



## ONE CYCLE INTERRUPTION

### **Why is Arc Flash Important?**

*Electrical workers have chosen the third most dangerous profession according to recent OSHA (the Occupational Safety and Health Administration, USA) statistics. In the USA alone, there are **10 OSHA - reportable arc-flash incidents** involving more than **one fatality every day**. Studies indicate that up to 80% of all Electrical Worker injuries are not due to shock (passage of electrical current through the body) but due to external burn injuries created by the intense and radiant heat energy of an electrical arc explosion. There is a great deal that can be done to prevent an Arc Flash explosion and to protect personnel if they are exposed to an Arc Flash. The National Fire Protection Association (NFPA) developed the NFPA 70E “Standard for Electrical Safety in the Workplace” to reduce the number of accidents which occur in the workplace. The standard provides guidance on Personal Protective Equipment (PPE) selection to greatly reduce or avoid injury in the event of an Arc Flash accident. To identify the ranges of hazards, the NFPA created Hazard/Risk Categories. This was intended to make the selection of PPE simpler for the consumer.*



**NFPA 70E Table I30.7(C)(11)(Simplified)**

Hazard/Risk Category (HRC)	Required Minimum Arc Rating of PPE (Cal/cm <sup>2</sup> )
HRC 0	N/A
HRC 1	4
HRC 2	8
HRC 3	25
HRC 4	40

## What Is Arc Flash?

The Arc-flash is a dangerous condition associated with release of energy, which is proportional to  $V \cdot I \cdot t$ .

$$E = C_f E_n (t/0.2)^x (610^x / D^x)$$

$$E = 1 \cdot 11.67 (0.77/0.2)^x (610^{0.973} / 910^{0.973}) = 30.44 (\text{cal/cm}^2)$$

where:

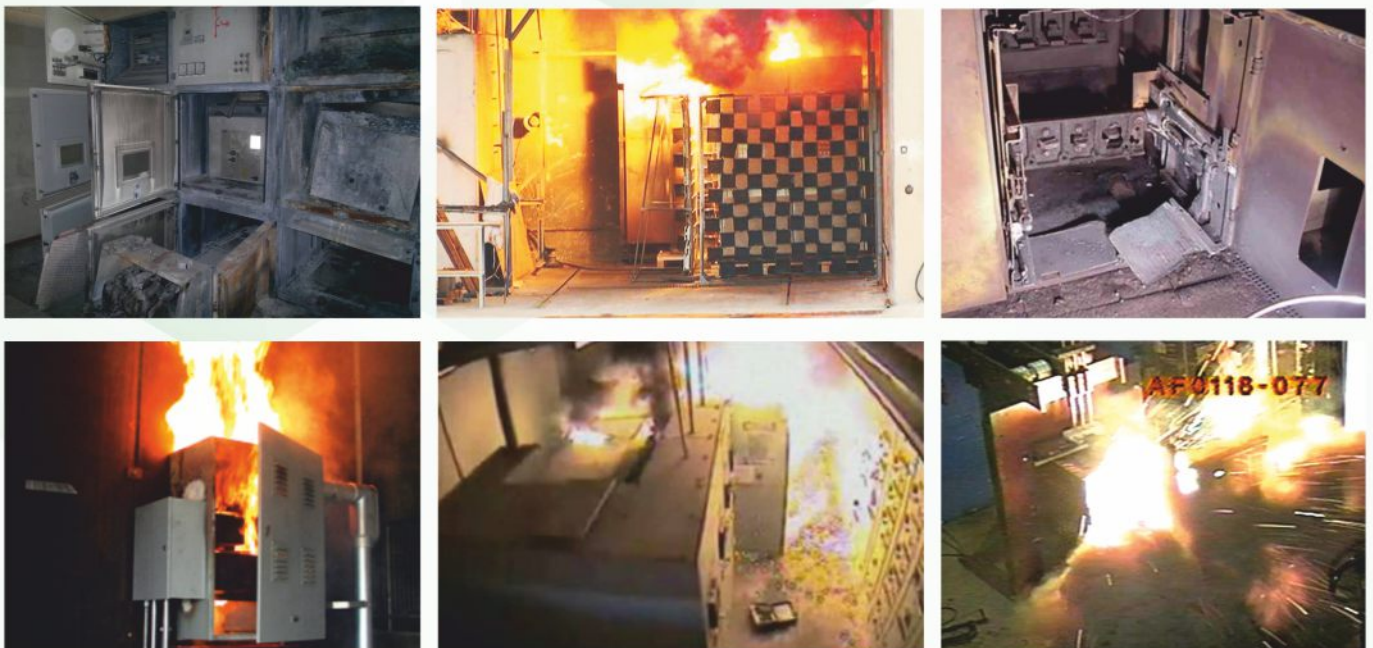
- $E$  is the incident energy ( $\text{cal/cm}^2$ )
- $C_f$  is 1.0 for voltages above 1kV
- $t$  is the arcing time (seconds)
- $x$  is the distance exponent

Formula for Incident Energy

While burning, the electric arc produces huge amounts of energy which result in:

- one of the highest temperatures on Earth, up to 19000°C (arc furnace 1600°-3000°C)
- flying shrapnel
- the strongest pressure wave and sound wave
- toxic smoke

All these effects are devastating to equipment and infrastructure as well as dangerous to personnel.



## How else to Protect?

Personnel safety is the top priority in the industry. However, the use of cumbersome, personal protective equipment is expensive for organizations and uncomfortable for their personnel. Besides, it demands periodical inspection and replacement. To reduce the heavy burden for companies allowing electrical workers to wear protective clothes which are less costly, light and convenient, the internal arc classification of switchgear has been introduced by the IEC in its standards. Nowadays, switchgear should be classified to withstand internal arc impacts during a period of time. This considerably reduces the risk of equipment destruction and fatalities. Nevertheless, the reinforced metal-clad enclosures, equipped with pressure relief flaps and gas exhaust ducts do not affect the total amount of the Incident Energy. As  $V \cdot I$  are given by the service conditions, only the arcing time ( $t$ ) is changeable.

## Aftermath of arc flashes VS arc classification and protection

No arc classification and protection  
Fault current 25 kA  
Arcing time 1 sec



Arc classified (1s), No arc protection  
Fault current 31,5kA  
Arcing time 1 sec



Arc classified (1s) and Arc protected  
Fault current 31,5kA  
Arcing time 80ms



### Total destruction

The most severe damage.

### Light damages

Only the CB compartment was damaged. Other panel compartments and adjacent panels remained intact.

Light damage is at arc initiation points. The panel is healthy and needs cleaning only.

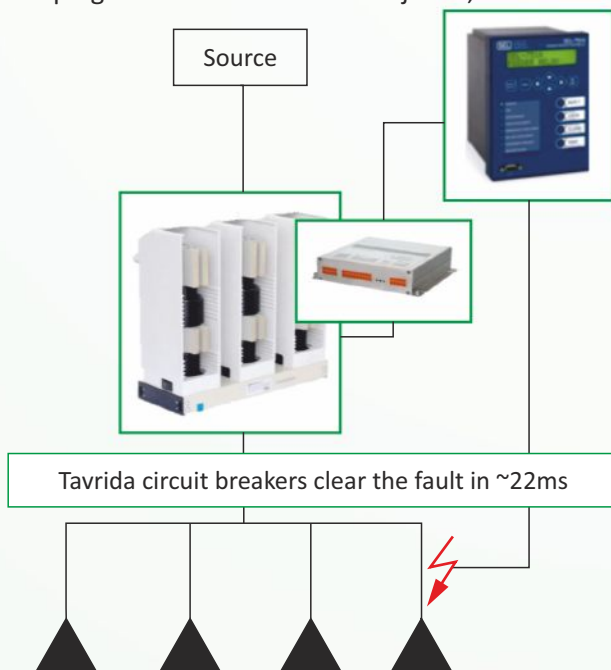
## How to minimize the arcing time?

The energy released in an arc flash is directly proportional to the arcing time. The less arcing time is provided the less destruction can result from the arc flash. The application of modern Arc Flash Relays such as SEL751A or VAMP321\* with optical sensors makes it possible to minimize relay response times up to 2ms whilst MV motor-spring VCB opening times are as long as five cycles (100 ms).

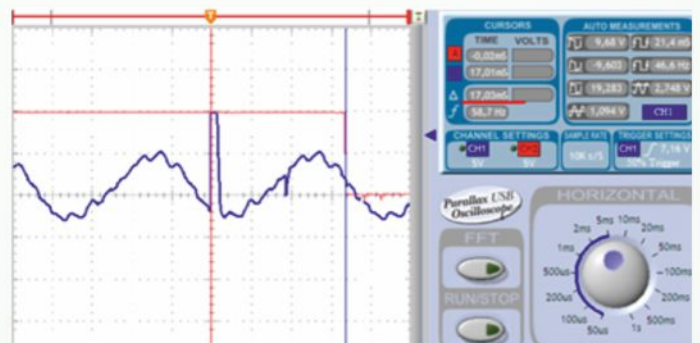
\* the above trademarks are the property of their respective companies

**Tavrida circuit breakers are designed with the entire concept in mind – optimizing the vacuum interrupter, insulation, magnetic actuator and control modules. This has resulted in the fastest circuit breaker, the one cycle interrupter - a breakthrough for fast switching and arc flash protection technology.**

Once the circuit breaker receives the trip signal from an Arc Flash Relay, it is able to interrupt in less than twenty milliseconds (ms) to provide an increased arc flash hazard mitigation – the fastest arc fault interruption in the industry – helping to reduce work-related injuries, fatalities and lost productivity.



Arc protection relay with high speed contacts operation time, ms	2
CM15 control module operation time, ms	4
Shell series circuit breaker opening time, ms	8
Arc clearing at next current zero crossing, ms	6
<b>TOTAL ARC FLASH CLEARING TIME, ms</b>	<b>&lt;22</b>
<b>INCIDENT ENERGY FOR UP TO 50kA FAULT cal/cm<sup>2</sup></b>	<b>&lt;1.8</b>
<b>HAZARD/RISK CATEGORY UP TO 50kA FAULT</b>	<b>HRC 0</b>



Tavrida circuit breakers are fully compatible with standard Arc Flash Relays.

## Incident Energy and Hazard/Risk Category to the absolute minimum

The table below shows Incident Energy vs. Clearing Time at the bolted fault currents ranking from 10 to 50kA. The colours from white to red highlight the Hazard/Risk Categories specified in the NFPA 70E “Standard for Electrical Safety in the Workplace”.

**The use of Tavrída circuit breakers combined with modern Arc Flash Relays lowers The Hazard/Risk Category to HRC0 at all fault currents, which is the absolute minimum and does not require electrical workers to wear Fire Protective Clothing.**

Bolted fault (kA)	Incident Energy (cal/cm <sup>2</sup> )*										
	Clearing time (sec)										
	0.02 (1 cycle)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
10	0.2	1.25	2.50	3.75	5.00	6.25	7.61	8.76	10.01	11.28	12.56
20	0.5	2.61	5.23	7.84	10.45	13.05	15.68	18.29	20.90	23.51	26.13
30	0.7	4.02	8.04	12.06	16.08	20.10	24.12	28.14	32.15	36.18	40.20
40	1.1	5.46	10.92	16.37	21.83	27.29	32.74	38.20	43.66	49.12	54.57
50	1.8	6.92	13.84	20.75	27.67	34.69	41.61	48.42	56.34	62.26	69.18

\* Incident Energy is calculated as per IEEE Std 1584-2002.

## AS Tavrída Electric Export

E-mail: [export@tavrida.eu](mailto:export@tavrida.eu)  
[www.tavrida.eu](http://www.tavrida.eu)

**Tallinn Office**  
 14, Visase str.  
 11415 Tallinn Estonia  
 Tel: +372 606 47 57  
 Fax: +372 606 47 59

**Moscow Office**  
 3rd floor, 1A, Grizodubovoy str.,  
 125252 Moscow Russia  
 Tel./Fax: +7 (499) 530-22-05

**Vilnius Office**  
 222 Ukmerges str.  
 07157 Vilnius Lithuania  
 Tel.: +370 688 50680

**Cairo Office**  
 25 Tayran Street (Mahmoud Shaltout),  
 Nasr City, Cairo, Egypt  
 Tel.: +20 10 00021868  
 Fax: +20 22 4035260  
 E-mail: [mmh@tavrida.eu](mailto:mmh@tavrida.eu)  
 Web: [www.tavrida.eu](http://www.tavrida.eu)

**Muscat Office**  
 P.O. Box 1102, CPO-Seeb,  
 P.C. 111, Mabellah Indl. Area,  
 Sultanate of Oman  
 Tel.: +968 9417 6184  
 E-mail: [gks@tavrida.eu](mailto:gks@tavrida.eu)  
 Web: [www.tavrida.eu](http://www.tavrida.eu)

### ROMANIA

**Energobit TAVRIDA**  
 Str. Luncii nr. 5A  
 Cod 400633 Cluj-Napoca, Romania  
 Tel: +40 264 207 500  
 Fax: +40 264 207 555  
 E-mail: [dan.tatar@energobit.com](mailto:dan.tatar@energobit.com)  
 Web: [www.tavrida.ro](http://www.tavrida.ro)

### POLAND

**Tavrída Electric Polska sp. z o.o.**  
 ul. Towarowa 23a  
 43-100 TYCHY  
 Tel.: +48 (32) 3271986,  
 +48 (32) 3270737,  
 +48 (32) 2193037  
 Faks: +48 (32) 3271987  
 E-mail: [telp@tavrida.pl](mailto:telp@tavrida.pl)  
 Web: [www.tavrida.pl](http://www.tavrida.pl)

### Your regional office

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