defective. Do not operate the equipment but rather reach out for assistance. Once the equipment cover is removed ARC Frash mitigation is required.

The previous page references NFPA 70E 2024 based on the Category risk/category work on energized live parts **“INCLUDING VOTAGE TESTING”** triggers various PPE provisions including Fire rated clothing “FR” rated, hearing protection, HD leather gloves, AR gloves or rubber insulating gloves with leather protectors. [4]

TESTING FOR ABSENCE OF VOLTAGE

Voltmeters used for testing and troubleshooting need to be CAT III rated, which includes UL or CSA listed, 600VAC/VDC rated. Surge protected 6KV, fused at 11A 1000VAC.

NFPA 70E does NOT permit using a noncontact type tester (see image) when testing for the absence of voltage on electrical systems rated at less than 1000 volts or less.

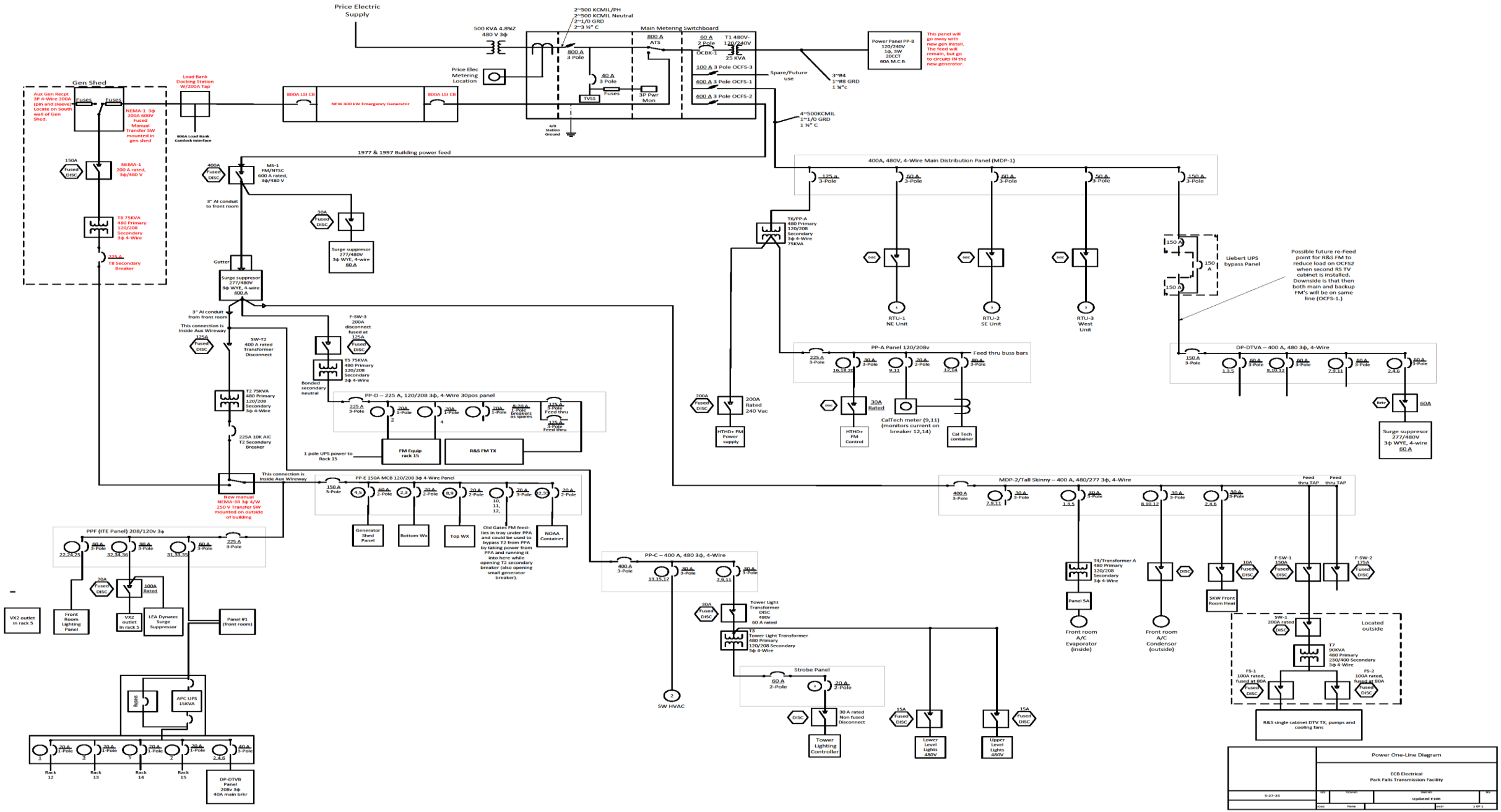
When testing for absence of voltage the meter first needs to first tested for voltage on a known energized source. Proceed with testing for absence of voltage phase to phase and phase to ground (earth) and retested on the known energized source.

KNOW YOUR PLANT

MAIN SERVICE DISCONNECT(s)

MAIN GROUNDING ELECTRODE CONNECTION-MASTER GROUND BAR

ONE LINE DRAWINGS


Price Electric Supply
2~500 KCMIL/PH
2~500 KCMIL Neutral
2~1/0 GRD
2~3 ½" C
500 KVA 4.8%Z
480 V 3ϕ
Main Metering Switchboard
800 A ATS
800 A 3 Pole
60 A 2 Pole
OCBK-1
T1 480V-120/240V 25 KVA
100 A 3 Pole OCFS-3
400 A 3 Pole OCFS-1
400 A 3 Pole OCFS-2
40 A 3 Pole Fuses
TVSS
3P Pwr Mon
Price Elec Metering Location
Spare/Future use
3~#4 1~#8 GRD 1 ¼" c
Power Panel PP-B 120/240V 1ϕ, 3W 20CCT 60A M.C.B.
This panel will go away with new gen install. The feed will remain, but go to circuits IN the new generator.
4~500KCMIL 1~1/0 GRD 1 ½" C
4/0 Station Ground
Gen Shed
Aux Gen Recpt 3P 4-Wire 200A (pin and sleeve) Locate on South wall of Gen Shed.
Fuses
NEMA-1 3ϕ 200A 600V Fused Manual Transfer SW mounted in gen shed
Load Bank Docking Station W/200A Tap
800A Load Bank Camlock interface
800A LSI CB
NEW 400 kW Emergency Generator
800A LSI CB
1977 & 1997 Building power feed
150A Fused DISC
NEMA-1 200 A rated, 3ϕ/480 V
T8 75KVA 480 Primary 120/208 Secondary 3ϕ 4-Wire
225 A T8 Secondary Breaker
400A Fused DISC
MS-1 FM/NTSC 600 A rated, 3ϕ/480 V
3" Al conduit to front room
30A Fused DISC
Surge suppresor 277/480V 3ϕ WYE, 4-wire 60 A
Gutter
Surge suppresor 277/480V 3ϕ WYE, 4-wire 400 A
3" Al conduit from front room
This connection is inside Aux Wireway
125A Fused DISC
SW-T2 400 A rated Transformer Disconnect
T2 75KVA 480 Primary 120/208 Secondary 3ϕ 4-Wire
225A 10K AIC T2 Secondary Breaker
F-SW-3 200A disconnect fused at 125A
Fused DISC
T5 75KVA 480 Primary 120/208 Secondary 3ϕ 4-Wire
Bonded secondary neutral
PP-D – 225 A, 120/208 3ϕ, 4-Wire 30pos panel
225 A 3-Pole
20A 1-Pole
40A 1-Pole
8,20 A 1-Pole breakers as spares
125 A 3-Pole Feed thru
15A 3-Pole Feed thru
1 pole UPS power to Rack 15
FM Equip rack 15
R&S FM TX
This connection is inside Aux Wireway
New manual NEMA-3R 3ϕ 4/W 250 V Transfer SW mounted on outside of building
PP-E 150A MCB 120/208 3ϕ 4-Wire Panel
150 A 3-Pole
60 A 2-Pole
20 A 2-Pole
20 A 3-Pole
Generator Shed Panel
Bottom Wx
Top WX
Old Gates FM feed-lies in tray under PPA and could be used to bypass T2 from PPA by taking power from PPA and running it into here while opening T2 secondary breaker (also opening small generator breaker).
NOAA Container
PPF (ITE Panel) 208/120v 3ϕ
60 A 3-Pole
30 A 3-Pole
225 A 3-Pole
20A Fused DISC
100A Rated
VX2 outlet in rack 5
Front Room Lighting Panel
VX2 outlet in rack 5
LEA Dynatec Surge Suppressor
Panel #1 (Front room)
Bypass
APC UPS 15KVA
20 A 1-Pole
40 A 3-Pole
Rack 12
Rack 13
Rack 14
Rack 15
DP-DTVB Panel 208v 3ϕ 40A main brkr
400A, 480V, 4-Wire Main Distribution Panel (MDP-1)
125 A 3-Pole
60 A 3-Pole
50 A 3-Pole
150 A 3-Pole
T6/PP-A 480 Primary 120/208 Secondary 3ϕ 4-Wire 75KVA
RTU-1 NE Unit
RTU-2 SE Unit
RTU-3 West Unit
150 A
Liebert UPS bypass Panel
Possible future re-Feed point for R&S FM to reduce load on OCFS2 when second RS TV cabinet is installed. Downside is that then both main and backup FM's will be on same line (OCFS-1.)
PP-A Panel 120/208v
Feed thru buss bars
225 A 3-Pole
30 A 3-Pole
20 A 2-Pole
60 A 3-Pole
16,18,20
9,11
12,14
200A Fused DISC
200A Rated 240 Vac
HTHD+ FM Power supply
30A Rated
HTHD+ FM Control
CalTech meter (9,11) (monitors current on breaker 12,14)
Cal Tech container
DP-DTVA – 400 A, 480 3ϕ, 4-Wire
150 A 3-Pole
60 A 3-Pole
1,3,5
8,10,12
7,9,11
2,4,6
Surge suppresor 277/480V 3ϕ WYE, 4-wire 60 A
MDP-2/Tall Skinny – 400 A, 480/277 3ϕ, 4-Wire
Feed thru TAP
400 A 3-Pole
30 A 3-Pole
7,9,11
1,3,5
8,10,12
2,4,6
PP-C – 400 A, 480 3ϕ, 4-Wire
13,15,17
7,9,11
30A Fused DISC
Tower Light Transformer DISC 480v 60 A rated
T3 Tower Light Transformer 480 Primary 120/208 Secondary 3ϕ 4-Wire
Strobe Panel
60 A 2-Pole
20 A 2-Pole
30 A rated Non fused Disconnect
Tower Lighting Controller
SW HVAC
15A Fused DISC
Lower Level Lights 480V
Upper Level Lights 480V
T4/Transformer A 480 Primary 120/208 Secondary 3ϕ 4-Wire
Panel 5A
Front room A/C Evaporator (inside)
Front room A/C Condensor (outside)
10A Fused DISC
5KW Front Room Heat
F-SW-1 150A Fused DISC
F-SW-2 175A Fused DISC
SW-1 200A rated DISC
Located outside
T7 90KVA 480 Primary 230/400 Secondary 3ϕ 4-Wire
FS-1 100A rated, fused at 80A Fused DISC
FS-2 100A rated, fused at 80A Fused DISC
R&S single cabinet DTV TX, pumps and cooling fans
Power One-Line Diagram
ECB Electrical
Park Falls Transmission Facility
9-27-23
Updated E106
None
1 OF 1

WLEF Transmitter Site AC Power Distribution for R&S Transmitter Installation

800A 277/480VAC 4 Wire Outdoor Electical Service Cabinet W/Generator Transfer Switch 2003

	Quantity	Label/LD	Description			Equipment			OCP		Motor Amp	Circuit Amp	Circuit Length		Feeder Size	EGC	Notes		Raceway Size		Type			Notes	
	1	CT Cabinet	800A CT Cabinet 1	Price Electric Coop		800A Service Disconnect			800	RK-5 Fuse	50	405	20		(2)-500KCM Per Phase & Neutral				(2) 3" GRMC					500 KVA 14.4KV to 480/277 4.8% Z	
	1	ATS-1	Automatic Transfer Switch			400KW Generator			800		50	225	10		(2)-500KCM Per Phase & Neutral	1/0 CU			Wire Duct						
	1	OCFS-1	Main Distribution Panel	MDP-1		480VAC Distribution			400	RK-5 Fuse	30	105	10		4-500KCMIL	1/0 CU			3" GRMC						
	1	OCFS-2	1977-1997 Building MDP-2	MS -1 MDP-2		480 VAC Distribution			400	RK-5 Fuse	20	50	10		4-500KCMIL	1/0 CU			3" GRMC						
	1	OCFS-3	Spare Disconnect	Aux Site Power Feeder		480VAC Distribution			100	RK-5 Fuse															
	1	OCBK-1	480-120/240 T1 25KVA XFMR	PP-B Generator Aux Power		PP-B Generator Panel			60	Circuit Breaker	1	25	25		#6 CU	#6 CU			1 1/2" GRMC						
												405													

400A OCFS-1 Feeder

	Quantity	Label/LD	Description		H.P.	Equipment	Controls	Actions	OCP	Location	Motor Amp	Circuit Amp	Circuit Length		Notes	Feeder Size	EGC	Disconnect	Secondary Disconnect Amperage	Secondary Disconnect Type	Raceway Size	Notes		Controled By	Notes
	1	MDP-1	400A Power Distribution Panel MCB						400																
	1	SW-T5	T5 75KVA 480-120/208		10	Transformer			125	Existing		45	20												
	1	RTU-1	North East Unit		10	HVAC			400	Existing		20	50												
	1	RTU-2	South East Unit		10	HVAC			125	Existing	8	20	40					NEMA 1			1 1/2" GRMC				Bond XO to station ground
	1	RTU-3	West Unit		10	HVAC			400	Existing		20	30												
	1	UPS	100 KVA UPS Bypass switch			DP-DTV Panels			150	Existing			40						200	NEMA 3R NF-HD	1 1/2" GRMC	LFMC RW for XFMR Cnct			Bond XO to station ground
		Space																							
Total					0						0	105													

1977 & 1997 Building-Power Distribution OCFS-2 Feeder

	Quantity	Label/LD	Description		H.P.	Equipment	Controls	Actions	OCP	Location	Motor Amp	Circuit Amp	Circuit Length		Notes	Feeder Size	EGC	Disconnect	Ampenage	Type	Raceway Size	Notes		Controled By	Notes
	1	MS-1	600A Fused Disconnect		40	1977 Original Service			450	Existing															
	1	Surge 1	30A Fused Disconnect			Shunt Surge arrestor																			
	1	Surge 2	In Line Surge Arrestor			Series Surge arrestor																			
	1	SW-T2	T2 75KVA 480-120/208			ATS-2 120/208 VAC Building Loads			110	Existing	15	40	30			3/0	#6				3" GRMC				
	1	PP-C	Distribution to Existing Loads		4	HVAC T3 Tower Lights			400	Existing		25				500 KCMIL	#2								
	1	FS-3	200A NEMA 1 HD Fusible feeder to T5 XFMR			T5 Feeder			125	1997 Addition	8	50	20			1/0-3 CU	#2 CU	NEMA 1	200	NEMA 1 F HD	1 1/2" GRMC				Bond XO to station ground
	1	MDP-2	400A MCB Power Distribution Panel 1997 Building			T4, 1997 RM HVAC			400	1997 Addition		20													
	1	FSW-I	200A NEMA 1 HD Fusible feeder to T7 XFMR		8	R&S 90 KVA CAB 1 XFMR			150A R/S	Pad Mount outside	10	45	40			(3) 1/0 CU	#4 CU		200	NEMA 3R NF-HD	1 1/2" GRMC	LFMC RW for XFMR Cnct			Bond XO to station ground
	1	FSW-2	Spare										40												
	1	FSW-3	T5 75KVA 480-120/208			PP-D			125	R&S TX Room	3	45	20			(3) #1 XHHW	#4 CU				1 1/2" GRMC	LFMC RW for XFMR Cnct			Bond XO to station ground
Total					5						13	225													

T2-75KVA 480-120/208VAC XFMR Secondary with (4) 4/0 XHHW2 GEC #2 CU Bonded to Station Ground 225A Secondary Circuit Breaker

Transfer Switch 250A 60KW 120/208 Generator with Main Circuit Breaker feeds ITE and FPE panelboards

ITE Panelboard 225A Main Circuit Breaker

Poles	Quantity	Label/LD	Description		H.P.	Equipment	Controls	Actions	OCP	Disconnect At XFMR	Motor Amp	Circuit Amp	Circuit Length		Notes	Feeder Size	EGC	Disconnect	Secondary Disconnect Ampenage	Secondary Disconnect Type	Raceway Size	Notes		Controled By	Notes
1	20	CB	Existing Lighting and Receptacle Circuits						20	SW-T2						#12	#12								
3	1	CB	UPS Bypass Panel			APC 15KW UPS			6							4-#6	#6	BP SW	60	Fused	1"				
3	1	CB	HT-10 FM Transmitter						60							3-#4	#6	NEMA-1	100	Non Fused	1-1/4"				
3	1	CB	Front XMTR Room			Lights and Receptacles			60							4-#6	#6		Main CB		1"				

FPE Panelboard 150A Main Circuit Breaker

FAULT CURRENT LIMITING

Fault current will be reduced by increasing the conductor distance between the source and the electrical equipment.

Installing current limiting fuses or electronic trip circuit breakers can reduce the fault current at the load point.

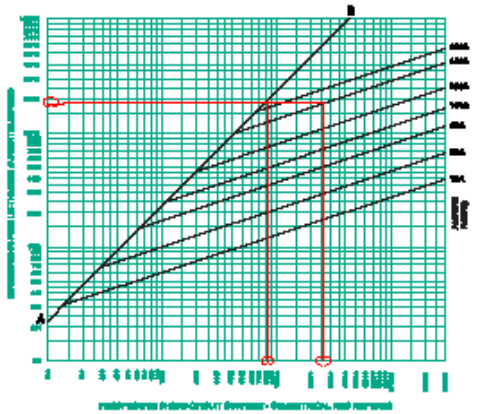
Other Mitigation methods for large industrial electrical systems:

Resistance Grounding-no neutral current available.

Arc detection equipment with shunt trip circuit breakers. High-Speed Detection—Arc-flash light sensing and overcurrent protection detect arc-flash hazards and send a trip signal to the breaker in as fast as 2 ms.

Many facilities require coordination of the opening of overcurrent devices. Coordination is done by layering tripping time curves of fuses and circuit breakers so that an upstream overcurrent device will not trip before a downstream OCP operates. Note: Reducing fault current reduces the available coordination range.

Low-Peak Class J, Dual-Element Time-Delay Fuses
LPJ_SP

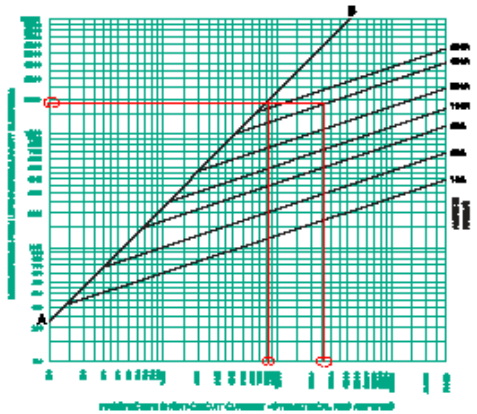


LPJ_SP Fuse – RMS Let-Through Currents (kA)

Prosp. Short C.C.	Fuse Size						
	1/10	1/4	1/2	1	2	3	4
	I_{peak}	I_{peak}	I_{peak}	I_{peak}	I_{peak}	I_{peak}	I_{peak}
1,000	1	1	1	1	1	1	1
2,000	1	1	1	2	2	3	3
3,000	1	1	1	2	3	5	5
10,000	1	1	2	2	4	6	6
15,000	1	1	2	3	4	7	9
20,000	1	1	2	3	4	7	10
25,000	1	1	2	3	5	8	10
30,000	1	1	2	3	5	8	11
35,000	1	1	2	4	5	9	12
40,000	1	2	3	4	6	9	12
50,000	1	2	3	4	6	10	13
60,000	1	2	3	4	6	11	14
80,000	1	2	3	5	7	12	15
100,000	1	2	4	5	6	12	17
150,000	1	2	4	6	9	14	19
200,000	2	3	4	6	9	16	21
250,000	2	3	5	7	10	17	23
300,000	2	3	5	7	11	18	24

Note: For I_{peak} value at 300,000 amperes, consult Factory.

Low-Peak Class J, Dual-Element Time-Delay Fuses
LPJ_SP



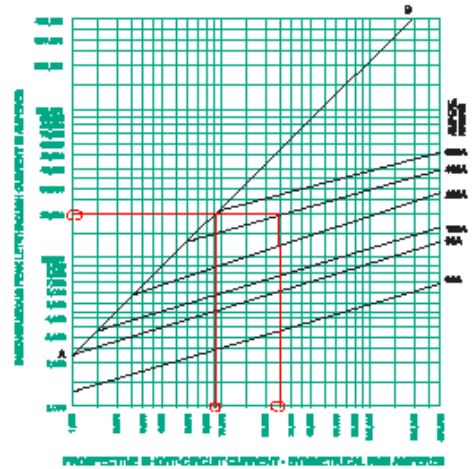
LPJ_SP Fuse – RMS Let-Through Currents (kA)

Prosp. Short C.C.	Fuse Size						
	1/10	1/4	1/2	1	2	3	4
	I_{peak}	I_{peak}	I_{peak}	I_{peak}	I_{peak}	I_{peak}	I_{peak}
1,000	1	1	1	1	1	1	1
2,000	1	1	1	2	2	3	3
3,000	1	1	1	2	3	5	5
10,000	1	1	2	2	4	6	6
15,000	1	1	2	3	4	7	9
20,000	1	1	2	3	4	7	10
25,000	1	1	2	3	5	8	10
30,000	1	1	2	3	5	8	11
35,000	1	1	2	4	5	9	12
40,000	1	2	3	4	6	9	12
50,000	1	2	3	4	6	10	13
60,000	1	2	3	4	6	11	14
80,000	1	2	3	5	7	12	15
100,000	1	2	4	5	6	12	17
150,000	1	2	4	6	9	14	19
200,000	2	3	4	6	9	16	21
250,000	2	3	5	7	10	17	23
300,000	2	3	5	7	11	18	24

Note: For I_{peak} value at 300,000 amperes, consult Factory.

See pages 67 to 69 for current-limiting definition and how to analyze fuse charts.

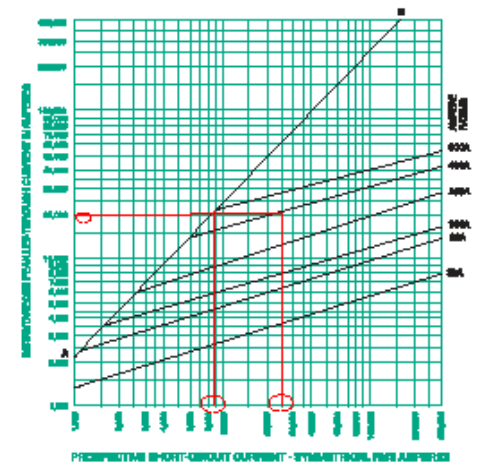
Low-Peak Class RK1 Dual-Element Time-Delay Fuses
LPN-RK_SP



LPN-RK_SP – RMS Let-Through Currents (kA)

Prosp. Short C.C.	Fuse Size					
	1/10	1/4	1/2	1	2	3
	I_{peak}	I_{peak}	I_{peak}	I_{peak}	I_{peak}	I_{peak}
1,000	1	1	1	1	1	1
2,000	1	1	1	1	2	2
3,000	1	1	2	3	3	3
5,000	1	2	2	3	5	5
10,000	1	2	3	4	7	8
15,000	1	2	3	5	8	11
20,000	1	3	3	5	8	11
25,000	1	3	3	6	9	12
30,000	2	3	4	6	9	12
35,000	2	3	4	6	10	13
40,000	2	3	4	6	10	13
50,000	2	3	4	7	11	14
60,000	2	3	4	7	11	15
70,000	2	3	4	7	12	16
80,000	2	4	5	8	12	16
90,000	2	4	5	7	16	17
100,000	2	4	5	8	13	17
150,000	2	4	6	8	16	18
200,000	3	5	8	11	16	20
250,000	3	5	7	11	17	21
300,000	3	6	7	12	18	22

Low-Peak Class RK1 Dual-Element Time-Delay Fuses
LPS-RK_SP

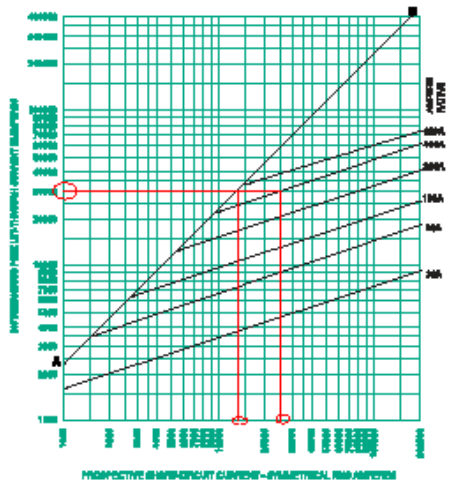


LPS-RK_SP – RMS Let-Through Currents (kA)

Prosp. Short C.C.	Fuse Size					
	1/10	1/4	1/2	1	2	3
	I_{peak}	I_{peak}	I_{peak}	I_{peak}	I_{peak}	I_{peak}
1,000	1	1	1	1	1	1
2,000	1	1	2	2	2	2
3,000	1	1	2	3	3	3
5,000	1	2	2	3	5	5
10,000	1	2	3	4	7	10
15,000	1	2	3	5	8	11
20,000	2	3	3	5	8	12
25,000	2	3	4	6	9	12
30,000	2	3	4	6	10	13
35,000	2	3	4	6	10	13
40,000	2	3	4	6	10	14
50,000	2	3	5	7	11	15
60,000	2	4	5	7	12	16
70,000	2	4	6	8	13	16
80,000	2	4	5	8	13	16
90,000	2	4	6	8	13	17
100,000	2	4	6	9	14	17
150,000	3	5	8	10	16	19
200,000	3	5	7	11	18	21
250,000	3	6	7	12	17	22
300,000	3	6	7	12	18	23

See pages 67 to 69 for current-limiting definition and how to analyze these charts.

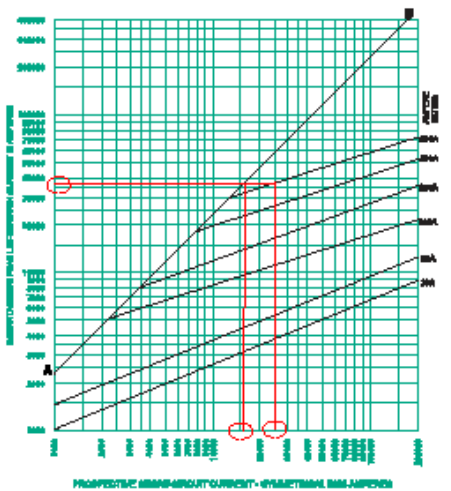
Fusetron Class RK5 Dual-Element Time-Delay Fuses FRN-R



FRN-R – RK5 Let-Through Currents (kA)

Prosp. Short C.C.	Fuse Size					
	30	60	100	200	400	600
	Amps	Amps	Amps	Amps	Amps	Amps
5,000	1	2	3	5	8	8
10,000	2	3	4	7	10	10
15,000	2	3	5	8	11	15
20,000	2	4	6	8	12	16
25,000	2	4	6	9	13	17
30,000	2	4	6	10	14	18
35,000	2	4	6	10	15	19
40,000	2	5	7	11	15	20
50,000	3	5	7	11	17	21
60,000	3	5	8	12	18	22
70,000	3	6	8	13	19	23
80,000	3	6	8	13	19	24
90,000	3	6	9	14	20	25
100,000	3	6	9	14	21	26
150,000	4	7	10	16	24	29
200,000	4	8	11	18	26	32

Fusetron Class RK5 Dual-Element Time-Delay Fuses FRS-R



FRS-R – RK5 Let-Through Currents (kA)

Prosp. Short C.C.	Fuse Size					
	30	60	100	200	400	600
	Amps	Amps	Amps	Amps	Amps	Amps
5,000	1	1	3	4	6	8
10,000	1	2	4	6	9	10
15,000	1	2	4	6	10	14
20,000	2	2	5	7	11	16
25,000	2	2	5	7	12	17
30,000	2	3	5	8	13	18
35,000	2	3	5	8	13	18
40,000	2	3	6	9	14	19
50,000	2	3	6	9	14	20
60,000	2	3	6	10	15	22
70,000	3	4	7	11	17	23
80,000	3	4	7	12	17	23
90,000	3	4	7	12	17	24
100,000	3	4	8	13	18	25
150,000	3	5	9	14	21	27
200,000	4	6	9	16	23	32

Other Mitigation methods for large industrial electrical systems:

Resistance Grounding-no neutral current available.

Arc detection equipment with shunt trip circuit breakers. High-Speed Detection—Arc-flash light sensing and overcurrent protection detect arc-flash hazards and send a trip signal to the breaker in as fast as 2 ms.

Many facilities require coordination of the opening of overcurrent devices. Coordination is done by layering tripping time curves of fuses and circuit breakers so that an upstream overcurrent device will not trip before a downstream OCP operates. Note: Reducing fault current reduces the available coordination range.

Circuit Diagrams [1]

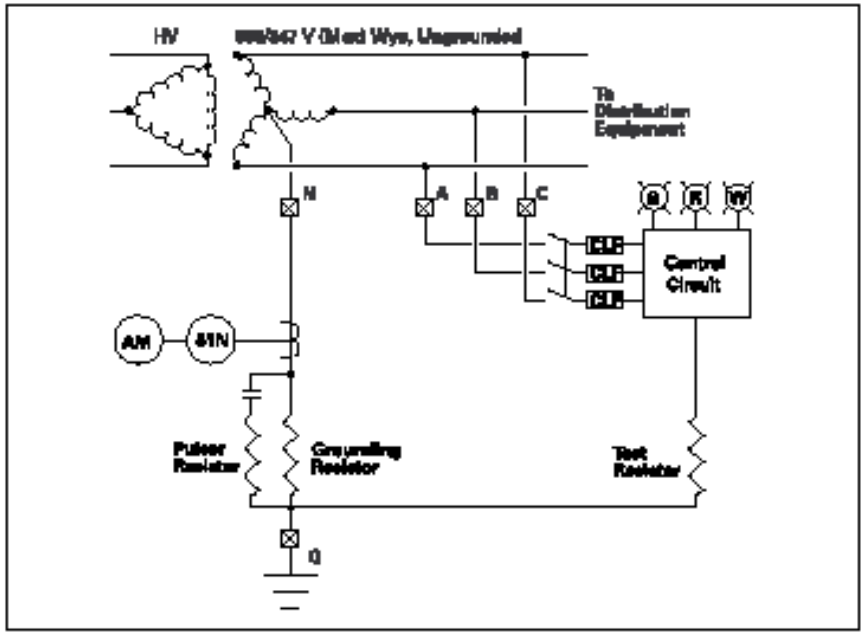
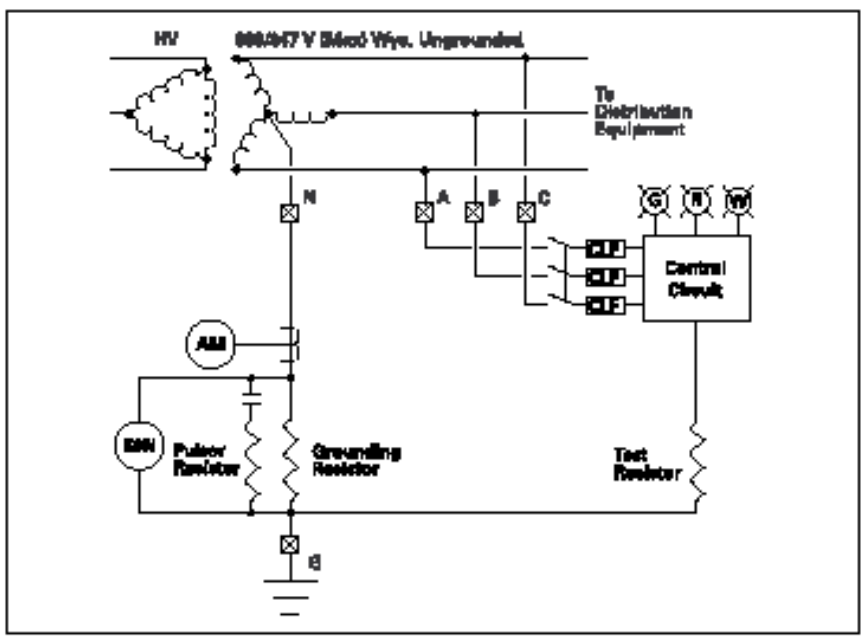


Figure 36.2-6. Four-Wire Source—Fault Detection via Current Relay



ENERGIZED ELECTRICAL WORK PERMIT

PART I: TO BE COMPLETED BY THE REQUESTER:

Job/Work Order Number _____

(1) Description of circuit/equipment/job location: _____

_____

(2) Description of work to be done: _____

_____

(3) Justification of why the circuit/equipment cannot be de-energized or the work deferred until the next scheduled outage:

_____

_____

_____ _____

Requester/title Date

PART II: TO BE COMPLETED BY THE ELECTRICALLY QUALIFIED PERSONS DOING THE WORK:

	Check when complete
(1) Detailed job description procedure to be used in performing the above detailed work: _____ _____	☐
(2) Description of the safe work practices to be employed: _____ _____	☐
(3) Results of the shock risk assessment: _____	
(a) Voltage to which personnel will be exposed	☐
(b) Limited approach boundary	☐
(c) Restricted approach boundary	☐
(d) Necessary shock, personal, and other protective equipment to safely perform assigned task	☐
(4) Results of the arc flash risk assessment: _____	
(a) Available incident energy at the working distance or arc flash PPE category	☐
(b) Necessary arc flash personal and other protective equipment to safely perform the assigned task	☐
(c) Arc flash boundary	☐
(5) Means employed to restrict the access of unqualified persons from the work area: _____	☐
(6) Evidence of completion of a job briefing, including discussion of any job-related hazards: _____	☐

(7) Do you agree the above-described work can be done safely? ☐ Yes ☐ No (If no, return to requester.)

_____ _____

Electrically Qualified Person(s) Date

_____ _____

Electrically Qualified Person(s) Date

PART III: APPROVAL(S) TO PERFORM THE WORK WHILE ELECTRICALLY ENERGIZED:

_____ _____

Manufacturing Manager Maintenance/Engineering Manager

_____ _____

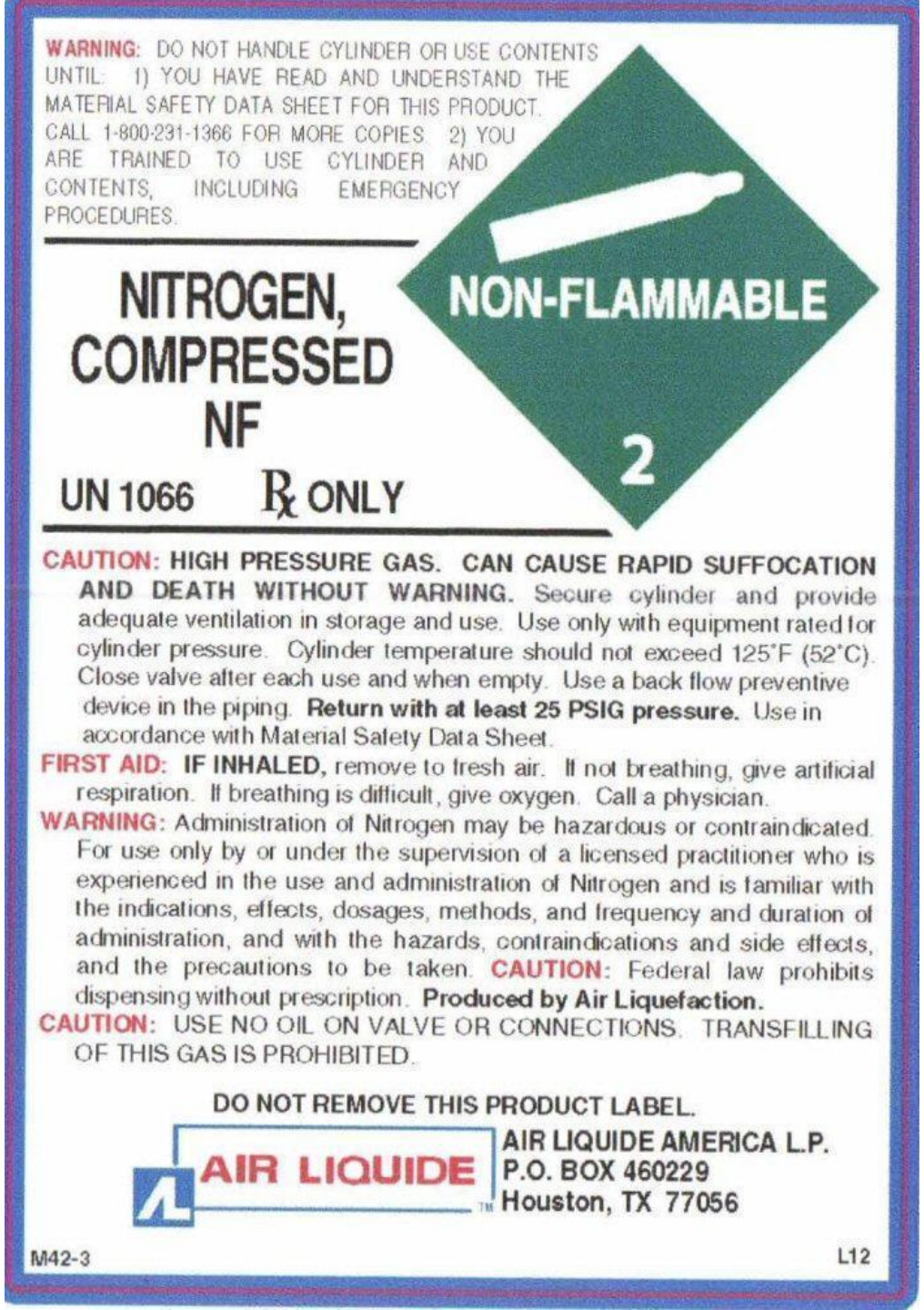
Safety Manager Electrically Knowledgeable Person

_____ _____

General Manager Date

Note: Once the work is complete, forward this form to the site Safety Department for review and retention.

Figure J.1 Sample Permit for Energized Electrical Work.



Nitrogen safety:
Average atmospheric Oxygen levels are 21% when oxygen levels drop below 19.5% in the room it may cause disorientation, difficulties breathing and suffocation if inhaled in sufficient quantities. If encountered ventilate the room and move any affected to an outdoor location. Seek medical treatment for severe cases.

SECTION 1: Identification of the substance/mixture and of the company/undertaking

1.1 Product identifier

Product name: Nitrogen, compressed

Trade name: Gasart 220 Stickstoff, Gasart 221 Stickstoff 5.0, Gasart 222 Stickstoff 4.6, Gasart 226 Stickstoff 5.6 / 6.0, Gasart 223 Biogon® N, E941, Gasart 225 Stickstoff 5.3, Gasart 224 Stickstoff ECD, Gasart 407 VERISEQ® GAN Pharma, Gasart 412 Stickstoff med.

Additional identification

Chemical name: Nitrogen
Chemical formula: N2
INDEX No. -
CAS-No. 7727-37-9
EC No. 231-783-9
REACH Registration No. Listed in Annex IV/V of Regulation (EC) No 1907/2006 (REACH), exempted from registration.

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses: Industrial and professional. Perform risk assessment prior to use.
Aerosol propellant. Balance gas for mixtures. Blanketing gas. Calibration gas. Carrier gas. Fire suppressant gas. Food packaging gas. Inerting gas. Inflating tyres. Laboratory use. Laser gas. Pressure head gas, operational assist gas in pressure systems. Process gas. Purge gas. Test gas.
Consumer use.
Beverage applications. Shielding gas in gas welding.
It is the responsibility of the end user to ensure that the product as supplied is suitable for its intended use.

Uses advised against Industrial or technical grade is unsuitable for medical and/or food applications or inhalation.

1.3 Details of the supplier of the safety data sheet

Supplier
Linde Gas GmbH
Carl-von-Linde-Platz 1
A-4651 Stadl-Paura

Telephone: +43 50 4273

E-mail: office@at.linde-gas.com

1.4 Emergency telephone number: Emergency number UMCO: +49 89 220 61012 (German), +44 1865 407333 (English)

Making our world more productive

SAFETY DATA SHEET
According to Regulation (EC) No. 1907/2006 (REACH) Article 31, Annex II as amended
Nitrogen, compressed

SECTION 4: First aid measures

General: In high concentrations may cause asphyxiation. Symptoms may include loss of mobility/consciousness. Victim may not be aware of asphyxiation. Remove victim to uncontaminated area wearing self contained breathing apparatus. Keep victim warm and rested. Call a doctor. Apply artificial respiration if breathing stopped.

4.1 Description of first aid measures

Inhalation: In high concentrations may cause asphyxiation. Symptoms may include loss of mobility/consciousness. Victim may not be aware of asphyxiation. Remove victim to uncontaminated area wearing self contained breathing apparatus. Keep victim warm and rested. Call a doctor. Apply artificial respiration if breathing stopped.

Eye contact: Adverse effects not expected from this product.

Skin Contact: Adverse effects not expected from this product.

Ingestion: Ingestion is not considered a potential route of exposure.

4.2 Most important symptoms and effects, both acute and delayed: Respiratory arrest.

4.3 Indication of any immediate medical attention and special treatment needed

Hazards: None.

Treatment: None.

SECTION 5: Firefighting measures

General Fire Hazards: Heat may cause the containers to explode.

5.1 Extinguishing media

Suitable extinguishing media: Material will not burn. In case of fire in the surroundings: use appropriate extinguishing agent.

Unsuitable extinguishing media: None.

5.2 Special hazards arising from the substance or mixture: None.

Hazardous Combustion Products: None.

QUESTIONS?

Acknowledgements

1-Cooper Bussman Technical Bulletin Current Limitation Charts. Resistance Grounding Arc Flash Video

2-DuraLable-Category Chart, Typical Arc Flash Label. With permission.

3- KM Kowalski-Trakofler, EA Barrett, CW Urban, GT Homce. "Arc Flash Awareness: Information and Discussion Topics for Electrical Workers Archived 2017-08-29 at the Wayback Machine". DHHS (NIOSH) Publication No. 2007-116D.

4-NFPA 70E 2024

5-Linde Gas plc Praxair