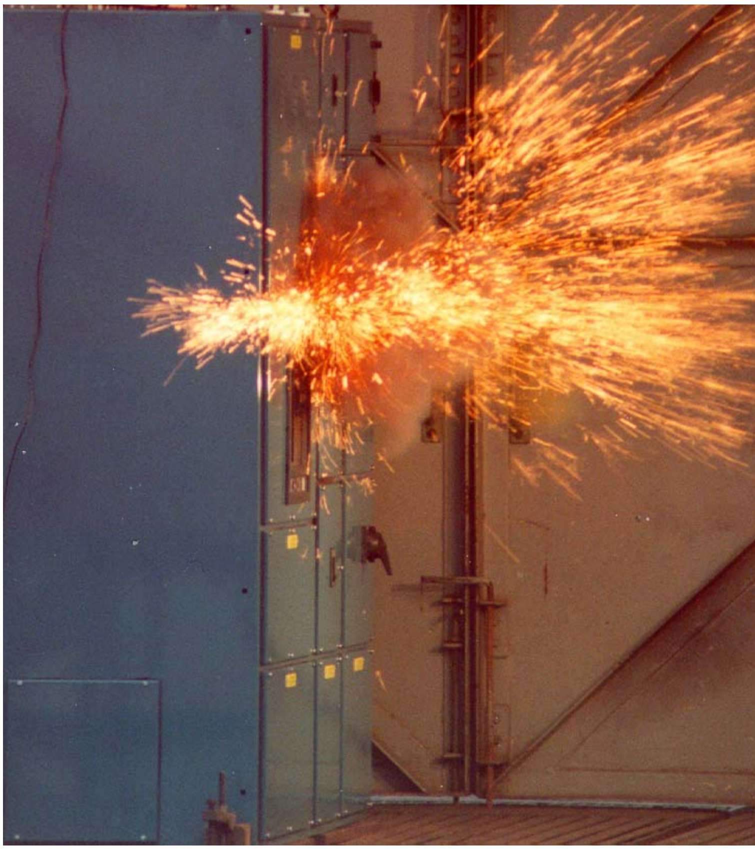
Thermography Code of Practice

Number 304



Electrical Thermography – Safe Approach Boundary

DRAFT 2
For comment

Credits

This Draft Code of Practice was produced for a working group including expert thermographers, and research consultants. Additional consultation with other persons and organisations results in this document being widely accepted by all sides of industry.

Working Group

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Addittional

This Code of Practice is one of a series that covers thermographic inspection and analysis methods in Electrical assessment. Others include:

301 Distribution systems
302 Batteries
303 HV installations

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Introduction

Since thermography of electrical systems always entails work near live equipment there is always the possibility of a flash hazard while in the vicinity of the live electrical parts. As the distance between a person and the exposed energised component decreases, the potential for the electrical accident increases.

An arc flash, shown in Fig.1, is caused by sudden discharge of electrical energy, like lightning, and depending on the circumstances, temperatures upwards of 20000°C (equivalent to four times that of the sun) can be generated. The intense heat from the arc causes rapid increase in air temperature resulting in a blast of high pressure air and that in itself can be a hazard.

Fig. 1. Energy discharge at flashover

Fig.2. Results of flashover

Fig. 2 shows the result of a flashover. In this instance the flashover occurred due to a leak in the substation roof. The leak was directly above the HV panel current transformer causing it to explode and, as can be seen, this resulted in the complete destruction of the HV panel. Fortunately, no person was present in the substation at the time of the incident.

There are a number of reasons for occurrence of flashover:

1. Dust or impurities on, or near, insulated components can provide a path for the current, allowing a flashover across the phases.

2. Corrosion of components can cause breakdown of insulation.

3. Condensation of vapours or water dripping on live components can be another cause.

4. Accidental contact between components, such as dropping a tool across phases.

5. Over-voltages across narrow spaces causing breakdown of insulating materials.

6. Partial discharge.

7. Disturbance of air flow inside energised panels while opening doors.

8. Improperly designed or utilized equipment.

Safe Approach Boundary

As the distance between the source of the flash and the thermographer increases, for each situation a point will be reached where it is safe to stand, as can be seen in Fig.3. This distance is regarded as the Unqualified Persons, Safe Approach Distance and the Limited Approach Boundary should never be crossed by the thermographer without guidance from the qualified person.

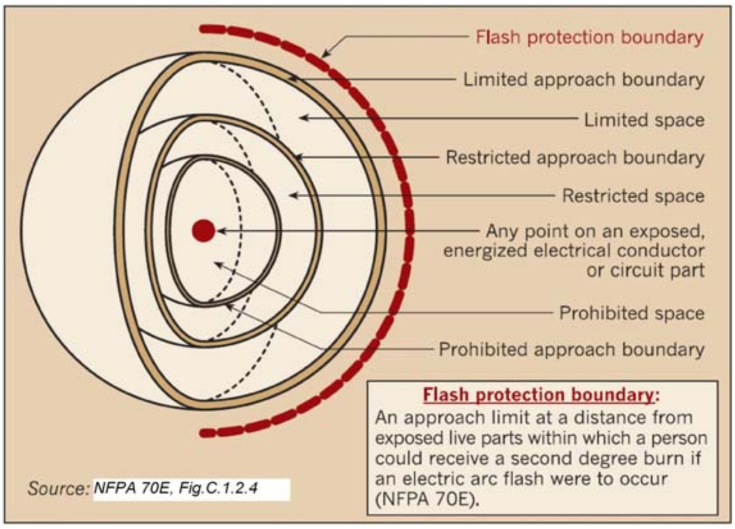

Fig.3. Flash protection boundary

Clarification of zones in Fig.3:

Flash protection boundary:

At voltage levels above 600V, the Flash Protection Boundary is the distance at which the incident energy equals 5J/cm^2 (1.2cal/cm^2). For situations where fault-clearance time is 0.1 sec, or less, the Fault Protection Boundary is the distance at which the incident energy level equals 6.24J/cm^2 (1.5cal/cm^2).

Limited approach boundary/ Limited space:

Where unqualified persons are working at, or close, to the Limited Approach Boundary, the designated person in charge will ensure that the work can be done properly.

Where there is a need for an unqualified person to cross the Limited Approach Boundary, a qualified person should be in attendance to provide advice of possible hazards.

Restricted approach boundary/Restricted space:

Under no circumstance shall the escorted unqualified person be permitted to cross the Restricted Approach Boundary.

Prohibited approach boundary/Prohibited space:

Crossing the Prohibited Approach Boundary and entering the Prohibited Space is considered the same as making contact with the exposed energised components.

Qualified person:

One who has the skills and knowledge related to the construction and operation of the electrical equipment and installation and has received safety training on the hazards involved.

The US National Fire Protection Association standard NFPA70E gives two formulae for calculation of the flash Protection Boundary:

$D_c = [2.65 \times MVA_b \times t]^{½}$

Or

$D_c = [53 \times MVA \times t]$

Where:

D_c = distance in feet from an arc source for a second-degree burn.

MVA_b = bolted fault capacity available at point involved (mega volt-amps).

MVA = capacity rating of transformer (mega volt-amps). For transformers with MVA ratings below 0.75 MVA, multiply the transformer MVA rating by 1.25.

t = time of arc exposure (seconds).

As can be seen, these formulae require comprehensive understanding of data required for the calculations and it is suggested that thermographers should not undertake such calculations unless they are also qualified Electrical Engineers.

NFPA 70E already provides a table for Approach Boundaries at various voltage ranges and this should be completely adequate for provision of required knowledge to allow safe working conditions for thermographers.

1	2	3	4	5
Nominal System Voltage Range, Phase to Phase	Limited Approach Boundary		Restricted Approach Boundary	Prohibited Approach Boundary
	Exposed Movable Conductor	Exposed Fixed Circuit Part		
Less than 50	Not specified	Not specified	Not specified	Not specified
50 to 300	3m	1m	Avoid contact	Avoid contact
301 to 750	3m	1m	300mm	25mm
751 to 15kV	3m	1.5m	660mm	180mm
15.1kV to 36kV	3m	2m	800mm	260mm
36.1kV to 46kV	3m	2.5m	840mm	440mm
46.1kV to 72.5kV	3m	2.5m	1m	640mm
72.6kV to 121kV	3.3m	2.5m	1m	820mm
138kV to 145kV	3.4m	3m	1m	940mm
161kV to 169kV	3.6m	3.6m	1.2m	1m
230kV to 242kV	4m	4m	1.6m	1.5m
345kV to 362kV	4.7m	4.7m	2.6m	2.5m
500kV to 550kV	6m	6m	3.5m	3.5m
765kV to 800kV	7.5m	7.5m	4.5m	4.5m

Table 1. Approximate Approach Boundaries to Live Parts for Shock Protection

Protective clothing and PPE

Once it has been established that work is to be performed on live equipment within the Flash Protection Boundary, based on the flash hazard risk analysis, appropriate flame resistant (FR) clothing and personal protection equipment (PPE) may be specified. This will be based on the incident energy exposure associated with the specific task and, under certain conditions, it may even be necessary to wear a complete flame resistant suit, as shown in Fig. 4.

Fig.4. Flash protection flame-resistant clothing

It should be remembered that the NFPA 70E estimates incident energy based on maximum value of power dissipated by arcing faults and these can be regarded as being on the conservative side.

There are other methods of calculating safe distances, such as, IEEE 1684 which provides an alternative method for estimating incident energy based on empirical equations developed from statistical data obtained from numerous laboratory tests and these are less conservative than the NFPA method.

Since the NFPA method provides more conservative results their calculations may be more appropriate for thermographers who are constantly on the move and may not always be able to accurately estimate distances to live equipment.

The standards and regulations discussed are generated in USA and do not apply to UK. At present there do not appear to be any UK standards for flashover calculations but as long as thermographers remember Fig. 3 and the data provided in Table 1 and also adhere to the safety regulations applicable to the site on which they are working there is a reasonable chance that no harm will come to them.

References

NFPS 70E Standard for Electrical Safety in the Workplace, 2004 Edition

NFPA 70B Recommended Practice for Electrical Equipment Maintenance, 2002 Edition

Practical solution guide to Arc Flash Hazards, ESA Inc., 2003

Five misconceptions about arc flash compliance, Kenneth Cybart, Plant Engineering May, 2007