

NOTES for PV Rated Safety Switches

Slide #2

Emphasize the difference between an AC and Dc Application due to the fact that DC has no “zero-crossing”, thus, it is more difficult to extinguish the arc in a Load Break application. Further, make it a point that MOST manufacturer’s have always had DC rated Safety Switches for MOTOR “horse Power” rated applications, but usually limited to a 50-HP rating.

Slide #3

Highlight the configurations that they require that at least 2-Pole be broken in series to extinguish the DC arc. Note where the “LOAD” is indicated, which would denote a MOTOR or BATTERY SYSTEM type application. Since in PV (see next slide) the “-” or GROUNDED conductor is not allowed to be broken/switched, and thus would not be shown in the diagram as being routed through the switch.

Slide #4

The BIG highlight-point-emphasis should be the FOURTH bullet and the NEC requirement to isolate the fuse from all potential sources, i.e., back-fed from either the PV Modules or the Inverter. Though highly unlikely, it is a Code Requirement. Only Eaton has this feature out of the box from the Factory. No other manufacturer at this time has a switch that complies unless it is altered in the field, which would void the UL listing. This would also apply to 4-Pole fused switches utilized to break/switch TWO (2) UNGROUNDED conductors.

Slide #7

This tech data, from another Major Manufacturer’s Catalog, would lead one to believe that their Safety Switch, could be utilized in DC applications, although NOT specifically mentioning PV DC applications...and still be UL Listed.

Slide #8

The following information, from the Manufacturer who has the largest market share in the PV Dc Safety Switch market, is why currently there are literally thousands of non UL and NEC compliant PV DC Safety Switch installations in the USA today that were approved by the AHJ’s. This has left the manufacturer, contractor, and the end user open to serious liability issues. (Think Toyota Accelerator recall proportions)

Slide #9

First, notice the date, August 2005. It does somewhat indicate that this first page is for “Standard” DC applications, and will be UL listed if wired per the following diagrams.

Slide #10

These diagrams would indicate a MOTOR or BATTERY SYSTEM type application

Slide #11

Notice they claim to have a UL File number – E2875 - but this file does NOT apply for a PV DC Application where EACH pole has an UNGROUNDED conductor running through it. The truth of the matter is, when verified with UL, this file number never applied to this configuration because the Safety Switch could never pass the UL testing in this configuration due to the enormous amount of energy needing to be extinguished. The next page verbiage verifies the wiring diagram of Figure 2

Slide #12

Note: One pole per “Inverter” or UNGROUNDED conductor

Slide #13

NOW notice the date, November 2007.

Slide #14

Notice how this reference to a UL File number has been deleted....and the next page verbiage hasn't changed from 2005....

Slide #15

So now we have NO UL Listing or File number for this application, but the Manufacturer does not mention that fact. Therefore, the assumption would be from the AHJ, Contractor and End User that it still maintains the UL98 Listing for DC applications when EACH pole is utilized to break/switch an UNGROUNDED conductor from a PV DC System.

Slide #16

Now the PLOT thickens. NOTICE the DATE. This occurred AFTER the Manufacturer was contacted by UL regarding the MISAPPLICATION of their UL98 DC Switch in PV DC applications where ALL three poles were breaking an UNGROUNDED conductor. Notice the RED BOX where it even verifies that this supersedes the 2007 Tech Data.

Slide #17

Notice the diagrams have not changed for the reference UL Listing/File. But the next page of the Tech Data is finally forthright regarding the application and UL.

Slide #18

Here it is FINALLY revealed that this switch is NOT UL listed for all three poles to break/switch the UNGROUNDED conductors. The Switch is only “Self-Certified” by the manufacturer. The NEC Article 100 – Definitions for “Labeled” and “Listed” equipment requires that products have “been tested and found suitable for a specified purpose.” “Self-Certification” by the manufacturer does NOT meet the intent or verbiage of the NEC 110.3. Additionally, the FUSES cannot be isolated from all potential sources per NEC 680.16....another violation.

Slide #19

Note: One pole per “Inverter” or UNGROUNDED conductor verbiage is still maintained even though it is in direct violation of the NEC

Slide #23

They have released a DECISION clarifying the use if UL98 DC Rated Safety Switches in NEC 690 Photovoltaic installations

Slide #26

Clear and concise application data referencing BOTH the UL and NEC directives.





PV Rated Safety Switches

Fred Paul – Specialist, Application Engineering
June 5th, 2010

DC Rated Safety Switches

- 600-Volt DC is hard to break **and** meet the UL Standard
 - DC has no sine wave – therefore, no zero crossing
 - Arcs last a long time – particularly at higher voltages
 - 50 operations @ 150%
6000 operations @ 100%
- 600-Volt DC rating on 2-Pole switches
 - Typical application was motors
 - 2-pole switch actually has 3-poles
 - Break “+” and “-” lines
 - Required three break points for 600-Volt DC
 - UL Test to Limited HP Ratings

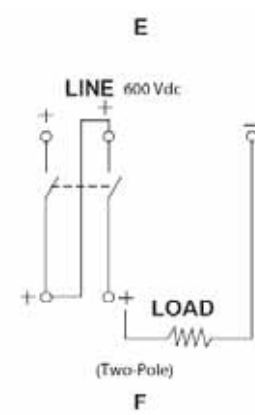
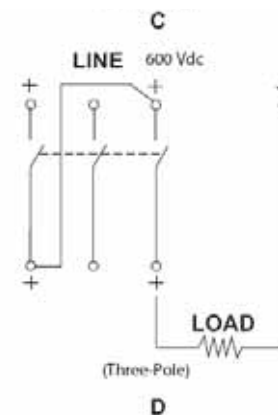
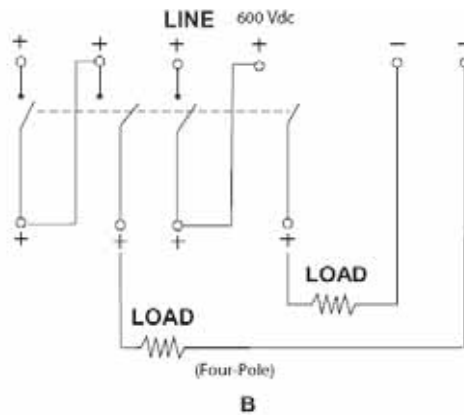
Table 8-45. Non-Fusible 277/480 – 600 Volts

System	Ampere Rating	Maximum Horsepower Ratings							
		Single-Phase ac			3-Phase ac			dc	
		240 Volt	480 Volt	600 Volt	240 Volt	480 Volt	600 Volt	250 Volt	600 Volt
2-Pole — 480 Vac — 600 Vac or dc ^① (Suitable for Service Entrance Use with a Neutral Kit Installed)									
	30	3	7-1/2	10	—	—	—	—	15
	60	10	20	25	—	—	—	—	25
	100	20	30	40	—	—	—	20	25
	200	15	50	50	—	—	—	—	50
	400	—	—	—	—	—	—	50	—
	600	—	—	—	—	—	—	—	—
	800	—	—	—	—	—	—	—	—
1200	—	—	—	—	—	—	—	—	
3-Pole — 480 Vac — 600 Vac, 250 Vdc (Suitable for Service Entrance Use with a Neutral Kit Installed)									
	30	3	7-1/2	10	10	20	30	5	—
	60	10	20	25	20	50	60	10	—
	100	20	40	50	40	75	100	20	—
	200	15	50	50	60	125	150	40	—
	400	—	—	—	125	250	350	50	—
	600	—	—	—	—	200	400	500	—
	800	—	—	—	—	—	500	500	—
1200	—	—	—	—	—	500	500	—	
4-Pole — 480 Vac — 600 Vac,		2-Phase ac			3-Phase ac				

DC Rated Safety Switches



- To be UL Listed and meet NEC, DC switches need to be wired utilizing a minimum of 2-poles



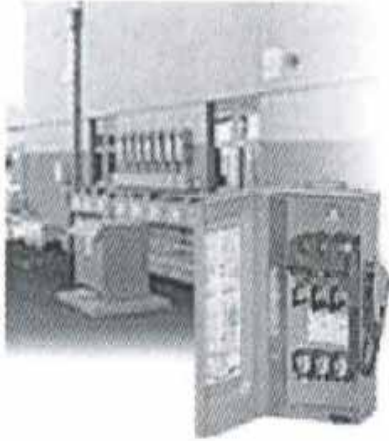
DC Switch Considerations for PV

- To be UL Listed and meet NEC, PV-DC switches need to be wired utilizing a minimum of 2-poles.
- For PV systems you only break the ungrounded conductor
- Normally utilize a FUSED Switch due to the low AIC rating of an UNFUSED Switch
- Must isolate the FUSE from ANY potential source when utilized in a PV system (NEC 680.16)

Confusing DC Safety Switch Data

- The following manufacturers' information would lead one to believe that all their DC Safety Switches are UL approved to be utilized in a PV-DC System

Confusing DC Safety Switch Data



Solar Installation Disconnect Switch

“Brand-X” provides a Photovoltaic Disconnect Switch solution encompassing all of the quality, durability and ease of use you have come to expect. The product offering spans 30–100 A. 2- and 3-pole fusible and non-fusible Heavy Duty Safety Switches. All “Brand-X” heavy duty safety switches with DC ratings (2- and 3-pole fusible and non-fusible) are Underwriters Laboratories® (UL®) Listed for use on DC applications when properly wired. Additionally:

Get more info . . .
Technical Data
Brochures
On-Line Catalog
Specifications
(CSI Standards)
Safety Switches



- Heavy duty safety switches are rated for 600 Vdc maximum open circuit voltage.
- Non-fusible safety switches may carry 100 percent of the nameplate current rating.
- Fusible safety switches may carry 80 percent of nameplate current rating (continuous use).
- Heavy duty switches are dc horsepower rated as indicated on the safety switch wiring diagram.
- Heavy duty switches have a 10,000 amperage dc short-circuit rating unless otherwise stated on the switch wiring diagram.

Confusing DC Safety Switch Data

Disconnect Switches

Type [30-600A] with Flange Mounted Operating Handle *Features and Ordering Information*



Features

- 30-600A, 600VAC and DC ratings
- UL Recognized (file # E121152 vol. 3) and CSA Certified under file number 154852
- Visible blade quick make and break switching action
- Panel and Flange mounted assemblies facilitate installation
- Panel mounted switches are variable depth
- Short circuit rating of 10,000 AIC with class H fuse, and of 200,000 AIC with class R or J fuses
- Flange mounted handles are Type 1 and 12 rated and padlockable in the off position with up to (3) padlocks with 5/16 hasps ①
- Meets UL98 requirements and suitable for both main and branch circuit applications
- A complete line of aux contacts are available
- Load break and horsepower rated
- Defeatable cover interlock standard with all handles
- Meets NFPA79 requirements

Confusing DC Safety Switch Data

- Adding to the confusion has been the misapplication of a “Standard” DC Switch in PV applications where it was assumed – based on the manufacturer’s Tech Data sheets – the product was UL Listed for the application when properly wired.

Confusing DC Safety Switch Data

Data Bulletin

08/2005

Direct Current and Photovoltaic Systems

Applying Heavy Duty Safety Switches (Fused and Not Fused) on DC and Photovoltaic Systems

Retain for future use.

GENERAL DC SYSTEMS

(for Photovoltaic, see next page)

All heavy duty safety switches with DC ratings (2- and 3-pole fusible and non-fusible) are Underwriters Laboratories® (UL®) Listed for use on DC applications when wired as shown in Figure 1 (A, B, C and D). Additionally:

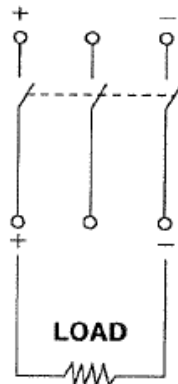
- Heavy duty safety switches are rated for 600 Vdc maximum open circuit voltage.
- Non-fusible safety switches may carry 100 percent of the nameplate current rating.
- Fusible safety switches may carry 80 percent of nameplate current rating (continuous use).
- Heavy duty switches are dc horsepower rated as indicated on the safety switch wiring diagram.
- Heavy duty switches have a 10,000 amperage dc short-circuit rating unless otherwise stated on the switch wiring diagram.

Figure 1: **General DC Systems
Fused and Non-Fusible Wiring Diagram**
(for Photovoltaic, see next page)

(Not Fused Shown)

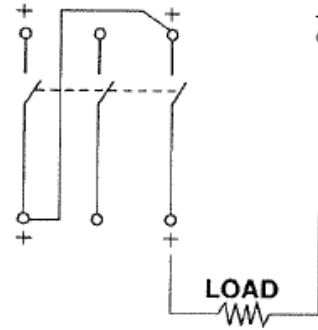
Confusing DC Safety Switch Data

LINE 600 Vdc



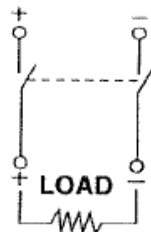
A

LINE 600 Vdc



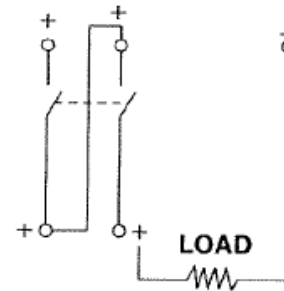
B

LINE 600 Vdc



C

LINE 600 Vdc



D

Confusing DC Safety Switch Data

Direct Current and Photovoltaic Systems
Data Bulletin

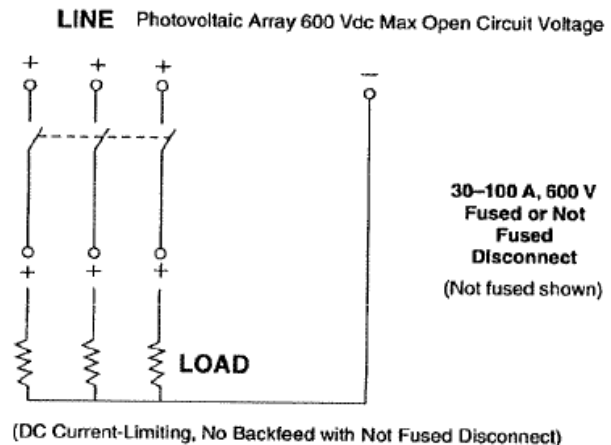
08/2005

PHOTOVOLTAIC SYSTEMS

has obtained a limited UL[®] Listing (File E2875, Vol. 1) for 30–100 A heavy duty safety switches (3-pole fusible and non-fusible) when used on photovoltaic systems (see tables below for limitations and ratings) and wired as shown in Figure 2. The National Electrical Code[®] (NEC[®]) does not allow the negative conductor to be switched when disconnecting photovoltaic systems (NEC Article 690).

NOTE: Heavy duty safety switches may be used on photovoltaic systems with a grounded negative feed. Refer to Figures 1B, 1D and 2.

Figure 2: Negative Grounded Feed per NEC Article 690



Confusing DC Safety Switch Data

Table 1: Limitations

Switch Nameplate Amperage 600 V	Maximum Current for the PV Array or Photovoltaic String	Rated Short-Circuit Current per Pole for the PV Array
30 A	18 A DC per pole	11.5 A (18/1.56)
60 A	60 A DC per pole	38 A (60/1.56)
100 A	100 A DC per pole	64 A (100/1.56)

- If a non-fusible disconnect is used, the inverter must not be capable of backfeeding currents into a short circuit or fault in the photovoltaic array or string.
- One inverter may be connected to each pole of the switch.
- Refer to Table 2 (below) for the lug wire range of heavy duty switches.

Table 2: Heavy Duty Safety Switch Wire Range

Ampere Rating	Conductors per Phase and Neutral	Wire Range of Safety Switch per Phase and Neutral AWG/kcmil *	Wire Range of Lug AWG/kcmil *
30 A	1	#12-6 (Al) or #14-6 (Cu)	#12-2 (Al) or #14-2 (Cu)
	2	#14-10 Cu solid or stranded	#14-10 Cu solid or stranded
60 A	1	#12-3 (Al) or #14-3 (Cu)	#12-2 (Al) or #14-2 (Cu)
100 A	1	#12-1/0 (Al) or #14-1/0 (Cu)	#12-1/0 (Al) or #14-1/0 (Cu)

* *

Confusing DC Safety Switch Data



11/2007

Data Bulletin

Direct Current and Photovoltaic Systems

Applying Heavy Duty Safety Switches (Fusible and Non-Fusible)
on DC and Photovoltaic Systems

Retain for future use.

GENERAL DC SYSTEMS

(for Photovoltaic, see next page)

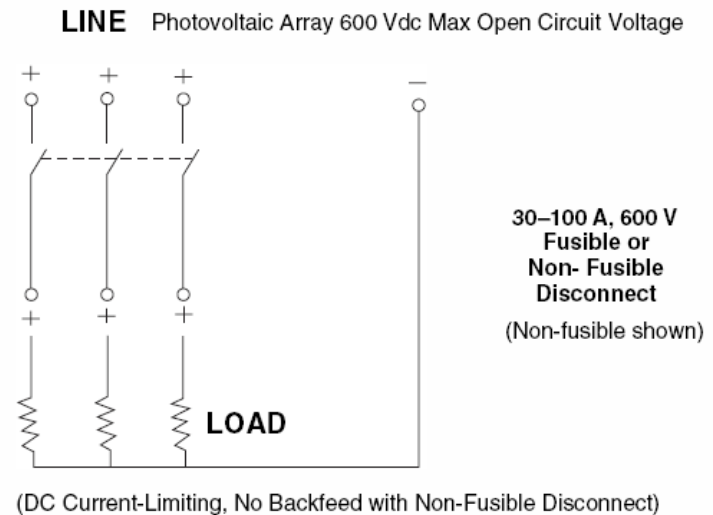
All heavy duty safety switches with DC ratings (2- and 3-pole fusible and non-fusible) are Underwriters Laboratories® (UL®) Listed for use on DC applications when wired as shown in Figure 1 (A, B, C and D). Additionally:

Confusing DC Safety Switch Data

PHOTOVOLTAIC SYSTEMS

NOTE: Heavy duty safety switches may be used on photovoltaic systems with a grounded feed. Refer to Figures 1B, 1D and 2.

Figure 2: Grounded Feed per NEC Article 690



NOTE: Negative grounding shown in Figure above; positive grounded systems are similarly allowed.

Confusing DC Safety Switch Data

Table 1: Limitations

Switch Nameplate Amperage 600 V	Maximum Current for the PV Array or Photovoltaic String	Rated Short-Circuit Current per Pole for the PV Array
30 A	18 A DC per pole	11.5 A (18/1.56)
60 A	60 A DC per pole	38 A (60/1.56)
100 A	100 A DC per pole	64 A (100/1.56)

- If a non-fusible disconnect is used, the inverter must not be capable of backfeeding currents into a short circuit or fault in the photovoltaic array or string.
- One inverter may be connected to each pole of the switch.
- Refer to Table 2 (below) for the lug wire range of heavy duty switches.

Table 2: Heavy Duty Safety Switch Wire Range

Ampere Rating	Conductors per Phase and Neutral	Wire Range of Safety Switch per Phase and Neutral AWG/kcmil *	Wire Range of Lug AWG/kcmil *
30 A	1	#12-6 (Al) or #14-6 (Cu)	#12-2 (Al) or #14-2 (Cu)
	2	#14-10 Cu solid or stranded	#14-10 Cu solid or stranded
60 A	1	#12-3 (Al) or #14-3 (Cu)	#12-2 (Al) or #14-2 (Cu)
100 A	1	#12-1/0 (Al) or #14-1/0 (Cu)	#12-1/0 (Al) or #14-1/0 (Cu)

Confusing DC Safety Switch Data

Data Bulletin

Direct Current and Photovoltaic Systems

Applying Heavy Duty Safety Switches (Fusible and Non-Fusible) on dc and Photovoltaic Systems

Replaces 3110DB0401 11/2007

11/2009

Retain for future use.

General dc and Photovoltaic Systems, UL[®] Listed, CSA[®] Certified (Files E2875 and E154282)

NOTE: Heavy duty safety switches may be used on photovoltaic systems with a grounded feed. Refer to Figures 1B, 1D, 1F and 2 (negative grounding shown; positive grounded systems are similarly allowed). For ungrounded systems, see National Electrical Code[®] (NEC[®]) 690.35 (NEC 2008, NFPA 70).

All heavy duty safety switches with dc ratings (2-, 3- and 4-pole fusible and non-fusible) are Underwriters Laboratories[®] (UL[®]) Listed and CSA[®] Certified for use on dc applications when wired as shown in Figure 1 (A, B, C, D, E, and F). Additionally:

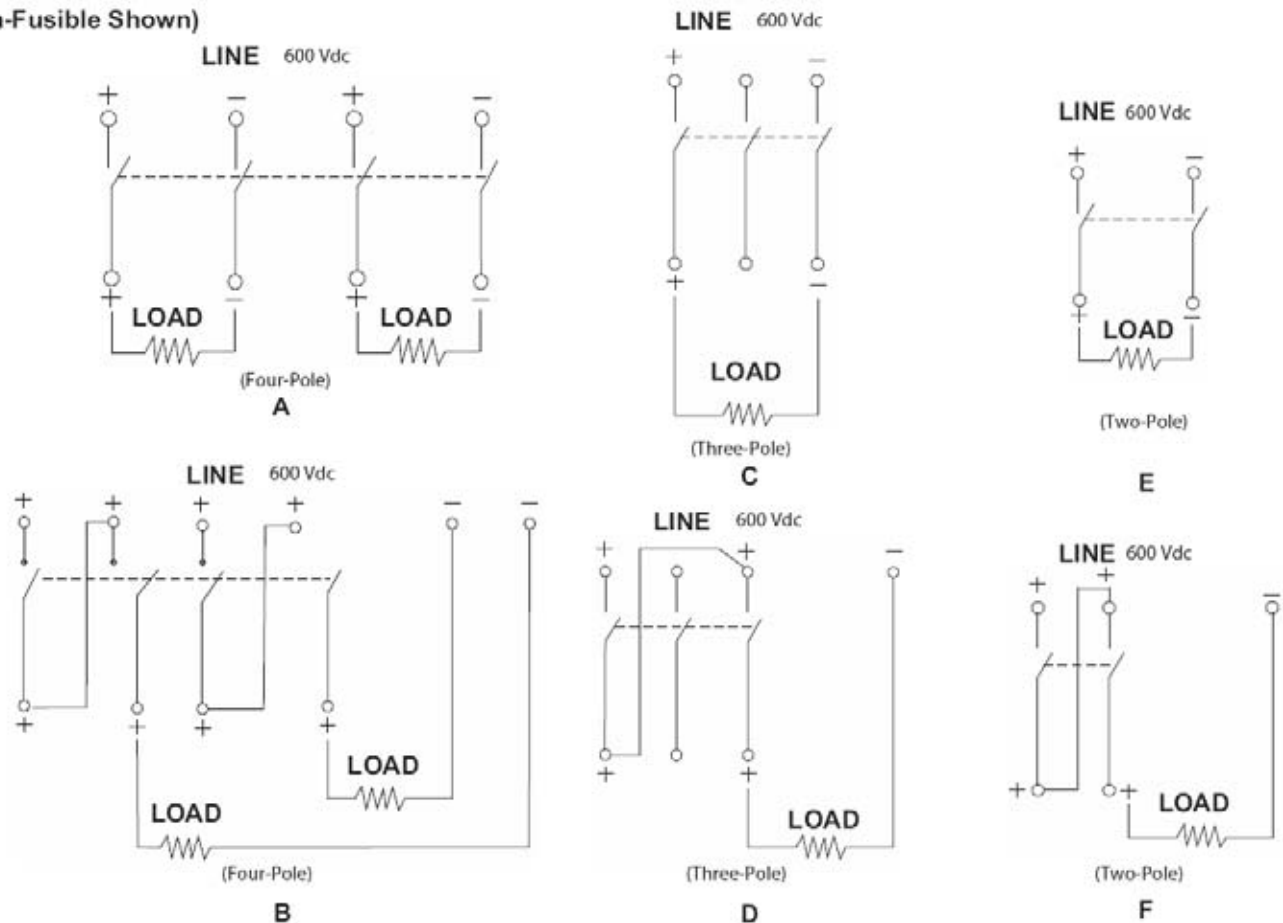
- Heavy duty safety switches are rated for 600 Vdc maximum open circuit voltage.
- Non-fusible safety switches may carry 100 percent of the nameplate current rating.
- Fusible safety switches may carry 80 percent of nameplate current rating (continuous use).
- Heavy duty switches are dc horsepower rated as indicated on the safety switch wiring diagram.
- Heavy duty switches have a 10,000 ampere dc short-circuit rating at 600 Vdc unless otherwise stated on the switch wiring diagram. Consult factory for short circuit current ratings at 250 Vdc.
- Refer to current Square D[®] Digest for lug wire range of heavy duty switches.

Figure 1: General dc and Photovoltaic Systems, Fusible and Non-Fusible Wiring Diagram

Confusing DC Safety Switch Data

Figure 1: General dc and Photovoltaic Systems, Fusible and Non-Fusible Wiring Diagram

(Non-Fusible Shown)



Confusing DC Safety Switch Data

Direct Current and Photovoltaic Systems
Data Bulletin

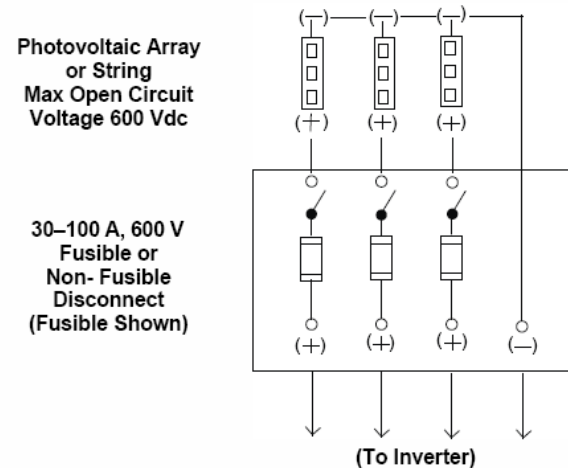
11/2008

Alternate Photovoltaic System
Wiring, Evaluated and
Self-Certified by

Not UL Listed



Figure 2: Grounded Feed per NEC Article 690



- Connect negative photovoltaic line (-) to case inside inverter for negative grounded system.
- Positive grounded systems are similarly allowed.
- For ungrounded systems, see NEC 690.35 (NEC2008, NFPA70).


Confusing DC Safety Switch Data

Current Ratings

Switch Nameplate 600 V	Switch dc Rating per Pole ¹	Photovoltaic Maximum Circuit Current ²	Photovoltaic Short-Circuit Current (I_{sc})
30 A	20 A	16 A dc per pole	12.8 A (20/1.56)
60 A	60 A	48 A dc per pole	38 A (60/1.56)
100 A	100 A	80 A dc per pole	64 A (100/1.56)

¹ The switch per pole rating must be at least the photovoltaic maximum circuit current multiplied by 125%.

² From NEC 2008 and NFPA 70, Article 690.8: the photovoltaic maximum circuit current is I_{sc} multiplied by 125%.

- If a non-fusible disconnect is used, the inverter must not be capable of backfeeding currents into a short circuit or fault in the photovoltaic array or string.
- **One inverter may be connected to each pole of the switch.** 
- Refer to current Square D Digest for lug wire range of heavy duty switches.

More Confusing Tech Data

Another major Manufacturer was contacted via their WEB based Tech Support service. It was asked if their “standard” UL98 DC Safety Switch could be used in PV DC Applications and do they have a UL1741 Listing. The response was:

There is a lot of confusion in the industry on this subject. UL is also in the process of evaluating UL98 Vs UL1741 for PV applications. At present no manufacturer has a 600A switch that is UL1741 listed but a standard 600V DC rated UL98 listed switch will work fine in the application.

Technically this is correct, since UL has decided that there is no need to add another Category for Safety Switches when applied with other UL1741 products, since UL98 already covers Safety Switches. But, “work just fine” is an incorrect statement.

More Confusing Tech Data

Remember, NEC 680.16 requires that the FUSES be isolated from ALL Potential sources. This is not possible with a “Standard” 600-VDC Safety Switch. Furthermore, using “dummy links” on the outside poles of the switch would be a violation of BOTH the UL Listing and the NEC.

More Confusing Tech Data

The same manufacturer went on to add:

Even though it is **VERY** unlikely that back feeding can occur, the NEC also requires that a label on the outside of the door of the switch be installed warning that the terminals in the switch can be hot when the switch is in the **OFF** position. *This label is normally field installed and supplied by the contractor.* When the switch is in the OFF position no current can flow through the switch in either direction so "back-feeding" cannot occur when the switch is OFF but again, there is a chance that some or the terminals can be hot that would not be in a "normal" installation.

The words “VERY unlikely”, “chance” and “normal” installation are very subjective in nature and have no place where the safety of human could be at risk.

What Has UL Done to Correct This?

UNDERWRITERS LABORATORIES INC. CERTIFICATION REQUIREMENT DECISION

This Certification Requirement Decision is prepared and published by Underwriters Laboratories Inc. (UL). It is normative for the applicable UL Product Certification Program(s); however, it is currently not part of the UL Standard(s) referenced below.

Product Category (CCN): WIAX, WHTY

Standard Number: UL 98

Edition Date: February 25, 2004

Edition Number: 13

Section / Paragraph Reference: 9.2.53 (New)

Subject: Use of DC Rated Switches in NEC Article 690 (Solar Photovoltaic Systems) Installations

What Has UL Done to Correct This?

DECISION:

(New Paragraph):

9.2.53 Switches rated for use on DC circuits may be marked "Suitable for use in accordance with NEC Article 690 Photovoltaic Installations," or equivalent.

RATIONALE FOR DECISION:

Installations of Solar Photovoltaic Systems are increasing, and questions arise about the use of traditional UL 98 disconnect switches in these applications. Switches with DC ratings may be applied in accordance with installation instructions in NEC Article 690. A new optional marking will allow manufacturers to indicate this as an acceptable application of UL 98 switches.

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Eaton is Leading the way in SAFETY!

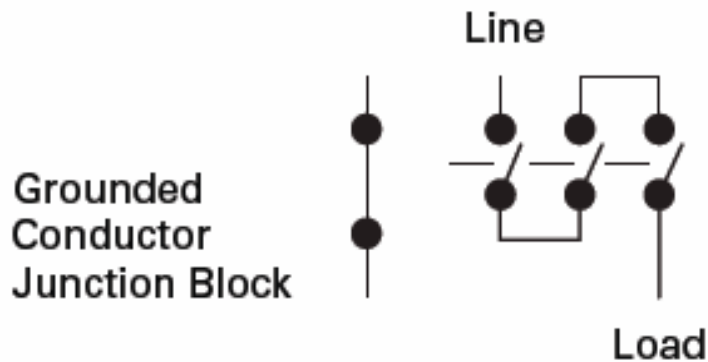


Eaton is Leading the way in SAFETY!

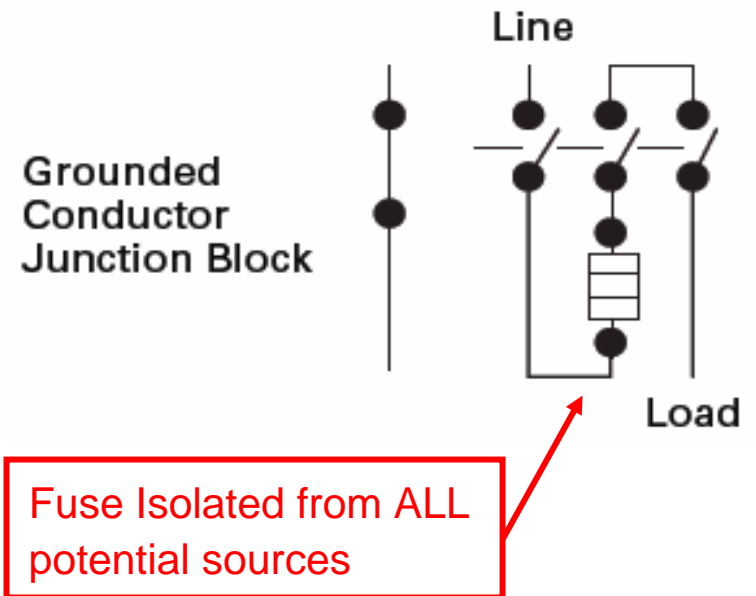
Unlike AC systems that possess a current sine wave with zero crossings, the interruption of higher voltage DC circuits requires an increased air gap to safely and quickly interrupt and break the arc. The increased gap is accomplished by wiring multiple poles of a single switch in series for safe arc interruption. All switch manufacturers require the use of multiple poles at 600 Vdc to maintain the UL® listing. For this reason, a switch should only be used to switch one circuit. The UL listing of these products does not permit multiple circuits to be switched by one switch. Eaton's new offering of PV switches have multiple poles factory-wired, and they are approved for NEC Article 690 applications right from the box. Other manufacturers require the contractor to add jumpers to a two- or three-pole switch, add a neutral, and add labels to meet this requirement. For fusible switches, the new Eaton PV switch requires only one fuse per switch—saving the customer at least one fuse on each switch.

FINALLY! - A True PV DC Safety Switch

Non-Fused Construction



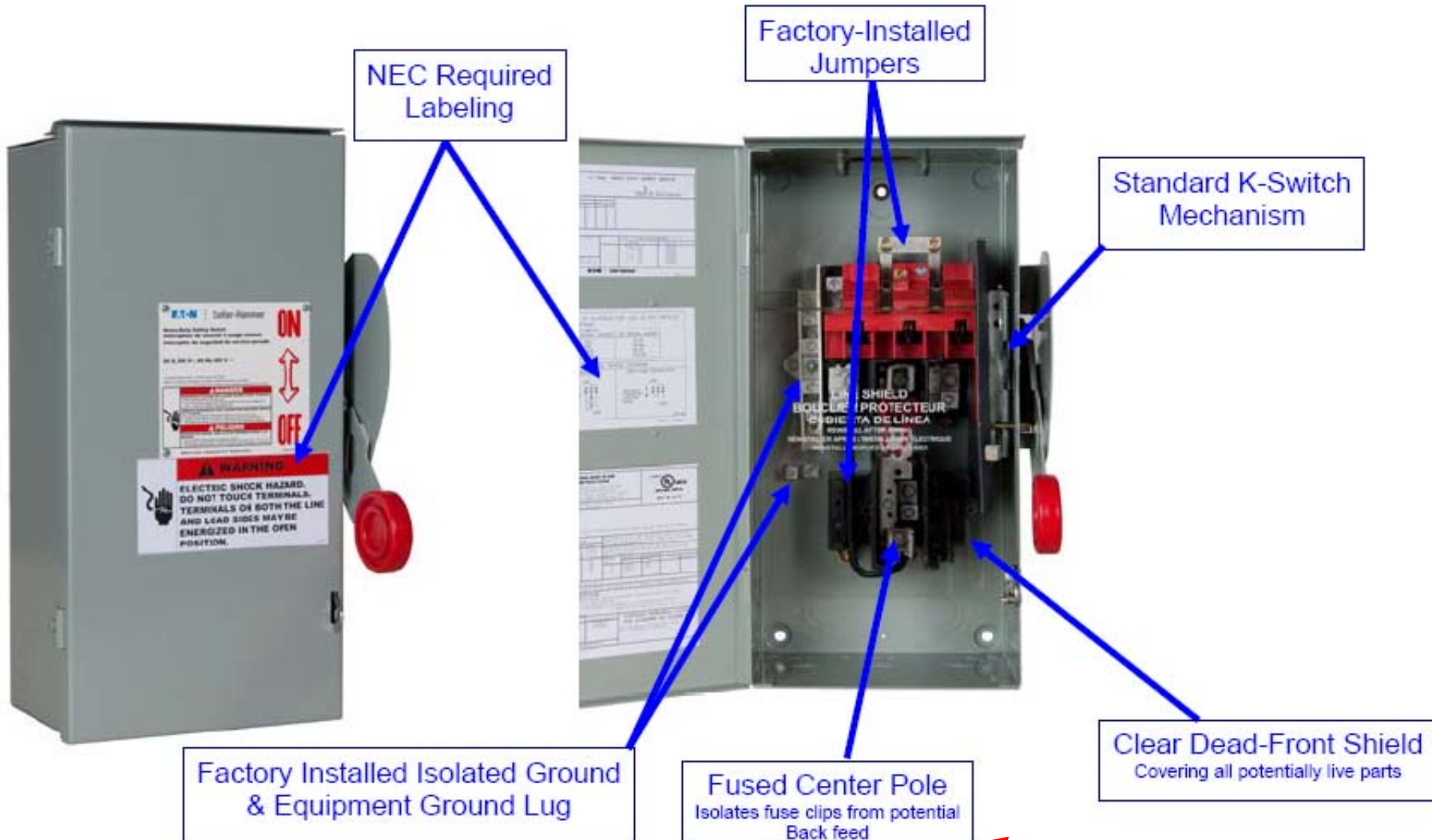
Fused Construction



FINALLY! - A True PV DC Safety Switch

- Marked as suitable for NEC 690 PV Applications up to 600-Volt DC
- UL98 Listed
- All switches are Single Pole for switching ONE Circuit / Conductor
- Clear polycarbonate dead-front to guard against accidental contact with live parts from ALL potential sources
- NEC 690.17 compliant labeling warning that the switch terminals may be energized in the “OPEN” position
- Two (2) required NEC 690.14(C) “PV System Disconnect” labels
- Isolated terminals for GROUNDED (“-”) conductor
- Ground lug for Equipment Grounding Conductor

FINALLY! - A True PV DC Safety Switch



FINALLY! - A True PV DC Safety Switch

- 30-600A
- 600-Volt DC only
- 1-Pole (One UNGROUNDED Conductor)
- NEMA 3R, 12 and 4X
- Fusible (Class R) and Non-Fusible
- Factory installed jumpers, neutral and labels
- Clear Dead-Front shield

EATON

Powering Business Worldwide