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Incident Energy Calculation for LV Switchgear:

Input Parameters:

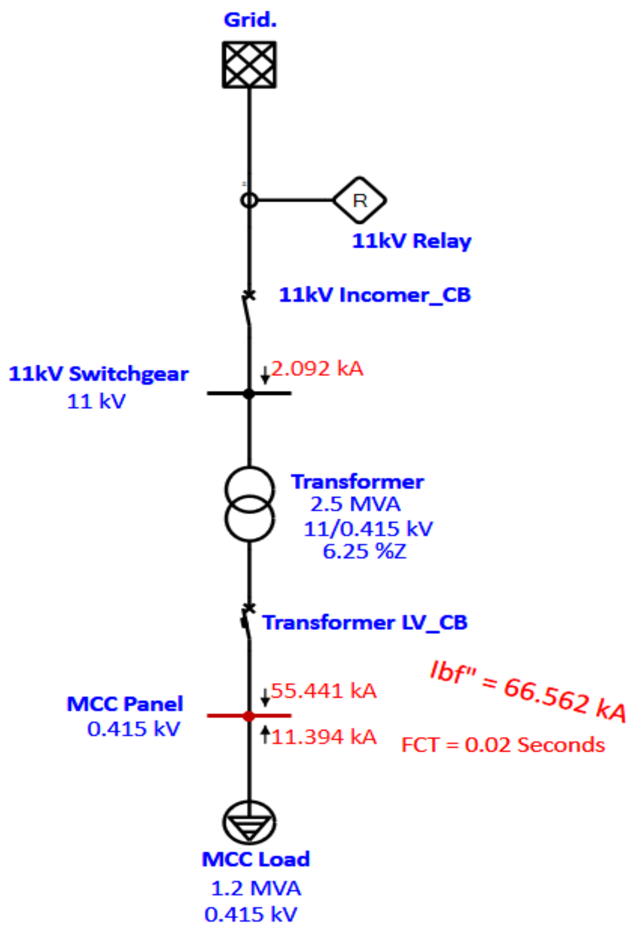
Configuration – VCB

Three-Phase System Voltage:

$V_{o/c}$ = 0.415 kV rms

Three-phase bolted fault current:

Ibf = 66.562kA



Gap between conductors (electrodes):

G = 25mm

Working distance:

D= 457.2 mm

Enclosure dimensions:

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Width = 305 mm

Height = 356 mm

Step 1: Determine the intermediate arcing current

For 600 V:

$$I_{arc\_Voc} = 10^{(k1+k2\log(I_{bf})+k3\log(G))}\,(k4I_{bf}^7 + k5I_{bf}^6 + k6I_{bf}^5 + k7I_{bf}^4 + k8I_{bf}^3 + k9I_{bf}^2 + k10)$$

where

I_{bf} - is the bolted fault current for three-phase faults (symmetrical rms) (kA)

Iarc_600 - is the average rms arcing current at Voc= 600V (kA)

G - is the gap distance between electrodes (mm)

lg - is log10

k1 to k10 are the Coefficients,

k1 = -0.04287 k2 = 1.035 k3 = -0.083 k4 = 0 k5 = 0 k6 = -4.783*10^{-9}

k7 = 1.962*10^{-6} k8 = -0.000229 k9 = 0.003141 k10 = 1.092

$$I_{arc\_600} = 10^{(-0.04287+1.035*\log(66.526)+(-0.083*\log(66.526))}\,(0*66.526^6 + 0.000000004783*66.526^5 + 0.000001962*66.526^4 + 0.000229*66.526^3 + 0.003141*66.526^2 + 1.092)$$

Iarc = 41.239 kA

Step 2: Find the final arcing current

$$I_{arc} = \frac{1}{\sqrt{\left(\frac{0.6}{Voc}\right)^2 * \left(\frac{1}{I_{arc_{600}}{}^2}\right) - \left(\frac{0.6^2 - Voc^2}{0.6^2 \times I_{bf}^2}\right)}}$$

$$I_{arc} = \frac{1}{\sqrt{\left(\frac{0.6}{0.43575}\right)^2 * \left(\frac{1}{41.239^2}\right) - \left(\frac{0.6^2 - 0.43575^2}{0.6^2 \times 66.562^2}\right)}}$$

Iarc final = 33.102kA

Determination of equivalent height and width:

$$Width_1 = 660.4 + (Width - 660.4) \times \left(\frac{Voc + A}{B}\right) \times 25.4^{-1}$$

$$Height_1 = 660.4 + (Height - 660.4) \times \left(\frac{Voc + A}{B}\right) \times 25.4^{-1}$$

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where

$Height_1$ is the equivalent enclosure height

$Width_1$ is the equivalent enclosure width

Width is the actual enclosure width (mm)

Height is the actual enclosure height (mm)

Voc is the open-circuit voltage (system voltage) (kV)

A is a constant equal to 4 for VCB and 10 for VCBB and HCB

B is a constant equal to 20 for VCB, 24 for VCBB and 22 for HCB

Table 6—Guidelines to determine the equivalent height and width

E.C.	Range	<508 (mm)	≥508 and ≤660.4 (mm)	>660.4 and ≤1244.6 (mm)	>1244.6 (mm)
VCB	$Width_1$	= 20 (if Typical) = 0.03937 × Width (if Shallow[a])	= 0.03937 × Width	obtained from Equation (11) and actual Width	obtained from Equation (11) with Width = 1244.6 mm
	$Height_1$	= 20 (if Typical) or = 0.03937 × Height (if Shallow[a])	= 0.03937 × Height	= 0.03937 × Height	= 49
VCBB	$Width_1$	= 20 (if Typical) or = 0.03937 × Width (if Shallow[a])	= 0.03937 × Width	obtained from Equation (11) and actual Width	obtained from Equation (11) with Width = 1244.6 mm
	$Height_1$	= 20 (if Typical) or = 0.03937 × Height (if Shallow[a])	= 0.03937 × Height	obtained from Equation (12) and actual Height	obtained from Equation (12) with Height = 1244.6 mm
HCB	$Width_1$	= 20 (if Typical) or = 0.03937 × Width (if Shallow[a])	= 0.03937 × Width	obtained from Equation (11) and actual Width	obtained from Equation (11) with Width = 1244.6 mm
	$Height_1$	= 20 (if Typical) or = 0.03937 × Height (if Shallow[a])	= 0.03937 × Height	obtained from Equation (12) and actual Height	obtained from Equation (12) with Height = 1244.6 mm

[a]Shallow only if V_{oc} < 600 V ac and the enclosure depth ≤ 203.2 mm (8 in) otherwise the enclosure is "Typical."

Height 1 – 20

Width 1 – 20

The equivalent enclosure Size value is,

$$ESS = \frac{Width_1 + Height_1}{2}$$

$$ESS = \frac{20 + 20}{2} = 20$$

ESS=20

The Correction factor (CF) for a "Typical enclosure" is

$$CF = \frac{1}{b_1 * ESS^2 + b_2 * ESS + b_3}$$

CF – Enclosure Size Correction actor

EES – Equivalent Enclosure Size

b1 to b3 are the Coefficients

b1 = −0.000302   b2 = 0.03441   b3 = 0.4325

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$$CF = \frac{1}{(-0.000302 * (20 * 20)) + (0.03441 * 20) + 0.43252}$$

CF=1

Step 3: The intermediate values of incident energy

Using the coefficients from Table 3andEquation (3), find the intermediate incident energy for 600 V:

k1 = 0.753364 k2 = 0.566 k3 = 1.752636 k4 = 0 k5 = 0 k6 = -4.783*10^{-9} k7 = 0.000001962 k8 = -0.000229 k9 = 0.003141 k10 = 1.092 k11 = 0

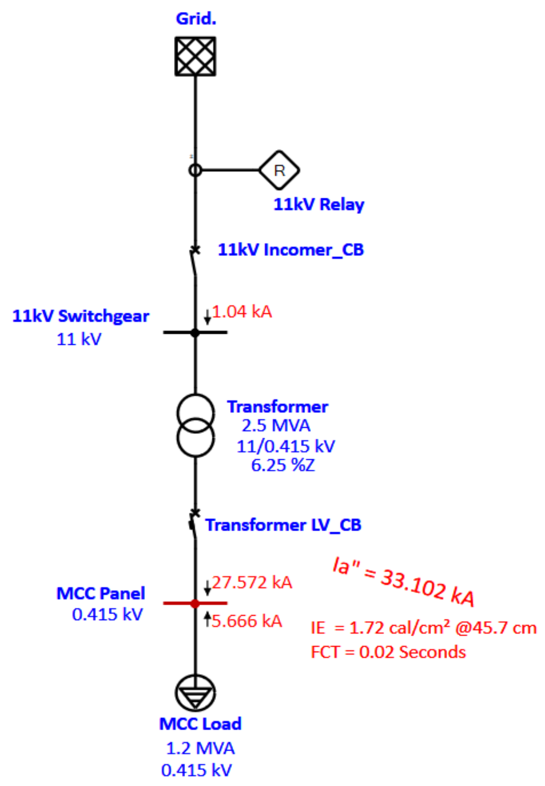
k12 = -1.598 k13 = 0.957

$$E \le 600 = \frac{12.552\ T}{50} \times 10^{\left(k1+k2l_gG+\left(\frac{k3I_{arc_{600}}}{k4I_{bf}^7+k5I_{bf}^6+k6I_{bf}^5+k7I_{bf}^4+k8I_{bf}^3+k9I_{bf}^2+k10I_{bf}^1}\right)\right)+k11l_gI_{bf}+k12I_gD+k13l_gI_{arc}+\log C.F}$$

$$E \le 600 = \frac{12.552 \times 20}{50} \times 10^{\left(0.753364+0.566*\log(25)+\left(\frac{1.752636*41.239}{0*66.5627+0*66.526^6+0.000000004783*66.526^5+0.000001962*66.526^4+0.000229*66.526^3+0.003141*66.526^2+1.092*66.526^1}\right)\right)+0*\log(66.562,10)+(-1.598*\log(457.2,10)+0.957*\log(33.102,10)+\log\left(\frac{1}{1}\right),10}$$

Incident Energy = 7.195 J/cm^2

Incident Energy = 7.195/4.184 = 1.72 Cal/cm2



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Determination of incident energy for Low voltage draw out Circuit breaker

An arc flash may occur in or behind a circuit-breaker (CB) compartment as follows,

- **With CB racked in but stab not on studs or not secure**
- **With no CB present – accidental contact during cleaning or inspection**
- **If CB fails because of over-duty or water or other contamination or internal mechanical failure**

Faults may also occur in cable-termination compartments, meter compartments, and in instrument or control power transformer compartments (PT or CPT).

With CB racked in but stab not on studs or not secure

If a CB is accessible, but the CB stabs are not securely linked to a stud (bus run back), an arc flowing away from the source of supply may appear to be the best alternative. VCBB, on the other hand, is a superior option because the arc cannot come straight out at the worker. The distance from the arc to the person is measured from where the bus stab connects to the CB,

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which is around 30.48cm (12in) behind the front of the low-voltage (LV) switchgear, plus another 45.7cm (18in) to the worker's body.

With no CB present – accidental contact during cleaning or inspection

If a CB is not present, enclosed equipment with horizontal bus, bus not terminated, HCB is the best selection.

If CB fails because of over-duty or water or other contamination or internal mechanical failure

When a CB is present and has an internal fault, for example, when the contacts are unable to interrupt the fault, the arc bursts upward into arc chutes for as long as the CB is there. Because the arc occurs near the front of the enclosure, with the CB frame shielding the back, the enclosure will have little impact while the equipment is contained. The bus is terminated using contacts that cause the arc to rise. The best option is the VCB. The distance between the arc and the person is measured from the CB contacts inside the CB, which are approximately 10.16cm (4in) inside the LV CB and 30.48cm (12in) outside.

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Reference:

Institute of Electrical and Electrical Engineers 1584 – "Guide for performing Arc-Flash Hazard calculation", 27 September 2018.