Bus Duct Design

I. Material
- I. Aluminium
- ii. Copper

II. Type
- i. Air Insulated (fabricated)
- ii. Sandwitch

III. Assembly
- i. Totally enclosed
- ii. Isolated phase bus

IV. Design Factors

A. Steady state current
- i. Temperature Factor
- ii. Material Factor
- iii. Enclosure Factor

B. Short circuit condition
- i. Thermal capability
- ii. Dynamic capability
- iii. Stress on bus-bar
- iv. Stress on support

I. Current Derating Factor for Busbars

a) Temperature Factor (Indal)
1. Temperature rise 40degree over ambient - 0.88
2. Temperature rise 30degree over ambient - 0.75

b) Material Factor (Indal)

Material	De-rating Factor
25M	1.02
B265WP	0.83
505WP	0.94
B515WP	0.92
545M	0.77
AS65	0.72

c) Enclosure Factor (Indal)

Enclosure	Bus area/Enclosure area	De-rating factor
Outdoor	1%	0.95
	5%	0.90
	10%	0.85
Indoor-Well ventilated	1%	0.85
	5%	0.75
	10%	0.65
Indoor-not ventilated	1%	0.65
	5%	0.60
	10%	0.50

II.Current Ratings of Busbars (Indal)

Siz-mm	1 Bar	2 Bar	3Bar	4 Bar
25.4 X 6.35	355	705	970	1100
28.1 X 6.35	520	1020	1350	1535
50.8 X 6.35	670	1290	1705	1940
63.5 X 6.35	810	1510	2000	2260
76.2 X 6.35	960	1740	2310	2620
101.6 X 6.35	1235	2140	2800	3200
127 X 6.35	1505	2510	3240	3700
152.4 X 6.35	1780	2860	3680	4240
50.8 X 9.53	830	1500	1970	2260
76.2 X 9.53	1180	2050	2660	3030

Siz-mm	1 Bar	2 Bar	3Bar	4 Bar
101.6 X 9.53	1495	2480	3150	3560
127 X 9.53	1860	2930	3660	4200
152 X 9.53	2120	3340	4080	4680
203.2 X 12.7	2750	4150	4900	5740
76.2 X 12.7	1355	2240	2830	3240
101.6 X 12.7	1740	2720	3360	3900
127 X 12.7	2080	3120	3900	4550
152.4 X 12.7	2420	3500	4400	5100
203.2 X 12.7	3060	4450	5300	6150
254 X 12.7	3640	5000	6000	6850

Sample Design Calculation for 1000kVA Transformer

Datas

Full load current (IN) –1333A
Short circuit current (IS) – 30000A
Ambient temperature – 35°C
Material for conductor – Aluminium alloy, D50S WP
Maximum allowable temperature on steady state for aluminium – 75°C
Initial temperature taken for short circuit condition (θ1) – 75°C
Fault duration taken – 1sec.
Maximum temperature allowed on short circuit condition (θ2) – 170°C
Temperature coefficient of resistance at 20°C for aluminium (α) – 0.0036
Allowable tensile stress on aluminium – 1025kg/cm²
Bus supports – SMC
Allowable shear stress on SMC – 55.5kg/cm²

Bus Duct Design

Duct Details

Type – Fabricated, totally enclosed
Conductor material – Aluminium alloy, D50SWP
Conductor size –2x127x6.35mm –Phase, 1x127x6.35mm – Neutral
Enclosure size - 400x300mm
Minimum distance between buses (S) – 100mm
Minimum distance between bus & enclosure – 50mm
Support – SMC, 2Way, Thickness - 10mm, Finger length - 19mm
End finger width –15mm, Middle finger width – 6mm
Distance between supports (L) – 30cm
Location of duct – Indoor, well ventilated

1.Steady state condition

Current rating of suggested buses (Table 3) – 2510A
De-rating factor for 40°C temperature rise – 0.88
De-rating factor for material (Table 1) – 0.94
Conductor area – 127x6.35x7 = 5645mm²
Enclosure area – 400x300 = 120000mm²
Conductor area/Enclosure area = 0.047 = 4.7%
Enclosure factor (Table 2) – 0.75
Actual current rating – 2510x0.88x0.94x0.75 = 1557A
As more than rated current, size suggested is adequate

2. Short circuit condition

a) Thermal capability

Temperature rise (t) = $(1.166 \times Is^2(1+\alpha \times \theta 1)x10^{-2})/A2$
Is = Short circuit current = 30000A
α = Temperature coefficient of resistance = 0.0036
$\theta 1$ = Initial temperature = 75°C
A = Area of conductor in mm2
Maximum permissible temperature rise = $\theta 2 - \theta 1 = 170 - 75 = 95°C$
$95 = (1.166x300002(1+0.0036x75) \times 10^{-2})/A2$
$A = \sqrt{(1.166 \times 300002 (1+0.0036 \times 75) \times 10^{-2})/95)} = 375\ mm^2$
(Thumb rule A= Is / 80))

Buses selected has size more than this and so adequate

b)Dynamic capability

Stress On Busbars
Electromagnetic force on short circuit (Fm) = $16x\ Is^2x10^{-4}$/S Newton/metre
S = Distance between bus-bars = 100mm
Fm = 16x300002x10-4/100 = 14400N/m = 1468kg/m =14.68kg/cm
Force on one bus (W) = 14.68/Number of bus-bars = 14.68/2 =7.34kg/cm
Maximum bending moment (M) = $WxL^2/8$
L = Distance between supports in cm. = 30cm.
Max. bending moment (M) = 7.34x302/8 =825kgcm
Modulous of section (Z) = $bd^2/6$
b= Width of bus-bar in cm. = 12.7cm
d = Thickness of bus-bar in cm = 0.635cm

Bus Duct Design

Modulous of section (Z) =12.7x0.635²/6 = 0.85cm³
Actual fibre force (F) = M/Z = 825/0.85= 970kg/cm²
Allowable tensile stress is 1025kg/cm², hence adequate.
Stress On Supports
Support reaction (F1) = Fm x L = 14.68 x 30 = 440kg
Force on one support (f) = F1/Number of supports at a point = 440/2 = 220kg.
Thickness of support = 10mm = 1cm.
Area (a) = (1.5x1 + 0.6x1) = 2.1cm²
Shear stress = f/a = 220/2.1 = 105kg/cm²
It exceeds allowable maximum stress on SMC, 55.5kg/cm².
Hence thickness increased to 20mm
Contact area = (1.5x2 + 0.6x2) = 4.2cm²
Now shear stress = 220/4.2 = 52.4kg/cm²
As it is less than allowable shear stress, 55.5kg/cm², supports selected adequate
Flexible Connection
Aluminium foil
Foil Thickness -0.457mm (26 SWG) (Max thickness for flexibility)
Foil Width – 125mm
Current density permissible for aluminium – 0.8 A/mm²
Continuous current – 1333A
Number of foils – 1333/ 0.8 x125x0.457 = 30Nos.
Duct Details
Type : Fabricated, totally enclosed
Material for conductor – Aluminium alloy, D50S - WP
Conductor size –2x127x6.35mm –Phase 1x127x6.35mm – Neutral
Enclosure size - 400x300mm
Minimum distance between phase buses – 100mm
Minimum distance between bus & enclosure – 50mm
Support – SMC, 2Way, Thickness - 20mm, Finger length - 19mm,
End finger width-15mm, Middle finger width-6m Distance between supports-30cm
Stiffeners - Size – 127.35mm x 127.35mm x 6.35mm - Spacing – 60cm
Location of duct – Indoor, well ventilated
Flexible connections – 125mm, 0.457mm foils, 30 nos. at both ends

BUS - DUCT