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PERCENT ARCING CURRENT USED TO CALCULATE INCIDENT ENERGY ON LOW VOLTAGE SYSTEMS

1.0 IEEE Standard 1584

In Section 5.2 of IEEE Standard 1584, equations are given for determining the arcing current. In Figure 1, the arcing currents are illustrated at different system voltages based on these equations. When an arc occurs, the current is less than the maximum possible fault current due to the impedance of the arc. The lower the system voltage, the more significant the arc impedance is in reducing the arcing fault current.

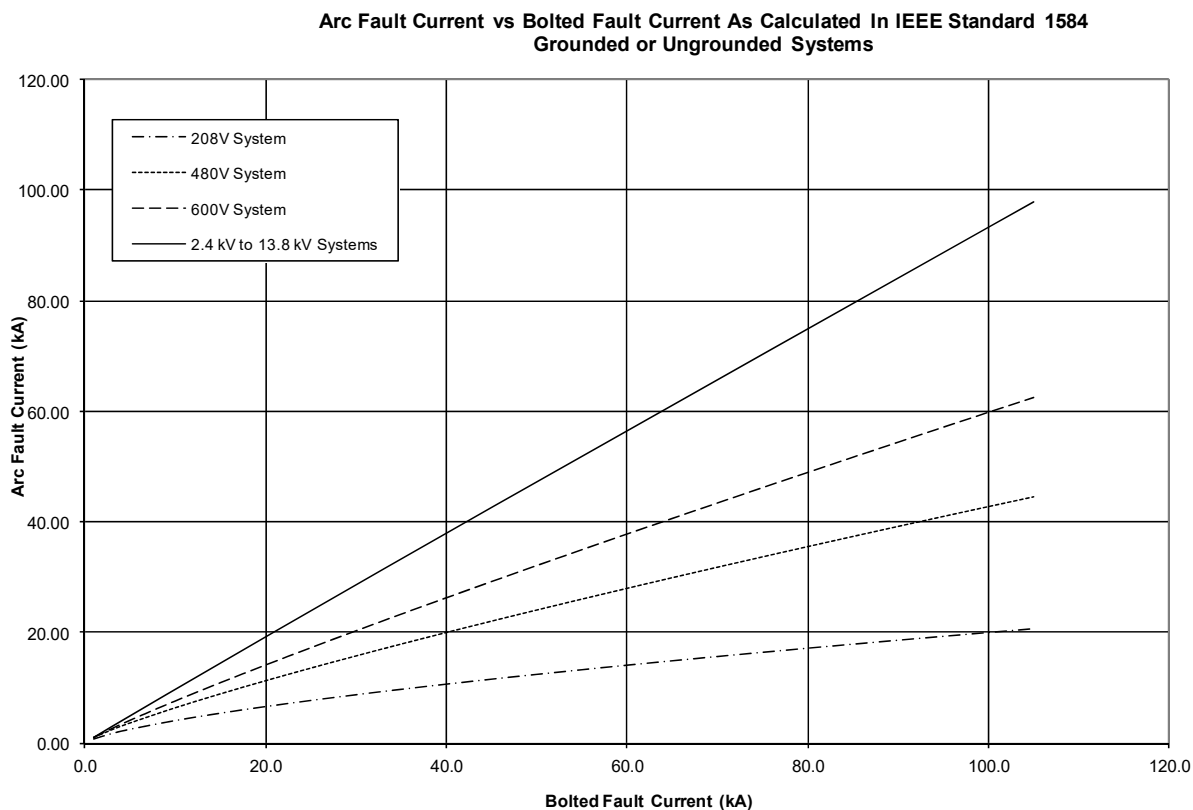


Figure 1

In IEEE 1584, it is recommended to use the current from Figure 1 and 85% of that value to evaluate the potential incident energy due to the variation in the arc current.

2.0 Variation in Arcing Current

The following table and graph summarize the actual data points that were used to develop the IEEE equations. This information was documented in “Practical Solution Guide of Arc Flash Hazards”, by ESA (developers of Easy Power).

Table 1: Variation of measured data about arc current estimated with IEEE 1584 equation for low voltage (includes both open and box)

Voltage (kV)	Percent Variation from Estimate (%)	
	Minimum	Maximum
0.2 / 0.24	-10 %	+57.2 %
0.4 / 0.48	-37.5 %	+23.4 %
0.6	-27.6 %	+27.4%

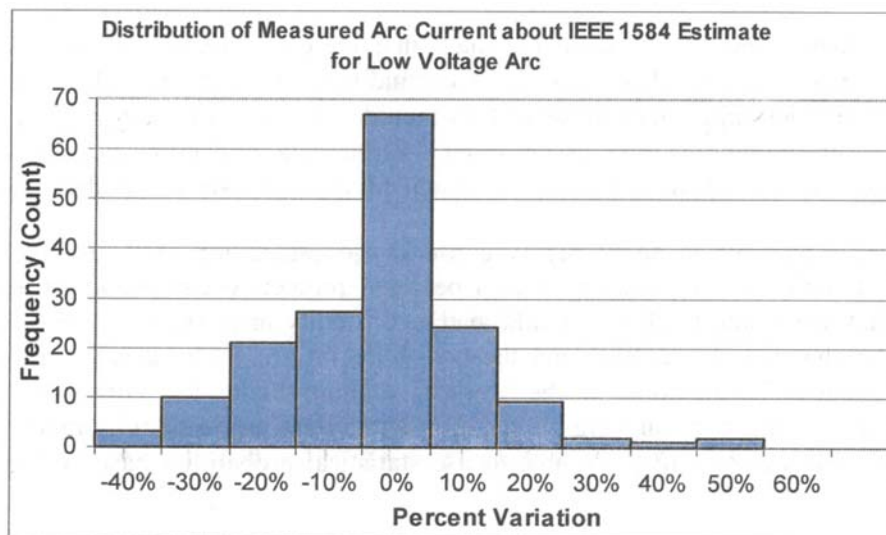


Figure 2: Distribution of measured arc currents about IEEE 1584 equations for low voltage arc currents from bolted fault currents.

The following observations are noted with respect to the data in Table 1 and Figure 2.

1. Since the measured arcing currents were in the range of -38% to +57% of the derived equation, there are a number of points outside of the range of 85% to 100% arcing current.
2. ESA suggests that +/- 25% on the 100% arcing current would give a 95% confidence in the results.
3. The positive variation currents are not likely to be significant in determining the PPE since the clearing time is either constant or faster than for the 100% arcing current. The negative variation is more significant due to the inverse clearing characteristics of fuses and trip units when going from high currents to low currents. In other words, it can take much longer to clear low magnitude currents, which typically results in higher incident energies.

4. Based on the data in Figure 2 and on the positive variations in current as being insignificant in determining the PPE level, the confidence levels of the actual arcing current being in the range are estimated as follows:
 - a. 85% and 100% Currents → 85% confidence level
 - b. 75% and 100% Currents → 95% confidence level
 - c. 70% and 100% Currents → 98% confidence level

This brief overview of a significant amount of test data indicates that the arcing current may vary outside the range of 85% to 100%, possibly on the order of 15% of the time for systems of < 1000V. Variations in bus phase spacing and enclosure dimensions can also have an effect on the arcing current magnitudes. Consequently, it is recommended to consider a wider range of arcing currents when analyzing systems of < 1000V.

3.0 Arc Flash Analysis Methodology

To assure that the incident energy calculations have adequately covered the possible operating conditions and the potential variations in the key parameters, the arc flash analysis would be done as follows.

1. System Operating Configurations – Various system operating configurations would be evaluated. This would include at least the minimum fault current condition and the maximum fault current condition. Depending upon the overcurrent characteristics of the protective device, the highest incident energy can occur at either high fault current or low fault current.
2. Component Parameters – If component parameters are not well defined, the parameters are to be varied over the planned range. This could include cable length, transformer impedance, etc.
3. Arcing Fault Current – IEEE Standard 1584 recommends using arcing fault currents of 85% and 100% of the values given by the formula in 1584 to account for the variation in the arcing current that could occur. As noted in Section 2.0, the low magnitude arcing currents can be outside of this range, possibly on the order of 15% of the time. The area of greatest concern tends to be the lower fault currents rather than the higher fault currents, due to the potentially long clearing times. In the analysis, three options to address this possible variation are the following:
 - A. *Option 1 - Allow for some margin in the pickup settings of low voltage circuit breaker trip units and medium voltage relays compared to the 85% arcing current.*
 - i. When determining the short time pickup setting of a low voltage circuit breaker trip unit, be sure that the upper value of the band of the breaker trip characteristic is more than 15% below the 85% arcing current, i.e. $0.85 \times 0.85 = 0.723$. (If there is no short time characteristic, this criteria would apply to the instantaneous setting.)
 - ii. When determining the setting for a definite time characteristic of a relay for a medium voltage circuit breaker that is protecting a low voltage system, allow for a 10% margin between the relay pickup and the lowest expected arcing current, which is estimated at 15% below the 85% arcing current. That would be $0.9 \times 0.85 \times 0.85 = 0.650$.
This method does not allow for taking into account lower arcing currents in fuse applications; however, the potential increase in the incident energy would tend to be lower for a fuse than for a circuit breaker.

- B. *Option 2 - Based on the analysis in Section 2.0, use arcing fault currents of 75% and 100%.*
- i. When determining the short time pickup setting of a low voltage circuit breaker trip unit, be sure that the upper value of the band of the breaker trip characteristic is less than the 75% arcing current. (If there is no short time characteristic, this criteria would apply to the instantaneous setting.)
 - ii. When determining the setting for a definite time characteristic of a relay for a medium voltage circuit breaker that is protecting a low voltage system, allow for a 10% margin between the relay pickup and the 75% arcing current. That would be $0.90 \times 0.75 = 0.675$. This method allows for taking into account lower arcing currents in fuse applications. This option would give approximately a 95% confidence level.
- C. *Option 3 - Based on the analysis in Section 2.0, use arcing fault currents of 70% and 100%.*
- i. When determining the short time pickup setting of a low voltage circuit breaker trip unit, be sure that the upper value of the band of the breaker trip characteristic is less than the 70% arcing current. (If there is no short time characteristic, this criteria would apply to the instantaneous setting.)
 - ii. When determining the setting for a definite time characteristic of a relay for a medium voltage circuit breaker that is protecting a low voltage system, allow for a 10% margin between the relay pickup and the 70% arcing current. That would be $0.90 \times 0.70 = 0.630$. This method allows for taking into account lower arcing currents in fuse applications. This option would give approximately a 98% confidence level. This is the recommended method of the three that are given.

4.0 Conclusion

In conclusion, it is recommended that the 100% and 70% arcing currents be used for arc flash analysis on low voltage systems, as outlined in Option 3 above.

1. This would result in approximately a 98% confidence level.
2. This option would give the maximum recommended trip unit and relay pickup settings that should be used. Where coordination and protection are not compromised, lower pickup settings can and should be used.