Orion Technical Services, LLC

Bus Span & Deflection Calculator
Help Documentation

This document provides instructions on the use and application of the Bus Span & Deflection Calculator. The tool has been developed to aid in calculations related to the design of electrical substation busses constructed using either tubular or angular aluminum bus.

The calculator is broken down into two (2) different calculation methods; 1) Calculation of Bus Deflection and 2) Calculation of maximum Bus Span Length. The first method calculates the deflection for a given bus type, bus length, and ice thickness. The second method solves for the maximum bus span for a given bus type, maximum deflection, and ice thickness.

Options to include the effect of bus damper cables and short circuit currents on the above calculations have been included to determine worst case values.

Once all of the input values have been entered into the input screen and the Calculate button is depressed, the results of the calculations are shown in the results window. Results are provided for several different calculation methods to insure that the worst case value is identified and used for the bus design.

The calculation methods and data used within the calculator are included below for reference.

Determination of Maximum Deflection for Aluminum Bus of a specified span length:

This calculation determines the maximum deflection based on the simple beam formula for uniformly distributed loads and the fixed beam formula for uniformly distributed loads.

$D = 5\ w\ L^4 / 384\ E\ I$ - for bare conductor – simple beam formula

or

$D = (w + w_i)\ L^4 / 384\ E\ I$ - for conductor with ice – fixed beam formula (fixed at both ends)

$w_i = (0.033\ \text{lbs.} / \text{in.}^3)\ \pi\ (r_2^2 - r_1^2)$ - weight of ice on the tubular conductor

$w_i = 3\ (0.033\ \text{lbs.} / \text{in.}^3)\ t\ h$ - weight of ice on angle conductors (only even angle conductors ie. 3x3)

Determination of Maximum Bus Span for Aluminum Bus:

Three separate methods are used to determine the maximum span of aluminum bus. Typically the lowest of the three methods are selected.

Simple Beam Method:

This method is based on the simple beam formula for uniformly distributed loads and the fixed beam formula for uniformly distributed loads.

$L = \sqrt[4]{D\ (384)\ E\ I\ /\ 5\ w}$ - Derived from the Simple Beam formula

or

$L = \sqrt[4]{D\ (384)\ E\ I\ /\ (w + w_i)}$ - Derived from the fixed beam formula with ice loading

Flexural stress at extreme fiber method:

This method is strictly dependant on the type aluminum bus being used and the length of bus being applied.

$f = w\ l^2 / 8\ S$ - for bare conductor – simple beam

$L = \sqrt{f\ (8)\ S\ /\ w} = \sqrt{(200{,}000)\ S\ /\ w}$

or

$f = (w + w_i)\ l^2 / 12\ S$ - for conductor with ice – fixed beam formula (fixed at both ends)

$L = \sqrt{f\ (12)\ S\ /\ (w + w_i)} = \sqrt{(300{,}000)\ S\ /\ (w + w_i)}$

Short Circuit Method:

This method is based on the force associated with a three phase fault flowing through the conductor and comparing it to the cantilever strength of the station post insulators to which the bus is connected to.

$F = 37.5\ A^2\ (1 \times 10^{-7})\ /\ d$ - for round conductor, 3Ø Asymmetrical Fault

$F = 43.2\ A^2\ (1 \times 10^{-7})\ /\ d$ - for single angle conductor, 3Ø Asymmetrical Fault

$L = (12)\ C\ /\ F$

Formula Variable Definitions and Units

A = Short circuit current (amps)

C = Cantilever Strength of Post Insulator (lbs.)

D = Deflection (in.)

d = Conductor spacing (in.)

E = Modulus of elasticity (lbs./ $in.^2$) (= 10×10^6 for aluminum)

F = Short circuit force (lbs./lineal ft.)

f = Fiber Stress (lbs./ $in.^2$)

h = height (and width) of angle conductor (in.)

I = Moment of Inertia ($in.^4$)

L = Span length (in.)

r_1 = Radius of tube (outside) (in.)

r_2 = Radius of ice (in.)

S = Section Modulus ($in.^3$)

t = thickness of ice (in.)

w = weight of tube (lbs. / in.)

w_i = weight of ice (lbs. / in.)

π = pie (3.1416)

ASA Schedule 40 Aluminum Pipe Conductors
Physical Properties

Nominal Pipe Size (in.)	Diameter (in.)		Wall Thickness (in.)	Area ($in.^2$)	Weight/ft. (lbs.)	Moment of Inertia ($in.^4$)	Section Modulus ($in.^3$)	Radius of Gyration (in.)
	Outside	Inside						
1/2	0.840	0.622	0.109	0.2503	0.294	0.0171	0.0407	0.2613
3/4	1.050	0.824	0.113	0.3326	0.391	0.0370	0.0705	0.3337
1	1.315	1.049	0.133	0.4939	0.581	0.0873	0.1328	0.4205
1 – 1/4	1.660	1.380	0.140	0.6685	0.786	0.1947	0.2346	0.5397
1 – 1/2	1.900	1.610	0.145	0.7995	0.940	0.3099	0.3262	0.6226
2	2.375	2.067	0.154	1.0745	1.264	0.6657	0.5606	0.7871
2 – 1/2	2.875	2.469	0.203	1.7041	2.004	1.530	1.064	0.9474
3	3.500	3.068	0.216	2.2285	2.621	3.017	1.724	1.164
3 – 1/2	4.000	3.548	0.226	2.6795	3.151	4.788	2.394	1.337
4	4.500	4.026	0.237	3.1740	3.733	7.232	3.214	1.510
5	5.563	5.047	0.258	4.2999	5.057	15.16	5.451	1.878

ASA Schedule 80 Aluminum Pipe Conductors
Physical Properties

Nominal Pipe Size (in.)	Diameter (in.)		Wall Thickness (in.)	Area ($in.^2$)	Weight/ft. (lbs.)	Moment of Inertia ($in.^4$)	Section Modulus ($in.^3$)	Radius of Gyration (in.)
	Outside	Inside						
1/2	0.840	0.546	0.147	0.3200	0.376	0.0201	0.0478	0.2505
3/4	1.050	0.742	0.154	0.4335	0.510	0.0448	0.0853	0.3214
1	1.315	0.957	0.179	0.6388	0.751	0.1056	0.1606	0.4066
1 – 1/4	1.660	1.278	0.191	0.8815	1.037	0.2418	0.2913	0.5238
1 – 1/2	1.900	1.500	0.200	1.0681	1.256	0.3912	0.4118	0.6052
2	2.375	1.939	0.218	1.4773	1.737	0.8679	0.7309	0.7665
2 – 1/2	2.875	2.323	0.276	2.2535	2.650	1.924	1.339	0.9241
3	3.500	2.900	0.300	3.0159	3.547	3.894	2.225	1.136
3 – 1/2	4.000	3.364	0.318	3.6784	4.326	6.281	3.140	1.307
4	4.500	3.826	0.337	4.4074	5.183	9.611	4.272	1.477
5	5.563	4.813	0.375	6.1120	7.188	20.67	7.432	1.839

Aluminum Single Angle (L) Conductors
Physical Properties

Angle Size (in.)	Thickness (in.)	Section Area (in.^{2})	Weight (lbs./ft)	Moment of Inertia (in.^{4})	Section Modulus (in.^{3})	Radius of Gyration (in.)
2 ½ x 2 ½	1/4	1.19	1.40	0.69	0.39	0.76
2 ½ x 2 ½	3/8	1.74	2.05	0.98	0.56	0.75
3 x 3	1/4	1.43	1.68	1.18	0.54	0.91
3 x 3	3/8	2.10	2.47	1.70	0.80	0.90
3 x 3	1/2	2.74	3.23	2.16	1.04	0.89
4 x 4	1/4	1.94	2.28	2.94	1.00	1.23
4 x 4	3/8	2.86	3.38	4.26	1.48	1.22
4 x 4	1/2	3.75	4.41	5.46	1.93	1.21
4 x 4	5/8	4.61	5.42	6.56	2.36	1.19

References:

Standard Handbook for Electrical Engineers, Fourteenth Edition, Copyright 2000
Manual of Steel Construction, American Institute of Steel Construction, Third Edition
Aluminum Standards and Data, Aluminum Association
Technical Data, A Reference For the Electrical Power Industry, Hubbell Power Systems, AEC-41, Rev. A