ETAP Arc-Flash Analysis

This document is an example of an ETAP validation test case. This case is just one of many test case scenarios for Arc-Flash Analysis (AF) which are part of the ETAP V&V program. This case is based on comparisons of ETAP ArcFault™ against published IEEE/NESC Standards.

Arc-Flash Analysis Validation Case # 2

<u>Comparison of ETAP Arc-Flash Results Against IEEE C2-2023 (NESC)</u>

Excerpt from Validation Case and Comparison Results from TCS-SC-369

Highlights

- Covers ETAP ArcFault™ methods which are Method 1 (Terzija/Koglin) and Method 2 (EPRI). The validation was performed as described in "High Voltage Arc Flash Assessment and Applications" [1].

- Incident energy comparisons between ETAP ArcFault™ methods against Tables 410-2 and 410-3 published in IEEE C2-2023 (NESC) [2] pages 576-577.

- Comparisons for:
    - Voltage ranges from 1.1 to 800 kV
    - Open-air equipment experiencing a line-to-ground arcing fault.
    - Various combinations of bolted fault currents (Ibf), gap between conductors, workings distances and clearing times.

System Description

IEEE C2-2023 (NESC) tables 410-2 and 410-3 were modeled in ETAP using multiple radial systems as shown in Fig. 1~2. Each radial system represents specific combinations of input electrical parameters provided in headers and footnotes of Table 410-2 of [2]. Each of the combinations are grouped based on incident energy levels for personnel working on open air equipment exposed to line-to-ground arcing faults. This document is only an excerpt of TCS-SC-369 [3] which includes more tables. This document also includes additional model validation comparisons covered in [1].

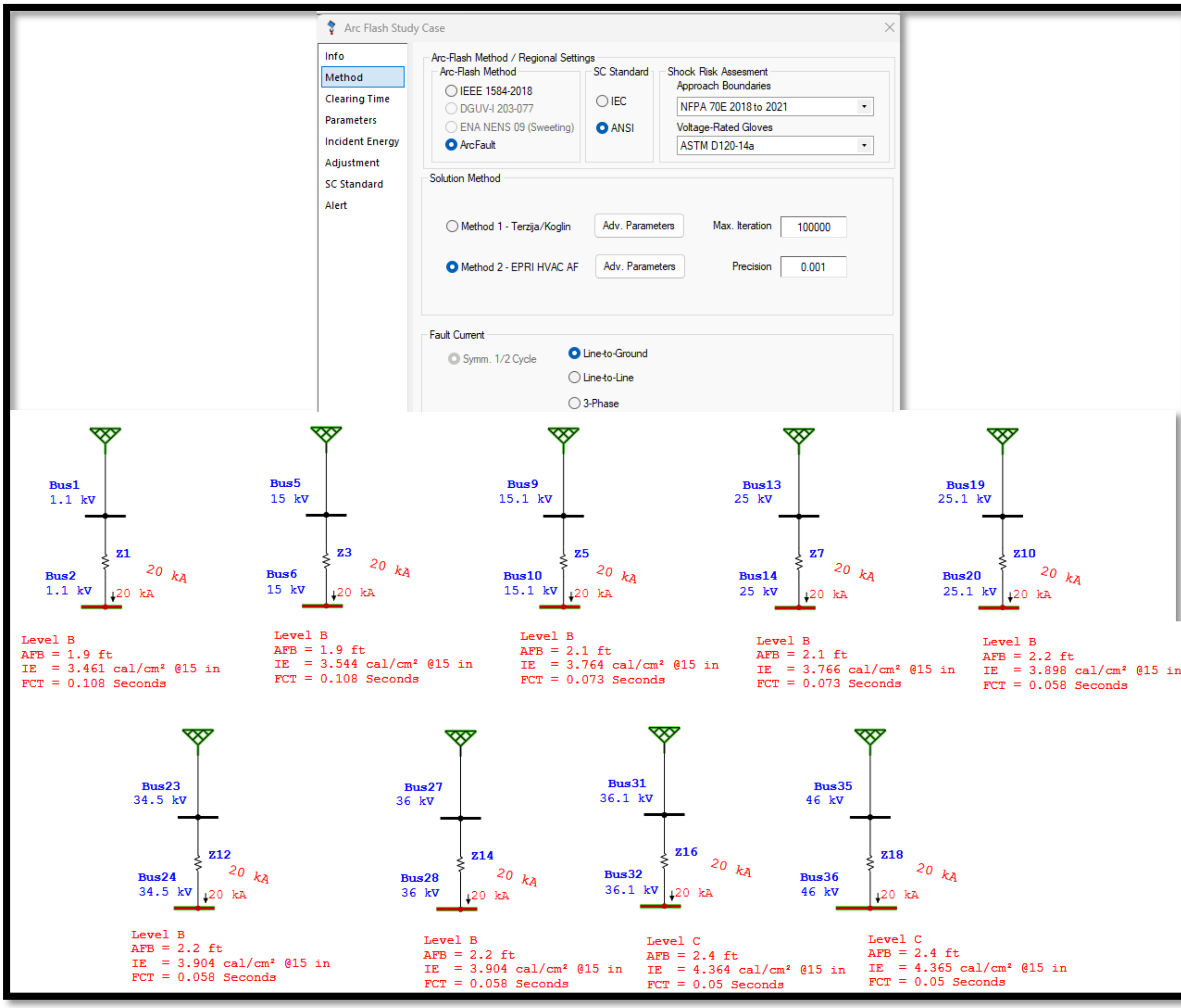

Fig 1: ArcFault™ Method 2 Results for 4 cal/cm² (Ibf = 20kA)

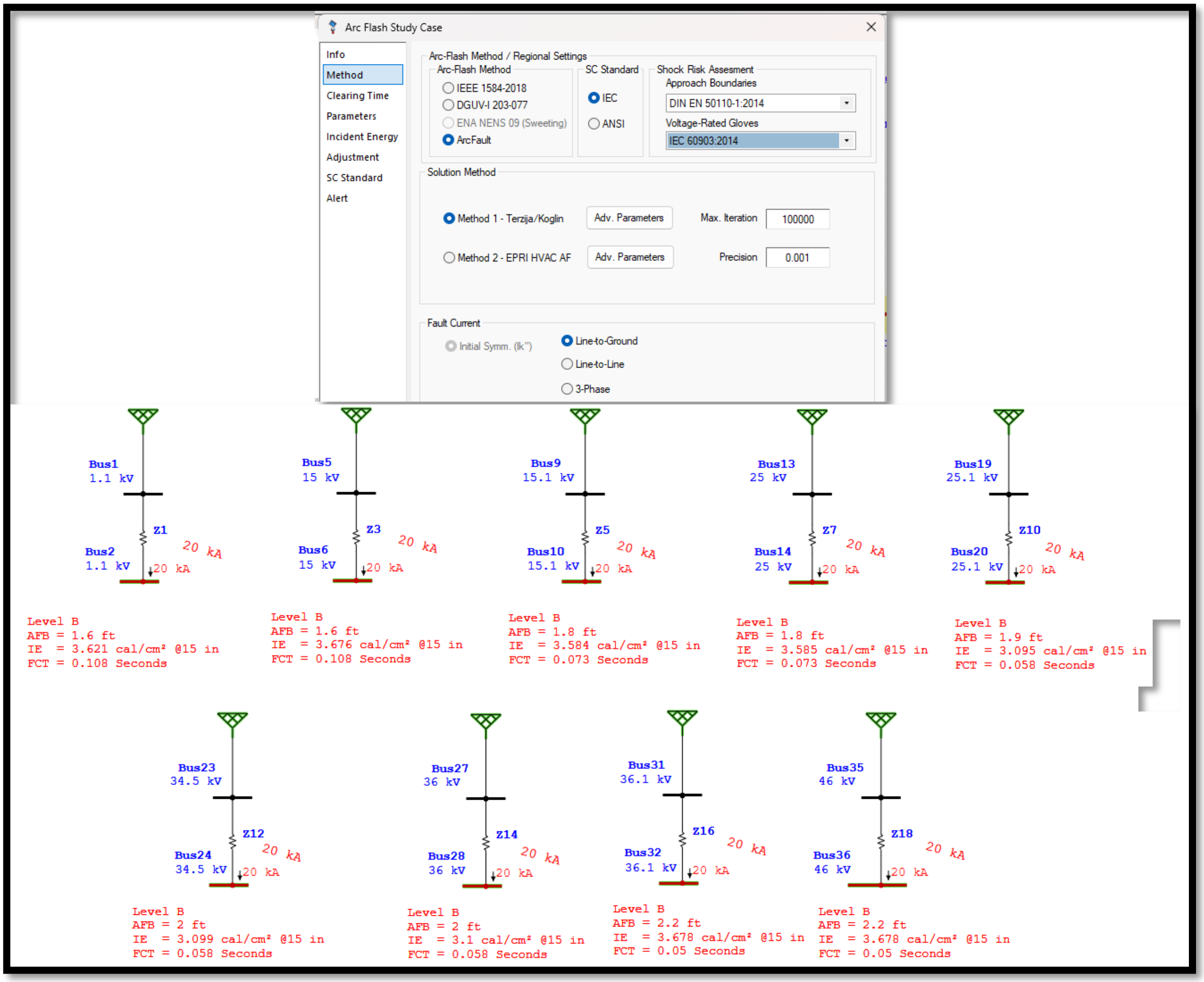

Fig. 2: ArcFault™ Method 1 Results for 4 cal/cm² (Ibf = 20kA)

Comparison of Results

In this section Figures 3 to 6 provide model validation comparisons for the ArcFault™ methods against references [1], and [2]. Details for the comparisons are summarized in Table 1 below.

Table 1: Summary of ArcFault™ Methods Comparisons

Figure Number	Scenario Description
Fig. 3	EPRI test result comparisons against ArcFault™ M2 results as performed in [1]
Fig. 4	Result comparisons of third-party methodologies, and ArcFault™ methods for 4 cal/cm² group when Ibf=5kA using tables from [2] as performed in [1]
Fig. 5	Result comparisons of third-party methodologies, and ArcFault™ methods for 4 cal/cm² group when Ibf=20kA using tables from [2] as performed in [1]
Fig. 6	Result comparisons of third-party methodologies, and ArcFault™ methods for 8 cal/cm² group when Ibf=20kA using tables from [2] as performed in [1]

The ETAP ArcFault™ methodologies are based on the empirical equations compiled and published in [1] which are based on actual test data for high voltage arcs. An example of the accuracy of the EPRI calculation method can be seen in Figure 3 as published in [1]. This figure shows recorded incident energy test data plotted against simulation results for various tests. It can be observed that statistical correction factors were introduced to make sure the model predictions were slightly higher than measured incident energies, yet not overly conservative.

The EPRI method in particular was funded by the DOE and other utilities to see how results of theoretically derived methods compare against actual test results. The EPRI findings and conclusions can be found in the EPRI report referenced in [1] of which Fig. 3 is an example.

The comparisons of Fig. 4 to 6 further validate the results of ETAP ArcFault™ methods. The values of 4, 8, 12 cal/cm^2 are target average values published in [2]. The comparisons show good correlation with the target average incident energy values. Some differences are visible between the published average values and the simulation results due to the variation in input parameters such as gap and working distance (which were calculated using the equations described in the table footnotes. Third party simulation software results follow the same trend.

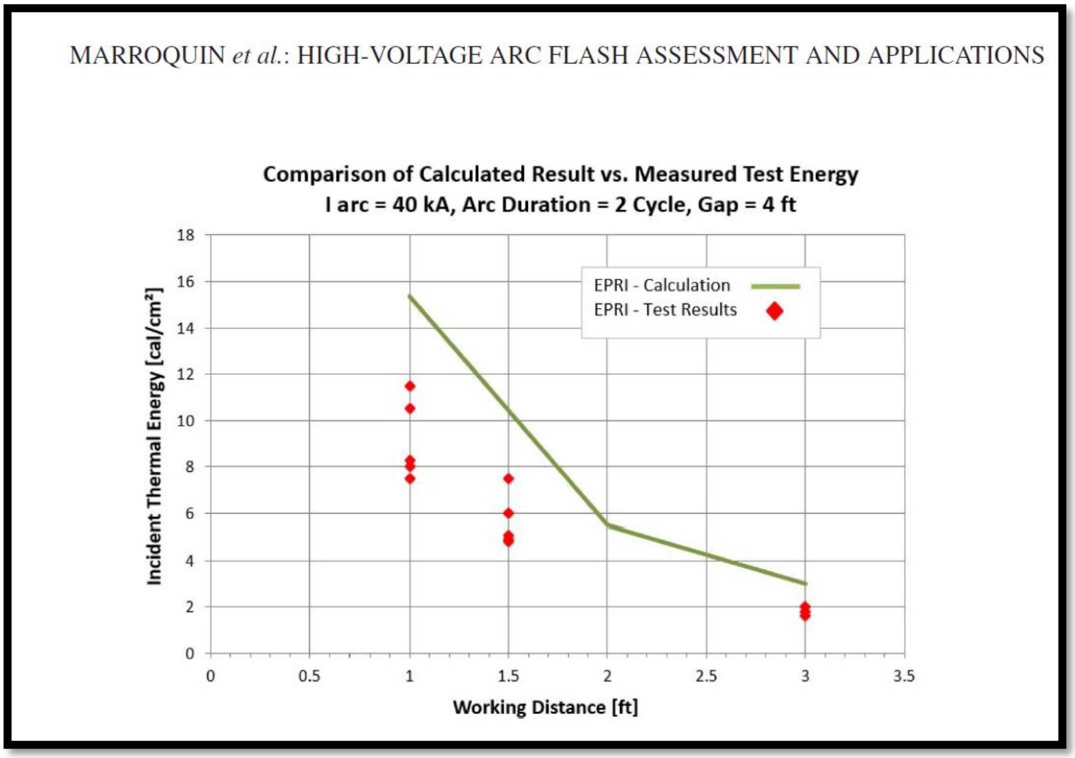

Fig. 3: Comparison of Method2 Incident Energy against Test Measurements from [1]

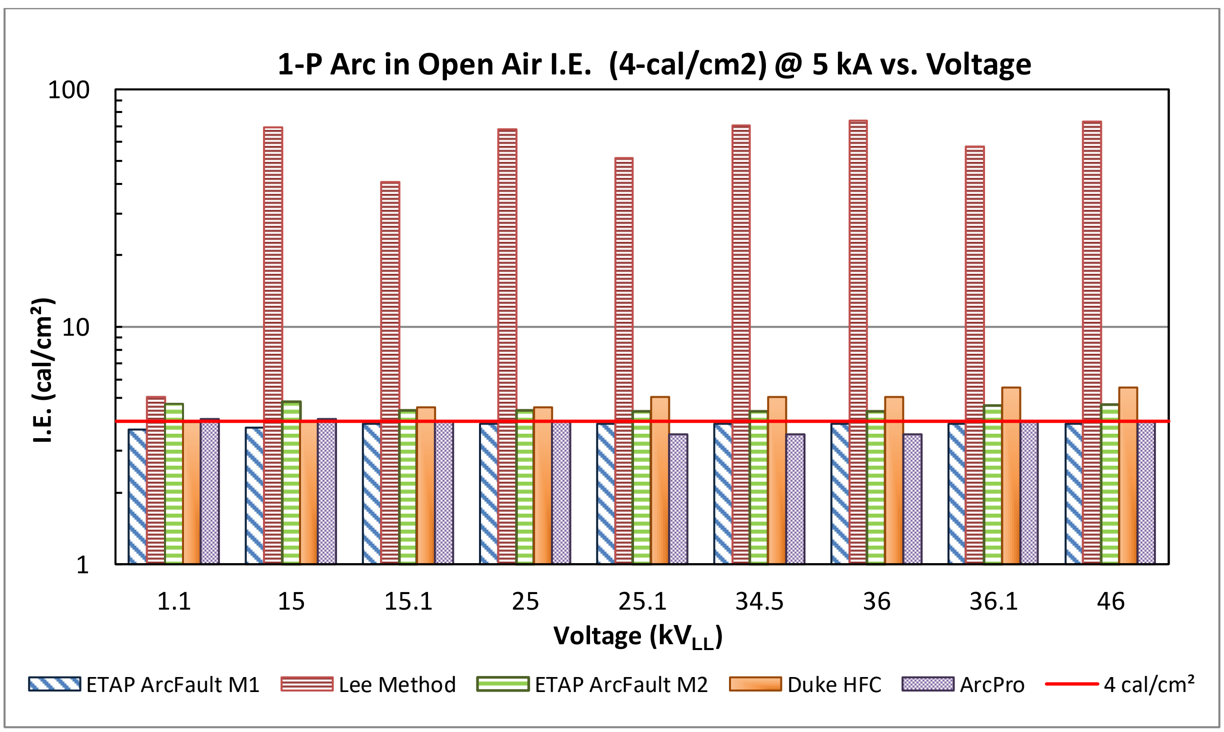

Fig. 4: IE comparisons for ETAP ArcFault Methods for 4 cal/cm² group (Ibf=5kA) from [1]

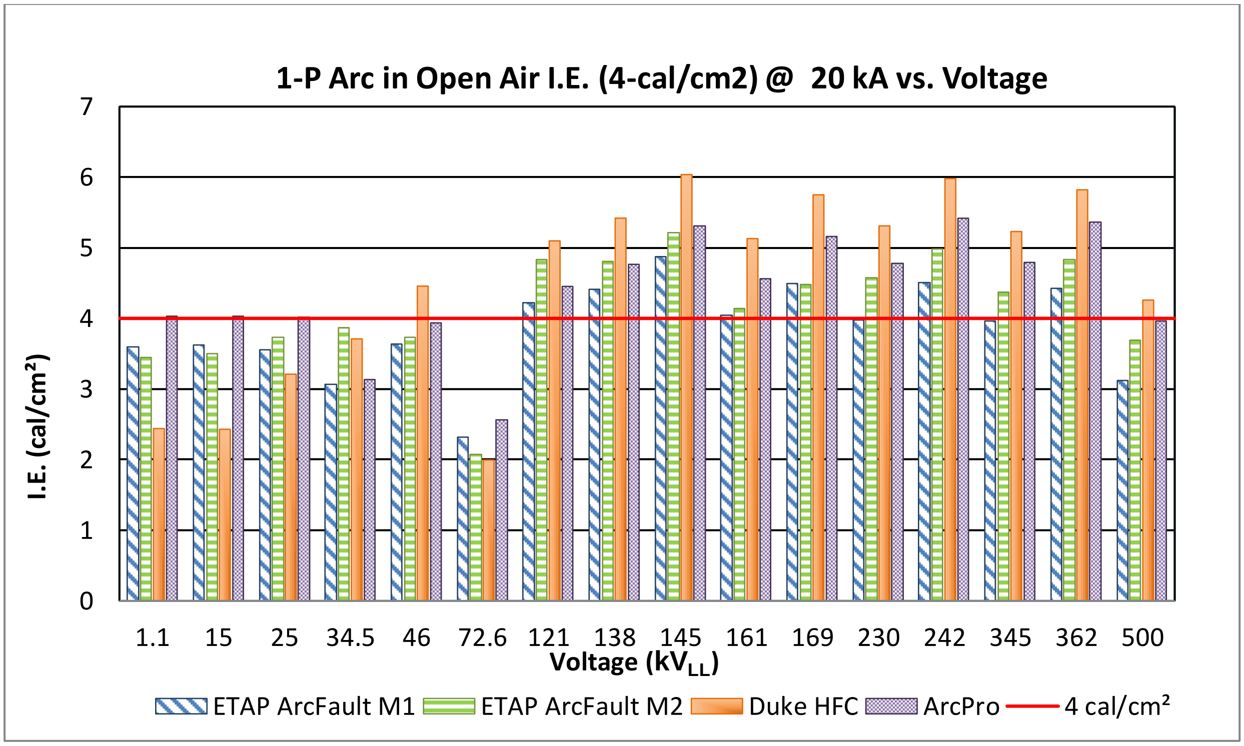

Fig. 5: IE comparisons for ETAP ArcFault Methods for 4 cal/cm² group (Ibf=20kA) from [1]

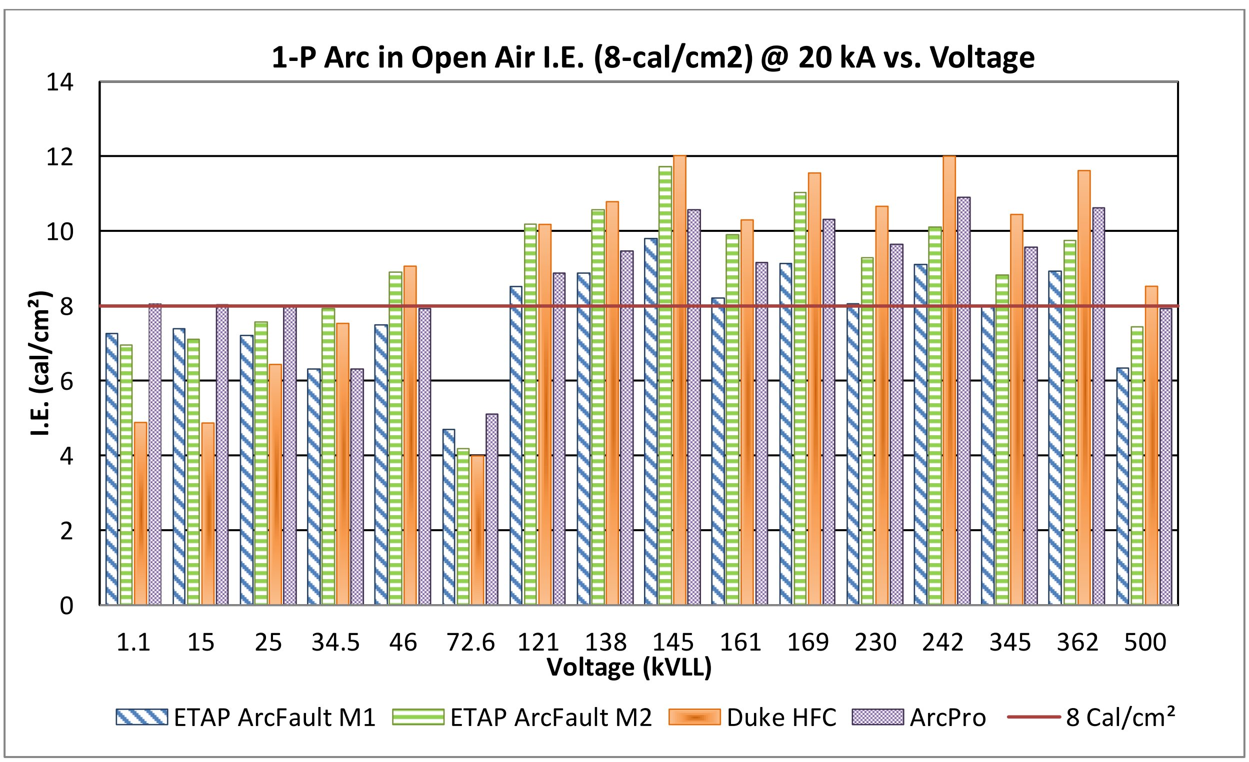

Fig. 6: IE comparisons for ETAP ArcFault Methods for 8 cal/cm² group (Ibf=20kA) from [1]

In conclusion, the validation efforts described in [1] prove that ArcFault™ methods are acceptable because of engineering analysis comparisons and also because they are based on real-life tests. Methods developed based only on theoretical assumptions may result in overly conservative results and may need further validation with test results.

References

[1]. Albert Marroquin, et., all, “HIGH VOLTAGE ARC FLASH ASSESSMENT AND APPLICATIONS”, IEEE Transactions on Industry Applications, vol. 56, issue: 3, May-June 2020

[2]. IEEE C2-2023, National Electrical Safety Code, New York, NY: IEEE

[3]. ETAP Arc-Flash Analysis V&V Documents, Case Number TCS-SC-369