ARC SUPPRESSION TECHNOLOGIES
7900 INTERNATIONAL DR STE 300, BLOOMINGTON, MN 55425
www.ArcSuppressionTechnologies.com

Arc-Flash Suppression in Microseconds

Introducing an Arc-Flash Suppression Factor (AFSF)

By Reinhold Henke and Robert P. Thorbus

Arc-Flash (AF)

During an arc-flash (**AF**) the arc-flash plasma turns into the dominant power load burning between the power conductors, being supported by the current the power infrastructure can supply; destroying everything in its path. The plasma current will be less than the bolted Short Circuit Current Rating (SCCR; e.g., transformer or battery) or the Interrupt Current Rating (ICR; e.g., circuit breaker or fuse) value.

The most prevalent form of arc-flash initiation is from a dielectric breakdown (**F-Arc-Flash**), also referred to as "**flash-over**".[1,2] Figure I shows an **AF** simplified, equivalent schematic diagram for comparison purposes.

Electronic Arc-Flash Suppressor (EAFS)

An **Electronic Arc-Flash Suppressor** (**EAFS**) within **microseconds** (**µs**) senses, detects, and confirms arc-flash initiation and plasma ignition (either F-Arc or T-Arc).[3] Once ignition is confirmed, the **EAFS** immediately creates a short circuit condition, causing the plasma to extinguish and the circuit breaker to trip, leaving behind a few microseconds of **Residual** ("abbreviated") **Arc-Flash** (**RAF**).

An **EAFS** is comprised of three main elements: (1) an arc initiation detector connected to (2) an arc plasma ignition detector connected to (3) a trigger-able arc plasma extinguisher. An **EAFS** should be agnostic of load type, power frequency, and power factor. Figure II shows a **RAF** simplified, equivalent schematic diagram for comparison purposes.

Arc-Flash Suppression Factor (AFSF)

An **Arc-Flash Suppression Factor** (**AFSF**) is the ratio of **AF energy** (E_{AF}) over **RAF energy** (E_{RAF}) (Fig. 3). The **AFSF** is a dimensionless, quantitative figure of merit allowing useful comparisons among different methods and means of arc-flash suppression.

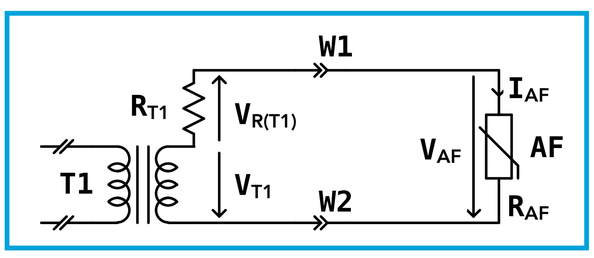

*Fig. 1: Simplified, equivalent schematic diagram for an **Arc-Flash** (**AF**); see table I*

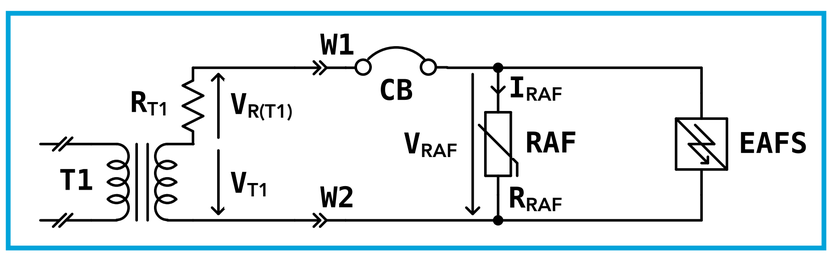

*Fig. 2: Schematic diagram of an **Electronic Arc-Flash Suppressor** (**EAFS**), and related **Residual** (microseconds) **Arc-Flash** (**RAF**); see table II*

Note: Infrastructure resistance and thermal effects are not included in these example calculations

$$AFSF = E_{AF} / E_{RAF}$$

$$AFSF = 149{,}604\ J / 45\ J$$

$$AFSF = 3{,}325$$

*Fig. 3: Arc-Flash Suppression Factor (**AFSF**)*

T1 Secondary Open Circuit Voltage (nominal)	V_{T1}	**480 V**
T1 Bolted Short Circuit Current	$I_{T1(BSC)}$	**20,000 A**
Arc-Flash Duration	T_{AF}	**0.167 s**
Arc-Flash Voltage	V_{AF}	**50 V**
T1 Internal Resistance	R_{T1}	**0.0240 Ω**
T1 Internal Power Dissipation During AF	$P_{R(T1)}$	**8,704,167 W**
T1 Internal Energy Release During AF	$W_{R(T1)}$	**1,303,992 J**
Arc-Flash Plasma Resistance	R_{AF}	**0.00279 Ω**
Arc-Flash Plasma Current	I_{AF}	**17,917 A**
Arc-Flash Plasma Power	P_{AF}	**895,833 W**
Arc-Flash Plasma Energy	E_{AF}	**149,604 J**

*Table I: **Arc-Flash** (**AF**) parameters, symbols, & definitions; example of calculated or measured values; see figure 1*

T1 Secondary Open Circuit Voltage (nominal)	V_{T1}	**480 V**
T1 Bolted Short Circuit Current	$I_{T1(BSC)}$	**20,000 A**
Residual Arc-Flash Duration	T_{RAF}	**0.00005 s**
Residual Arc-Flash Voltage	V_{RAF}	**50 V**
T1 Internal Resistance	R_{T1}	**0.0240 Ω**
T1 Internal Power Dissipation During RAF	$P_{R(T1)}$	**8,704,167 W**
T1 Internal Energy Release During RAF	$W_{R(T1)}$	**390 J**
Residual Arc-Flash Plasma Resistance	R_{RAF}	**0.00279 Ω**
Residual Arc-Flash Plasma Current	I_{RAF}	**17,917 A**
Residual Arc-Flash Plasma Power	P_{RAF}	**895,833 W**
Residual Arc-Flash Plasma Energy	E_{RAF}	**45 J**

*Table II: **Residual Arc-Flash** (**RAF**) parameters, symbols, & definitions; example of calculated or measured values; see figure 2*

Why Microseconds Matter

While **milliseconds** (**ms**) may seem of short duration, every **millisecond** that an arc-flash plasma burns, more destruction occurs, including the potential for infrastructure destruction as well as human injuries and/or deaths. Shortening arc-flash events from **milliseconds** to **microseconds**, **yields a many-thousand-fold reduction of the arc-flash event's energy and damage**.

For example, the energy contained in an arc-flash that is extinguished in **50µs** is **1000 times** less than the energy contained in an arc-flash burning for **50ms**. Given that typical U.S. arc-flash calculations are based on ten **60Hz** cycles, or **167ms**, duration[4], **EAFS** reduces potential arc-flash damage by a factor of **3,325** … after the approximate **50µs**, no further calculations are needed.

Using a ballistic artillery projectile as an analogy for an arc-flash, an electronic arc-flash suppressor would stop the projectile within a few inches from the shell casing … leaving it inert at the bottom of the barrel. That's why microseconds matter!

References:
1. R.Henke and R.P.Thorbus, "The Arc Species Zoo," May 2021
2. R.Henke and R.P.Thorbus, "Parallel Arcs and Series Arcs," February 2022
3. A less-likely mode of arc-flash, referred to as "arc-over", results from metallic connection, or T-Arc-Flash. While relevant to EAFS design, T-Arc-Flash is deemed not relevant for this overview
4. Arc Flash, https://en.wikipedia.org/wiki/Arc_flash, cited February 24, 2022