



# Interpretation

## Section 41.

### Section 41. Supply and communications systems—Rules for employers

#### Table 410-4—Clothing and clothing systems—voltage, fault current, and maximum clearing time for medium voltage 1 kV to 36 kV enclosed equipment

(2023 Edition, page 256)

(30 August 2023) IR600

**Question:** What type of fault are the fault current values listed in Table 410-4? For example, are the fault current values for phase-to-ground or three-phase faults? The type of fault can be a significant difference in the values of fault current and the clearing time for different cases since when relay protection is used, different protection elements are often used for different fault types.

**Discussion:** Table 410-4 was added to the 2023 NESC. The table provides significant benefit to users of the 2023 NESC as the table fills a gap in the previous edition of the NESC for arc-flash protection recommendations for enclosed equipment.

Tables 410-1, 410-2, and 410-3 were in the previous version of the NESC. Tables 410-2 and 410-3 are like Table 410-4 as each of those tables provides a recommended arc-flash PPE clothing system rating based on fault currents and clearing time. Tables 410-2 and 410-3 also include voltage factors to consider. Separate voltage factors are not part of Table 410-4 as the table applies for 1 kV to 36 kV systems.

Tables 410-2 and 410-3 each have notes that state the fault type associated with the fault current values in the table. Each of those notes state the fault type is for open air phase-to-ground arcs and not for phase-to-phase arcs or enclosed arcs (arc in a box).

Below is Note 1 for Table 410-2:

<sup>1</sup> These calculations are based on open air phase-to-ground arc. This table is not intended for phase-to-phase arcs or enclosed arcs (arc in a box).

Below is Note 1 for Table 410-3:

<sup>1</sup> These calculations are based on open air phase-to-ground arc. This table is not intended for phase-to-phase arcs or enclosed arcs (arc in a box).



The 2023 NESC does not provide any statement concerning the fault type associated with the fault currents listed in Table 410-4.

- The table title does not provide a statement about the fault type for the table.
- The four notes to the table do not provide a statement about the fault type for the table.
- The content of Section 41 does not provide a statement about the fault type for the table.
- No other portion of the 2023 NESC provides a statement about the fault type for the table.

Without knowing the fault type, it is not possible to properly apply the values in the table. The reason for the problem is two-fold.

#### First Issue – Fault Current Values

Electrical power systems can have vastly different phase-to-ground fault and three-phase fault current values. If it is assumed the values in the table are for phase-to-ground faults but the actual values are for three-phase faults, then an individual may be in the wrong fault current row of the table as often the three-phase fault values are higher than phase-to-ground values. If the wrong row of the table is used, then that could lead to significant underprotection of a person as the wrong clothing systems may be chosen.

For example, if a live-front transformer system has 13 kA of phase-to-ground fault current, 16 kA of three-phase fault current, and an assumed clearing time of 30 cycles, then a person would be directed to a “25 cal system” when considering the 13 kA fault current but would need a “40 cal system” if the 16 kA of fault current is considered. Below is the portion of Table 410-4 that would provide these clothing system recommendations, which could leave a person improperly protected.

At least one major manufacturer of electrical system modeling software has assumed the fault currents are phase-to-ground faults. After checking with that manufacturer, they stated they “assumed” phase-to-ground faults are what the table is based on, but they have no justification for that decision.

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Fault current (kA)	Live-front transformer, live-front terminations, and horizontally racked circuit breaker <sup>3</sup>		
	8 cal system	25 cal system	40 cal system
	Max clearing time (cycles)	Max clearing time (cycles)	Max clearing time (cycles)
15	11	35	55
20	8	25	41

For many facilities (such as industrial facilities and campuses), phase-to-ground fault currents may be limited by current limiting resistors or reactors. Often the currents are limited to hundreds of amperes instead of thousands of amperes that would occur if the system was solidly grounded. If the phase-to-ground currents are used with Table 410-4 for those impedance grounded systems, then extremely long fault clearing times would be allowed, allowing most facilities to use an “8 cal system” when the exposure may be much higher.

### Second Issue – Fault Clearing Time

Except when fuses are used, the clearing time can vary significantly for phase-to-ground and three-phase faults. Protection systems typically have a faster clearing time for phase-to-ground faults than for three-phase faults. Using the phase-to-ground clearing time could lead an individual to choose the wrong clothing system listed in Table 410-4.

### Summary

It is critical for the user of Table 410-4 in the 2023 NESC to understand the type of fault currents listed in the table. Without knowing the fault type (such as phase-to-ground or three-phase) to be used with Table 410-4, the user cannot be certain of the right fault current type to use. Similarly, knowing the fault type used with Table 410-4 is required for the user of the table to be able to determine the proper fault clearing time. These issues lead to assumptions and possible misapplication of the table, potentially leaving personnel significantly underprotected for arc-flash events.

Simply, without the fault type information for the table, the table is not able to be used properly.



## Interpretation

The Interpretations Request Subcommittee reviewed your request and developed the following consensus response:

The requirements in Table 410-4 are based upon the papers by Eblen and Short referenced in Footnotes 2, 3, and 4 of Table 410-4:

[B32] Eblen, M. L., and Short, T. A., "Medium Voltage Arc Flash in Open Air and Padmounted equipment," *IEEE Transactions on Industry Applications*, vol. 48, issue: 1, pp. 245–253, 2012.

[B33] Eblen, M. L., Short, T. A., and Lee, W. J., "Medium-Voltage Arc Flash in Switchgear and Live-Front Transformers," *IEEE Transactions on Industry Applications*, vol. 52, issue: 6, pp. 5280–5288, Nov.–Dec. 2016.

Thus, the values in Table 410-4 are based upon three-phase faults.