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DESIGN PROGRAM ZIP FILE

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DISTRIBUTION DESIGN - OVERHEAD
OVERHEAD DESIGN PROGRAMS
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OVERHEAD DESIGN PROGRAMS
MAIN PROGRAM FEATURES

Overview

The Overhead Line Design Programs are now contained in a single executable file. This replaces the MS Excel files used previously. There are two other files required for the full operation of the software; Help.pdf and Conductor.OHD. The following steps are required when using the program for the first time. They will only need to be followed once.

Program Installation Steps

- Create a new folder to store the program in (e.g. “C:\LocalData\OHVB5”).
- Unzip **OHLDP.exe, Conductor.OHD** and **Help.pdf** into the folder created.
- Create a shortcut to the folder on your desktop.
- Run **OHLDP.exe**.
- On the first run of OHLDP.exe a fourth file is automatically created called **LnSTDProg.cfg**. This file contains the location of the conductor database so it can be automatically loaded on start-up.
    - In the main menu click on the **Database File Location** button.
    - Select the path to the folder created previously (e.g. “C:\LocalData\OHVB5”) and click on the **Open** button.

Main Menu

This menu is the first window displayed when the Overhead Line Design Programs are opened. It contains the buttons used to select each of the different programs, as well as allowing access to some general information **About** the software and the button to manually select the conductor **Database File Location**.

The bar at the bottom of the screen alternates between a description of the program the cursor is over, or it displays the location of the database file that has been loaded.

Operating Instructions

- To access any of the options displayed, click on the appropriate button.
- To return to this menu click the **Menu** button.

General Controls

Design Name and Number:
- Enter a description of the current design. This description will be displayed on any electronically stored or hardcopy design produced.

To Print:
- Click the **Print** button to print current window to a hard copy.

To Create a PDF File:
- Click **Print to PDF** and enter a file name to save the current window

To Save the Current Scenario:
- Click **Save Scenario**
- Enter a **Scenario Number (1, 2 or 3)**

To Load a Saved Scenario:
- Click on **Scenario 1, Scenario 2** or **Scenario 3** to load desired scenario

NOTE: Exiting from one program and moving onto another program by clicking the MENU button will reset the SAVE SCENARIO and current data will be lost.

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DISTRIBUTION DESIGN - OVERHEAD
OVERHEAD DESIGN PROGRAMS
MAIN PROGRAM FEATURES

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OVERHEAD DESIGN PROGRAMS
CONDUCTOR SELECTION

Overview

The conductor selection form is displayed any time the **Select A Conductor** button is clicked. This form allows a conductor selected from either the Ergon Standard conductors list or a list of All Conductors. Any relevant conductor information is then displayed in the program which the conductor was selected from. Alternatively there is the option of searching the conductor database by entering a search string.

Once a conductor has been selected, a detailed description of the conductor can be accessed through the **CONDUCTOR DETAILS** button.

To use the program

Using the Standard Conductor Selection Form

- Select either **Ergon Standard** conductors or **Ergon ALL** conductors
- If **Ergon ALL** is selected, the range of conductors can be restricted to **Metric, Imperial** or **ALL** conductors.
- Select **Conductor Type** from the drop down list – only valid for Ergon ALL conductors.
- Select the **Conductor Description** from the drop down list.

Using the Conductor SEARCH Function

- Click the **SEARCH** button to open the Search Conductor Form
- Enter the search string in the text box
- Click **Start Search** to find the first match (if one exists)
- If a match is found, click the **Continue Search** button to find any other conductors matching the search criteria.
- Alternatively click **Select Conductor** to use the conductor matching the search criteria

Using the CONDUCTOR DETAILS Function

- Select a conductor using one of the previous two methods.
- Click on the **Conductor Details** button.
- Select either **Electrical/Mechanical Data**, **Preform Fittings** or **Compression Fittings** by clicking on the buttons provided.

OVERHEAD DESIGN PROGRAMS
CONDUCTOR TENSION CHANGE PROGRAM

Overview

The program is designed to calculate the change in tension of a conductor given its initial stringing condition and nominated operating conditions. Both the horizontal swing and vertical sag at mid span under this tension are also calculated and can be displayed and compared graphically. Additionally, the conductor sag at a specified point, under a specific wind and temperature condition can be displayed.

The tension under the operating conditions is calculated by solving the equation below for T_o:

$$\left(\frac{c_1 wl}{T}\right)^2 - T = \left(\frac{c_1 w_o l}{T_o}\right)^2 - T_o + c_2 t$$

Where $c_1 = \sqrt{\frac{EA}{24}}$, $c_2 = \alpha EA$

- l = ruling span (MES) (m)
- T = tension under the initial conditions (N)
- W = weight of the conductor under the initial conditions (N/m)
- T_o = tension under the operating conditions (N)
- w_o = weight of the conductor under the operating conditions in N/m
- t = temperature under the initial conditions less the temperature under the operating conditions (^{o}C)
- E = final Modulus of Elasticity (Pa)
- A = total sectional area of the conductor (m²)
- α = the coefficient of linear expansion (per ^{o}C)

The vertical sag and horizontal swing is calculated from the following equations:

$$S_V = \frac{W \times L^2}{8 \times T} \qquad S_H = \frac{P \times D \times L^2}{8 \times T}$$

Where
- S_V = vertical sag at mid span (m)
- S_H = horizontal swing at mid span (m)
- W = conductor weight (N/m)
- P = wind pressure under final conditions (Pa)
- D = conductor diameter (m)
- L = span length (m)
- T = final tension (N)

The conductor transition span, depending on the region selected is always taken into account. If the ruling span exceeds the transitions span, the tension of the conductor under the selected conditions will be limited. In such instances, the limitation boundary is for limit state conditions applicable for the selected region instead of the selected stringing conditions.

The program allows the change in tension to be calculated either by selecting conditions from drop down lists or by entering all relevant data. This is contained on two separate sheets, entitled **Conductor Tension Change Select**, to select conditions from drop down lists, and **Conductor Tension Change Enter**, to enter all relevant data into spaces provided.

For the **Conductor Tension Change Enter** form a conductor can be selected using the select conductor button.

OVERHEAD DESIGN PROGRAMS
CONDUCTOR TENSION CHANGE PROGRAM

__To use the program__

- Under Conductor Tension Change on the main form choose the **Select** or **Enter** button.

Using the Conductor Tension Change Program (Select Version):

- Select a Conductor by clicking the **Select Conductor** button.
- Select the **Stringing Tension** from the drop down list. If an unlisted value is required, type the **Stringing Tension** in the drop down list.
- Enter the **Ruling Span (MES)** in the Ruling Span text box.
- Enter the **Actual Span** in Actual Span text box.
- Select the **Ground Clearance Operating Temperature** from the drop down list. If an unlisted value is required type the **Ground Clearance Operating Temperature** in the drop down list.
- Select the **Region** in which the construction is situated by clicking the desired option.
- Click the **Calculate Tension** button to calculate and display the tension, vertical sag and horizontal swing under the selected conditions.
- To find the conductor sag at a specified point enter the location along the span as either a **percentage of span length** or by **entering a span location in metres** and selecting the appropriate operating condition.
- Click **Calculate Sag** to update the sag at the specified point
- To view the horizontal swing and vertical sag profiles graphically, click **Graph Conductor Sag**
- Using the checkboxes, select the **Sag Profile/s** which are required to be displayed

Using the Conductor Tension Change Program (Enter Version):
There are three choices – final tension, stringing tension level attachment height and stringing tension different attachment heights. Note that this does not take into account the transition span.
For **all calculation types :-**

- Manually input the **Conductor Data**, consisting of **Overall Diameter**, **Total Cross-sectional Area**, **Calculated Breaking Load**, **Unit Mass**, **Final Modulus of Elasticity** and **Coefficient of Linear Expansion** in the text boxes provided.
- Alternatively select a Conductor by clicking the **Select Conductor** button.

For **final tension :-**

- Enter the **Initial Operating Conditions**, including the **Initial Conductor Tension**, **Initial Conductor Temperature** and **Initial Wind Pressure** in the text boxes provided.
- Input the **Span Details,** consisting **Ruling Span (MES)** and **Actual Span**.
- Input the **Final Operating Conditions**, consisting of **Final Wind Pressure** and **Final Temperature**.
- Click the **Calculate** button to calculate and display the tension, vertical sag and horizontal swing under the conditions entered.

For **stringing tension for level attachment height :-**

- Enter the **Measured Vertical Conductor Sag** at mid-span in the text box provided.
- Input the **Span Details,** consisting **Ruling Span (MES)** and **Actual Span**.
- Input the **Final Operating Conditions**, consisting **of Conductor Temperature and Wind Pressure at time of Measurement**.
- Click the **Calculate Tension** button to calculate and display the initial tensions in kN and %CBL.

For **stringing tension - different attachment height :-**

- Enter the **Conductor Profile** consisting of **Difference in Conductor Attachment Heights** and **Distance from First Pole to Lowest Point on Span** in the text boxes provided.
- Input the **Span Detail, Actual Span** in the text box provided.
- Click the **Calculate Tension** button to calculate and display the initial tensions in kN and %CBL. A **Graphical Span Representation** will be shown to verify the line profile.

OVERHEAD DESIGN PROGRAMS
MAXIMUM SPAN – MID SPAN CLEARANCE LIMITATION PROGRAM

Overview

The program is designed to calculate the maximum span for a chosen construction to ensure the separation at mid span is adequate to prevent conductor clashing.

The maximum span is calculated in accordance to C(b)1 Guidelines for Design and Maintenance of Overhead Distribution and Transmission Lines, Clause 9.3.

The equation below calculates the valid mid span clearance:

$$\sqrt{X^2 + (1.2Y)^2} \geq \frac{U}{150} + k\sqrt{D + l_i}$$

Where

- X = is the projected horizontal distance in metres between the conductors at mid span
- Y = is the projected vertical distance in metres between the conductors at mid span
- U = is the rms vector difference in potential (kV) between the two conductors when each is operating at its nominal voltage
- K = is a constant, normally equal to 0.4, but consideration should be given to increasing it outside of Region A
- D = is the greater of the two conductor sags in metres at the centre of an equivalent level span and at a conductor operating temperature of 50˚ in still air
- l_i = is the length in metres of any free swing suspension insulator associated with either conductor

The conductor transition span, depending on the region selected is taken into account. If the ruling span exceeds the transition span, the tension of the conductor under the selected conditions will be limited. In such instances, the limitation boundary is for limit state conditions applicable for the selected region instead of the selected stringing conditions.

The program is designed so that different pole construction can be chosen at each end of the span i.e. both crossarm construction and deviation angle can be chosen at each end. Option is given to select the crossarm length, either as standard construction or at other defined dimension.

In instances where a different pole construction is selected at each end of the span, the horizontal distance between the conductors at mid span is found by taking the average of the distances between the conductors at each end of the span. The same is also applied for vertical distance.

To use the program

- Under Maximum Span on the main form choose the **Select** button.
- Select a Conductor by clicking the **Select Conductor** button.
- Select the **Line Voltage** of the conductor
- Select the **Region** in which the construction is situated from the options available
- Select the **Stringing Tension** from the drop down list.
- Enter the **Ruling Span (MES)** in the corresponding textbox

For Poles 1 and 2:

- Enter the **Deviation Angle** in the corresponding textbox
- Select the **Construction Type** from the drop down list.
- Select the **Crossarm Height** from the pole tip from the drop down list.
- Select the **Crossarm Length** from the drop down list
- Click the **Calculate** button to calculate and display the maximum span limited by the mid span clearance.

OVERHEAD DESIGN PROGRAMS
MAXIMUM SPAN – MID SPAN CLEARANCE LIMITATION PROGRAM

Assumptions

- For Intermediate constructions where a pin insulator is used, the depth of the crossarm is 125mm in all instances.
- The projected vertical and horizontal distances are based on distances in Dwg 3131 in the “Layout Clearances” section for 11/22/33kV construction.
- The maximum span is calculated under the operating conditions of 0Pa at 50°C.

OVERHEAD DESIGN PROGRAMS
ALLOWABLE POLE TIP LOADS PROGRAM

Overview

The program is designed to calculate the allowable pole tip load under limit state and sustained load conditions.

It determines the allowable pole tip loads based on either the pole strength or the foundation strength after allowance for wind on the exposed pole area. If the pole strength is less than compared to the foundation strength, then this is taken as the allowable pole tip loads or vice versa. The factor limiting the allowable pole tip loads is displayed with the calculated allowable pole tip loads.

The allowable pole strengths are dependant on if the pole is new or existing:

- For a **new pole** the allowable pole strengths are based on the ultimate pole strength factored by 0.72 for Limit State and 0.2 for sustained loads.
- For an **existing pole with no change in tip load** the allowable pole strengths are based on the ultimate pole strength factored by 0.72 for Limit State and 0.2 for sustained loads.
- For an **existing pole with a change in tip load** the allowable pole strengths are based on the ultimate pole strength factored by 0.72 for Limit State and 0.2 for sustained loads.

The allowable foundation loads are calculated based on C(b)1 Guidelines for Design and Maintenance of Overhead Distribution and Transmission Lines, Appendix C.

The relevant diameters are based on pole strength group S2. These diameters allow calculation for wind load and foundation load as provided by the following equations:

For Wind on Pole

Diameter at ground = $(D_B - D_T) / (H - 2) \times (2 - J) + D_B$
Pole Centroid = $((2 \times D_T + D_G) / (D_T + D_G) \times h) / 3$
Pole Taper = $(D_2 - D_T) / (H - 2)$
Area = $((D_T + D_G) \times h) / 2$
Wind on Pole (kN) = (Area x Wind Pressure) /1000
Wind on Pole refer to pole tip (kN) = (Wind on Pole x Pole Centroid) / h

For Foundation Loads

Average below ground Diameter = D_T + Pole Taper x (h + J/2)
Maximum Tip Load to avoid over turning P_o (Limit State) = $(K \times 1.8 \times D \times J^3) / (12 \times (h + ¾J)$
Maximum Tip Load to avoid overturning P_o (Sustained) = $(K \times 0.5 \times D \times J^3) / (12 \times (h + ¾J)$

Where
D_T = pole tip diameter (m)
D_G = diameter at ground level (m)
D_B = diameter 2m from butt (m)
D = average below ground diameter (m)
J = setting depth (m)
H = pole length (m)
h = pole height above ground (m)
K = passive soil reaction per unit depth (kPa/m)
P_o = maximum tip load to avoid overturning (kN)

(The allowable pole tip load is then the lower of P_o; the foundation failure load and the pole element strength less the wind load on the pole referred to the pole tip (applicable to limit state only).)

The program allows the allowable pole tip load to be calculated either by selecting conditions from drop down lists or by entering all relevant data. This is contained in two separate programs. Either the **Select Version** or the **Enter Version** can be opened by pressing the appropriate button on the main menu.

OVERHEAD DESIGN PROGRAMS
ALLOWABLE POLE TIP LOADS PROGRAM

To use the program

- Under Allowable Pole Tip Loads on the main form choose the **Select** or **Enter** button.

Using the Allowable Pole Tip Loads Program (Select Version):

- Select the **Pole Length** from the drop down list.
- Select the **Pole Strength** from the drop down list. (The nominal pole strength is only used in the calculation of wind loads)
- Select the **Setting Depth** from the drop down list.
- Select the **Soil Type** from the options provided
- Select whether there is **Unstabilised** or **Stabilised Backfill.**
- Select whether the pole is a **New Pole** or is already **In Service.**
- If **In Service** is selected then enter the **Calculated Pole Working Strength** and select either **No Load Change** or **Load Change**.
- Select the **Region** in which the pole is situated, either Regions A & B or Region C.
- Click the **Calculate Pole Tip Loads** button to calculate and display the Allowable Pole Tip Load under limit state and sustained load conditions.

Using the Allowable Pole Tip Loads Program (Enter Version):

- Enter the **Pole Details**, consisting of the **Pole Length**, **Pole Strength**, **Diameter at Pole Tip**, **Diameter 2m from Pole Butt** and **Setting Depth**.
- Input the **Soil Details**, including the **Passive Soil Reaction** per unit depth and selecting either **Stabilised Backfill** or **Unstabilised Backfill**
- Enter the **Operating Conditions**, consisting of the **Pole Wind Pressure** (1300Pa for Region A and B or 1700Pa for Region C).
- Click the **Calculate Pole Tip Loads** button to calculate and display the Allowable Pole Tip Load under limit state and sustained load conditions.

Assumptions

- The poles are of strength group S2 as the values for the pole tip diameters and the diameters 2m from the butt of the pole are that of pole strength group S2. The allowable foundation loads for pole strength group S1 will be marginally less and allowable foundation loads for pole strength group S3 will be marginally greater.
- When the option of stabilised backfill is chosen the average below ground diameter is increased by 0.1m to account for the stabilised backfill.
- As defined in Table C.1 of C(b)1, "**Good**" soil is well compacted rock soil, hard clay and well bonded sand and gravel with good surface water drainage with a passive soil reaction per unit depth of **600kPa/m**; "**Medium**" soil is compact medium clay, well bonded sandy loam, bonded sand and gravel with reasonable surface water drainage with a passive soil reaction per unit depth of **300kPa/m**; "**Poor**" soil is soft clay, poorly compacted sand and soil that tend to absorb large amounts of water (excluding slush) with a passive soil reaction per unit depth of **150kPa/m**.

OVERHEAD DESIGN PROGRAMS
CROSSARM DESIGN

Overview

The program is designed to calculate the allowable weight span for intermediate, strain and termination constructions under Limit State, Sustained and Maintenance conditions based on the strength of both the crossarm and the bolted joint.

The allowable weight span is calculated with reference to AS1720.1-1997 Timber Structures Part 1: Design Methods and using the following equations:

Weight of Conductor = Load Factor x Conductor Weight (kg/km) x Allowable Weight Span (m) x 9.81 x 10^{-3}

Transverse Conductor Load = Load Factor x Conductor Tension x Sin(0.5 x Angle of Deviation x π /180)

Transverse Wind Load = Wind Span x Wind Pressure x Conductor Diameter (m)

Longitudinal Conductor Load = Load Factor x Conductor Tension x Cos(0.5 x Angle of Deviation x π /180) x Longitudinal Tension Component

X-Arm Weight = (1100 x (x-arm length (mm) / 2000) x (x-arm width (mm) / 1000) x (x-arm depth (mm) / 1000) x 9.81 + Insulator Weight (N)) x Load Factor

Vertical Bending Moments = (Weight of Conductor x Distance between application point and pole CL) + (Transverse Conductor Load x Distance between application point and x-arm CL) (Transverse Wind Load x Distance between application point and x-arm CL) + (X-Arm Weight x Distance between application point and pole CL x No. X-Arms) + (Wt of Men and Equipment x Distance between application point and pole CL)

Horizontal Bending Moments = (Longitudinal Load x Distance between application point and pole CL)

Stress due to Vertical Bending Moments = Vertical Bending Moments x (x-arm depth (mm) / 2000) / (I_x x No. X-Arms x 10^6)

Stress due to Horizontal Bending Moments = Horizontal Bending Moments x (x-arm width (mm) / 2000) / (I_y x No. X-Arms x 10^6)

Stress due to Tension = (Transverse Conductor Load + Transverse Wind Load) / (x-arm width (mm) x (x-arm depth (mm) – hole diameter (mm)))

Extreme Fibre Stress in Bending = Stress due to Vertical Bending Moments + Stress due to Horizontal Bending Moments

Combined bending and tension (AS1720.1-1997 Clause 3.6.2)

= Vertical Bending Moments / (Design Timber Stress in Bending x Z_x x 10^6) + Horizontal Bending Moments / (Design Timber Stress in Bending x Z_y x 10^6) + Stress due to Tension / Design Timber Stress in Tension <= 1

The program is designed with the option of selecting either a single or double crossarm construction for both Strain and Termination constructions, and either a flat or delta construction for the Intermediate construction. There is the option of choosing a particular crossarm size according the voltage of the conductor, or entering in the data for a different crossarm size.

The minimum weight span between limit state, sustained and maintenance conditions is displayed as the allowable weight span for the selected crossarm.

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OVERHEAD DESIGN PROGRAMS
CROSSARM DESIGN PROGRAM

A sheet number is provided in each sheet for labelling purposes.

To use the program

- Select a Conductor by clicking the **Select Conductor** button.
- Select the **Line Voltage** of the conductor.
- Select the **Stringing Condition** from the drop down list. If an unlisted value is required type the **Stringing Tension** in the drop down list.
- Enter the **Ruling Span (MES)** in the corresponding textbox.
- Enter the **Wind Span** in the corresponding textbox
- Enter the **Deviation Angle** in the corresponding space textbox
- Select the **Region** in which the pole is situated, either Regions A & B or Region C.
- Select an **Intermediate**, **Angle**, **Strain** or **Termination** crossarm construction.
- Select the **Construction Type** or **No. of Crossarms** from the drop down list.
- Select the **Crossarm Size** from the drop down list. If **Other** is selected, type the **Crossarm Length**, **Width** and **Depth** in the corresponding textboxes.
- Select **Insulator Type** from the drop down list.
- Click the **Calculate** button to calculate and display the Allowable Weight Span for the crossarm.

Assumptions

- The Longitudinal Tension Component of 5% does not apply to the Termination crossarm.
- The Longitudinal Tension Component of 5% does not apply to the Strain crossarm under the Maintenance load condition.
- For the Termination crossarm, an allowance is made for the load due to the conductor weight to be supported by one crossarm only, even if there is a double crossarm.
- Load factors are listed in the “Crossarm Design” section of this manual.
- Design Timber Stresses are listed in the “Crossarm Design” section of this manual.
- The Weight of Men and Equipment (listed in the “Crossarm Design” section of this manual) is only taken into account under the Maintenance load conditions.
- The bolted joint is in accordance with AS1720.1 Section 4.4, specifically Equation 4.4(3), using joint group J2.
- The Transverse Wind Load is only taken into account under Limit State and Maintenance load conditions.
- Loading on the pin insulators is not taken into account. For deviation angle limits on the pin insulators, refer to the table in the “Insulators” section of this manual.

OVERHEAD DESIGN PROGRAMS
ALLOWABLE WIND SPAN PROGRAM

Overview

The program is designed to calculate the allowable wind span under limit state load and checks the condition of the pole under sustained load for standard crossarm constructions. It takes into account the transverse loads due to wind pressures and deviation angle on the conductor. It also displays appropriate messages according to the design parameters entered.

This version of the program integrates the "Allowable Pole Tip Loads" program and calculates this on the background prior to calculating the allowable wind span.

The program uses the following calculations:

For conductor attached to the pole:

Transverse Deviation Angle Load on the Conductors = 2 x Sin (Deviation Angle x π / (2x180)) x Conductor Tension x 1

Transverse Wind Load on the Conductors = Wind Span x Conductor Diameter x Wind Pressure x 1

For conductors attached to the crossarm:

Transverse Deviation Angle Load on the Conductors = 2 x Sin (Deviation Angle x π / (2 x 180)) x Conductor Tension x (No. of conductors – 1)

Transverse Wind Load on the Conductors = Wind Span x Conductor Diameter x Wind Pressure x (No. of conductors – 1)

Referred to the Pole Tip:

Transverse Deviation Angle Load Referred to the Pole Tip = ((Transverse Deviation Angle Load on the Conductor attached to the Pole x Height from Ground to Conductor attached to the Pole) + (Transverse Deviation Angle Load on the Conductors attached to the Crossarm x Height from Ground to Conductors attached to the Crossarm)) / Pole Height Above Ground

Transverse Wind Load Referred to the Pole Tip = ((Transverse Wind Load on the Conductor attached to the Pole x Height from Ground to Conductor attached to the Pole) + (Transverse Wind Load on the Conductors attached to the Crossarm x Height from Ground to Conductors attached to the Crossarm)) / Pole Height Above Ground

For subsidiary LV conductor:

Transverse Deviation Angle Load on the Conductor = 2 x Sin (Deviation Angle x π / (2 x 180)) x Conductor Tension

Transverse Wind Load on the Conductors = Wind Span x Conductor Diameter x Wind Pressure

Loads referred to pole tip:

Transverse Deviation Angle Load Referred to the Pole Tip = (Transverse Deviation Angle Load on the Conductor x Height from Ground to LV Conductor) / Pole Height Above Ground

Transverse Wind Load Referred to the Pole Tip = (Transverse Wind Load on the Conductor x Height from Ground to LV Conductor) / *h*

Service Load Referred to the Pole Tip = LV Service Load x Height from Ground to LV Conductor) / Pole Height Above Ground

OVERHEAD DESIGN PROGRAMS
ALLOWABLE WIND SPAN PROGRAM

The Total Limit State Load on the Pole is calculated as follows:

Total Load = Transverse Deviation Angle Load (under limit state load conditions) Referred to the Pole Tip (HV) + Transverse Wind Load (under limit state load conditions) Referred to the Pole Tip (HV) + Service Load (under limit state load conditions) Referred to the Pole Tip (LV) + Transverse Deviation Angle Load (under limit state load conditions) Referred to the Pole Tip (LV) + Transverse Wind Load (under limit state load conditions) Referred to the Pole Tip (LV)

The Total Sustained Load on the Pole is calculated as follows:

Total Load = Transverse Deviation Angle Load (under sustained load conditions) Referred to the Pole Tip (HV) + Service Load (under sustained load conditions) Referred to the Pole Tip (LV) + Transverse Deviation Angle Load (under sustained load conditions) Referred to the Pole Tip (LV)

The total loads on the pole, limit state and sustained, should not exceed the net allowable pole tip loads entered, which are the loads calculated from the "Allowable Pole Tip Loads" program.

The transition span of the conductor, depending on the region selected, is taken into account. If the ruling span exceeds the transition span, the tension of the conductor will be limited. This may also limit the allowable wind span. In such instances, the initial conditions when performing the tension change operation are the limit state conditions for the selected region instead of the selected stringing conditions.

The program allows the allowable wind span to be calculated by either selecting conditions from drop down list or by entering all relevant data into the spaces provided. This is contained in two separate sheets, entitled **Select Version**, to select conditions from drop down lists, and **Enter Version**, to enter all relevant data into the spaces provided

To use the program

- Under Allowable Wind Span on the main form choose the **Select** or **Enter** button.

Using Allowable Wind Span Program (Select Version):

- Select a Conductor by clicking the **Select Conductor** button.
- Select the **Number of Phases**.
- Select the **Stringing Tension** from the drop down list. If an unlisted value is required type the **Stringing Tension** in the drop down list.
- Enter the **Ruling Span** in the corresponding text box.
- Enter the **Deviation Angle** in the corresponding text box.
- Select the **Region** in which the construction is situated.
- Select the **Pole Length** from the drop down list.
- Select the **Pole Strength** from the drop down list.
- Select the **Setting Depth** from the drop down list.
- Select the **Soil Type** from the options provided.
- Select the **Backfill Type** from the options provided.
- Select the **Line Voltage** of the conductor.
- Select the **Construction Type** from the drop down list.
- If applicable select the **Crossarm Height** from the drop down list (intermediate delta only).
- Select whether to **Allow for Subsidiary LV ABC**
- If applicable select the **LVABC Conductor Type** from the drop down list.
- If applicable select the **LVABC Stringing Condition** from the drop down list.
- Select whether to **Allow for LV ABC Service**
- Click the **Calculate Wind Span** button to calculate and display the Allowable Wind Span and the limiting conditions.

OVERHEAD DESIGN PROGRAMS
ALLOWABLE WIND SPAN PROGRAM

Using Allowable Wind Span Program (Enter Version):

- Enter the **Pole Details**, consisting of the **Pole Length** and **Setting Depth.**
- Enter the **Net Allowable Pole Tip Loads** for **Limit State** and **Sustained** load conditions.
- Enter the **Operating Conditions**, consisting of **Limit State Wind Pressure on Conductors**.
- Enter up to six sets of **Conductor Details**, including **Limit State Conductor Tension**, **Sustained Conductor Tension**, **RL from Pole Tip**, **Deviation Angle**, **No. of Conductors** at the particular RL and **Conductor Diameter**.
    - Click the **Calculate Wind Span** button to calculate and display the Allowable Wind Span

Assumptions

- For the Intermediate constructions where a pin insulator is used, the depth of the crossarm is 100mm in all instances.
- The transverse load for a service (if applied) is 1.5kN under limit state conditions and 0.15066kN under sustained load conditions.
- The point of attachment for a LV conductor is 2m below the HV crossarm bolt, or in the case of a S.W.E.R. construction, 2m below the pole tip. If there are two LV circuits, the separation between them is 0.3m. These separations are listed in the "Layout Clearances" section of this manual.
- In the Wind Span Program (Enter Version) where the RL from the pole tip is to be entered, it should be noted that in instances where the conductor is below the pole tip a positive number should be entered and in instances where the conductor is above the pole tip, a negative number should be entered.
- The Wind Span Program (Enter Version) does not take the transition span of the conductor into account.

OVERHEAD DESIGN PROGRAMS
MAXIMUM SPAN – GROUND CLEARANCE LIMITATION PROGRAM

Overview

The program is designed to calculate the maximum span for a chosen construction to ensure that the minimum ground clearance limit is not exceeded.

The maximum span for ground clearance is calculated in accordance with C(b)1 Guidelines for Design and Maintenance of Overhead Distribution and Transmission Lines, Appendix E.

The following equations are used to find the maximum span:

$$D = \frac{WL^2}{8T}, \qquad C = \frac{T}{W}, \qquad x_1 = C\tanh^{-1}\left(\frac{h}{S}\right) - \frac{L}{2}$$

$$S = \sqrt{\left(2C\sinh\frac{L}{2C}\right)^2 + h^2}, \qquad y_1 = C\left(\cosh\frac{x_1}{C} - 1\right)$$

Where D = conductor sag (m)
W = weight of conductor (N/m)
L = actual span length (m)
T = tension (N)
C = catenary constant (m)
x_1 = horizontal distance between the lowest conductor support and the point of minimum ground clearance (m)
h = height difference between conductor supports (m)
S = stressed conductor length (m)
y_1 = vertical distance between the lowest conductor support and the point of minimum ground clearance (m)

The conductor transition span, depending on the region selected is always taken into account. If the ruling span exceeds the transition span, the tension of the conductor under the selected conditions will be limited. In such instances, the limitation boundary is for limit state conditions applicable to the selected region instead of the selected stringing conditions.

The program is designed so that a different pole construction can be chosen at each end of the span i.e. different crossarm construction, pole height or setting depth. There is an option given to select the minimum ground clearance from either the standard clearance for the construction or another, which can be entered.

To use the program

- Under Maximum Span on the main form choose the **Select** button.
- Select a Conductor by clicking the **Select Conductor** button.
- Select the **Line Voltage** of the conductor
- Select the **Region** in which the construction is situated from the options available
- Select the **Layout Temperature** from the drop down list.
- Select the **Ground Clearance** from the drop down list.
- Select the **Stringing Tension** from the drop down list.
- Type the **Ruling Span (MES)** in the corresponding space (this should be selected) and press Enter.
- Select whether to **Allow for subsidiary LV ABC** conductor
    - Select the **Conductor Type** for the LV Conductor from the drop down list.
    - Select the **Stringing Condition** of the LV Conductor from the drop down list.

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DISTRIBUTION DESIGN - OVERHEAD
OVERHEAD DESIGN PROGRAMS
MAXIMUM SPAN – GROUND CLEARANCE LIMITATION

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OVERHEAD DESIGN PROGRAMS
MAXIMUM SPAN – GROUND CLEARANCE LIMITATION PROGRAM

For Poles 1 and 2:

- Select the **Pole Length** from the drop down list.
- Select the **Setting Depth** from the drop down list.
- Select the **Construction Type** from the drop down list.
- If **Other** is selected, enter the **Distance from Pole Top to Lowest Conductor.**
- Select the **Crossarm Height** from the pole tip from the drop down list.
- Click the **Calculate** button to calculate and display the maximum span limited by the ground clearance.

<u>Assumptions</u>

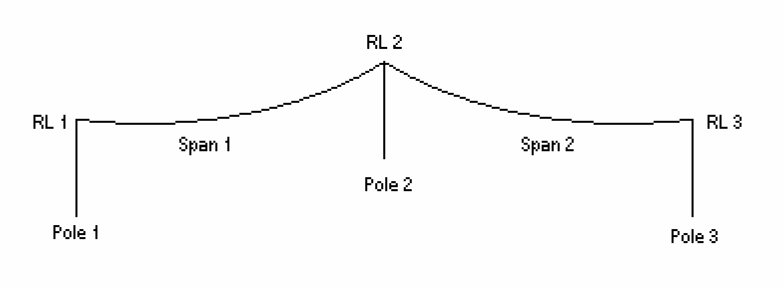
- For the Intermediate crossarms where a pin insulator is used, the depth of the crossarm is 100mm in all instances.
- The foundation is sufficient to support full pole strength utilisation.
- The point of attachment for the LV conductor is 2m below the HV crossarm bolt, or in the case of a S.W.E.R construction, 2m below the pole tip. If there are two LV circuits, the separation between them is 0.3m. These separations are listed in the “Layout Clearances” section of this manual.
- The standard minimum ground clearance for a HV conductor is 6.0m and for a subsidiary LV conductor is 5.8m.
- The layout temperature for HV conductors in urban areas is 75°C and in rural areas is 60°C and for LV conductors is 80°C.

OVERHEAD DESIGN PROGRAMS

ALLOWABLE WEIGHT SPAN PROGRAM

Overview

The program is designed to calculate the weight span of a particular construction, either a terminating span or multiple spans. In the case of multiple spans, the weight span for Pole 2 is calculated given the details of the spans on either side, as shown below.



The weight span for Pole 2 is calculated using the following equations:

Straight Line RL at P3 = RL1+(RL3 – RL1)*(Span 1/(Span 1+Span 2))
Distance Below Top of P2 = RL2 – Straight Line RL at P3
Catenary Constant = Tension (N) / Weight (N/m)
Pole 2 Wind Span = (Span 1 + Span 2) / 2
Sag (Span 1) = $(\text{Span } 1)^2$ / (8 x Catenary Constant)
Sag (Span 2) = $(\text{Span } 2)^2$ / (8 x Catenary Constant)

Pole 2 Weight Span = (1 + (2 x Distance Below Top of P2 x Catenary Constant) / (Span 1 x Span 2)) x Pole 2 Wind Span)

The program allows the weight span to be calculated either by selecting conditions from drop down lists or by entering all relevant data. This is contained in two separate programs. Either the **Select Version** or the **Enter Version** can be opened by pressing the appropriate button on the main menu.

The Multiple Span Select part of the program is designed so that a different pole construction can be selected for each pole ie. different RL at each pole base, pole length, setting depth and construction type. The **Multiple Span Enter** program is designed so that selections of pole construction need not be made. The Conductor RL for each pole is entered instead.

For both the Multiple Span Enter and Multiple Span Select versions, the weight span under the Limit State, Sustained and Maintenance load conditions is calculated as is the weight of the conductor at Pole 2 under each load condition.

In accordance with C(b)1 Guidelines for Design and Maintenance of Overhead Distribution and Transmission Lines, Appendix E the following equations are used to calculate the weight span for a terminating span using catenary model:

Catenary Constant = Tension (N) / Weight (N/m)
h = height difference between conductor RL
x_2 = Catenary Constant x SinH^{-1} (h / (2 x Catenary Constant x SinH (Span Length / 2 x Catenary Constant))) + Span Length / 2

The program allows the weight span for a terminating span to be calculated either by selecting conditions from drop down lists or entering all relevant data into spaces provided. This is contained in separate programs, entitled **Terminating Span Select**, to select conditions from drop down lists, and **Terminating Span Enter**, to enter all relevant data into spaces provided.

Like the **Multiple Span Select** and **Multiple Span Enter** versions, the **Terminating Span Select** program is designed so that a different pole construction can be selected for each pole i.e. different RL at each pole base, pole length, setting depth and construction type. The **Terminating Span Enter** program is designed so that selection of pole construction need not be made. The Conductor RL for each pole is entered instead.

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DISTRIBUTION DESIGN - OVERHEAD
OVERHEAD DESIGN PROGRAMS
WEIGHT SPAN

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OVERHEAD DESIGN PROGRAMS
ALLOWABLE WEIGHT SPAN PROGRAM

For both the Terminating Span Enter and Terminating Span Select sheets, the weight span under the Limit State, Sustained and Maintenance load conditions is calculated as is the weight of the conductor at the terminating pole under each load condition.

The conductor transition span, depending on the region selected is always taken into account. If the ruling span exceeds the transition span, the tension of the conductor under the selected conditions will be limited. In such instances, the limitation boundary is for limit state conditions applicable for the selected region instead of the selected stringing conditions. This will limit the weight span and the conductor weight at the point specified.

<u>To use the program</u>

- Under Allowable Weight Span on the main form choose the **Select** or **Enter** button.

Using Weight Span: Multiple Span Program (Select Version):

- Select a Conductor by clicking the **Select Conductor** button.
- Select the **Stringing Condition** from the drop down list.
- Select the **Region** from the options available.
- Select the **Line Voltage** of the conductor
- Enter the **Ruling Span (MES)** in the corresponding textbox
- Type the **Span 1** in the corresponding textbox
- Type the **Span 2** in the corresponding textbox

For Poles 1, 2 and 3:

- Enter the **RL at Pole Base** in the corresponding textbox
- Select the **Pole Length** from the drop down list.
- Select the **Setting Depth** from the drop down list.
- Select the **Construction Type** from the drop down list.
- Click the **Calculate** button to calculate and display the Weight Span for Pole 2 under limit state, sustained and maintenance load conditions and the conductor weight at the insulator.

Using Weight Span: Multiple Span Program (Enter Version):

- Manually input the **Conductor Data**, consisting of **Overall Diameter**, **Total Sectional Area**, **Calculated Breaking Load**, **Unit Mass**, **Final Modulus of Elasticity** and **Coefficient of Linear Expansion** in the text boxes provided.
- Alternatively select a Conductor by clicking the **Select Conductor** button.
- Select either **Ergon Standard** conductors or **Ergon ALL** conductors
- Select **Conductor Type** from the drop down list – only valid for Ergon ALL conductors.
- Select the **Conductor Description** from the drop down list.
- Enter the **Operating Conditions**, consisting of **Initial Tension**, **Initial Pressure**, **Initial Temperature**, **Final Pressure**, and **Final Temperature**.
- Enter the **Span Details**, consisting of **Span 1, Span 2** and **Ruling Span (MES)**.
- Enter the **Stringing Condition**, consisting of the
- Enter the **Conductor RL at Pole 1**.
- Enter the **Conductor RL at Pole 2**.
- Enter the **Conductor RL at Pole 3**.
- Click the **Calculate** button to calculate and display the Weight Span for Pole 2 under the limit state, sustained and maintenance load conditions and the conductor weight at the insulator.

Using Weight Span: Terminating Span Program (Select Version):

- Select a Conductor by clicking the **Select Conductor** button.
- Select the **Stringing Condition** from the drop down list.
- Select the **Region** from the options available.
- Select the **Line Voltage** of the conductor
- Enter the **Ruling Span (MES)** in the corresponding textbox
- Enter the **Actual Span** in the corresponding textbox

OVERHEAD DESIGN PROGRAMS
WEIGHT SPAN PROGRAM

For the Non-terminating and Terminating Pole:

- Enter the **RL at Pole Base** in the corresponding textbox
- Select the **Pole Length** from the drop down list.
- Select the **Setting Depth** from the drop down list.
- Select the **Construction Type** from the drop down list.
- Click the **Calculate** button to calculate and display the Weight Span for the Terminating Pole under the limit state, sustained and maintenance load conditions and the conductor weight at the insulator.

Using Weight Span: Terminating Span Program (Enter Version):

- Manually input the **Conductor Data**, consisting of **Overall Diameter**, **Total Sectional Area**, **Calculated Breaking Load**, **Unit Mass**, **Final Modulus of Elasticity** and **Coefficient of Linear Expansion** in the text boxes provided.
- Alternatively select a Conductor by clicking the **Select Conductor** button.
- Enter the **Non-terminating Pole Conductor RL**.
- Enter the **Terminating Pole Conductor RL**.
- Enter the **Operating Conditions**, consisting of **Initial Tension**, **Initial Pressure**, **Initial Temperature**, **Final Pressure**, and **Final Temperature**.
- Enter the **Span Details**, consisting of the **Actual Span and Ruling Span (MES)**.
- Click the **Calculate** button to calculate and display the Weight Span for the Terminating Pole under the limit state, sustained and maintenance load conditions and the conductor weight at the crossarm**.**

Assumptions

- For the Intermediate constructions where a pin insulator is used, the depth of the crossarm is 100mm in all instances.
- The enter sheets do not take the transition span of the conductor into account.
- The weight span and weight is calculated for the highest conductor on the pole.

OVERHEAD DESIGN PROGRAMS
RULING SPAN (MES) PROGRAM

Overview

This program is designed to calculate the mean equivalent span (**MES**), or ruling span, and the running span for a number of entered span lengths.

The mean equivalent span is calculated in accordance with C(b)1 Guidelines for Design and Maintenance of Overhead Distribution and Transmission Lines, Appendix E.

Equation (3) states that the ruling span is calculated using:

$$L_r = \sqrt{\frac{\sum_{i=1}^{n} L_i^3}{\sum_{i=1}^{n} L_i}}$$

Where

- L_r = is the mean equivalent span
- L_i = is the horizontal span length of span I
- n = is the number of spans between strain structures.

This program allows up to 90 individual span lengths to be entered in the spaces provided to calculate the mean equivalent span and running span.

To use the program

- Enter the relevant **Span Lengths** in the boxes provided.
- Click the **Calculate** button to calculate and display the Mean Equivalent Span and the Running Span for the Span Lengths entered.

Assumptions

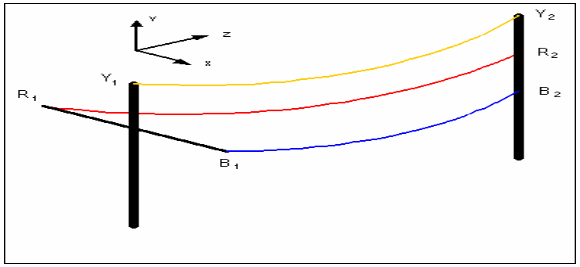
- Equation (3) applies for lines in flat to undulating terrain. In very mountainous terrain with large differences in elevation between structures, use of Equation (4) in appendix E of C(b)1 Guidelines for Design and Maintenance of Overhead Distribution and Transmission Lines may be required.

OVERHEAD DESIGN PROGRAMS

PHASE SEPARATION PROGRAM

Overview

The program is designed to check the risk of conductors clashing in constructions such as shown below:



The colour, Red, Yellow and Blue as shown above represent each conductor and the program shows a graphical representation of the conductor configuration.

The program takes the inputted data and performs the following calculations in order to find whether the construction is suitable using the following equations:

$$L_{ACT} = \sqrt{(Y_2 - Y_1)^2 + (X_2 - X_1)^2 + (Z_2 - Z_1)^2}$$

$$CosX = \frac{Y_2 - Y_1}{L_{ACT}}$$

$$CosY = \frac{X_2 - X_1}{L_{ACT}}$$

$$CosZ = \frac{Z_2 - Z_1}{L_{ACT}}$$

Where L_{ACT} = actual conductor length (m)
X_1 and X_2 = x-coordinates for structures 1 and 2
Y_1 and Y_2 = y-coordinates for structures 1 and 2

(These calculations are performed for each conductor individually.)

$$Cos\tau = CosX_1 \times CosX_2 + CosY_1 \times CosY_2 + CosZ_1 \times CosZ_2$$

$$\tau(rad) = ACos(Cos\tau)$$

$$\tau(°) = \tau(rad) \times \frac{180}{\pi}$$

$$Sin\tau = Sin\tau(rad)$$

Where $CosX_1$ and $CosX_2$ = value for $CosX$ for conductors 1 and 2
$CosY_1$ and $CosY_2$ = value for $CosY$ for conductors 1 and 2
$CosZ_1$ and $CosZ_2$ = value for $CosZ$ for conductors 1 and 2

(These calculations are performed for each conductor in combination with each other conductor, ie. Red-Yellow, Yellow-Blue and Blue-Red.)

With the use of matrices with the following configuration:

$$\begin{matrix} Y_2 - Y_1 & X_2 - X_1 & Z_2 - Z_1 \\ CosX_1 & CosY_1 & CosZ_1 \\ CosX_2 & CosY_2 & CosZ_2 \end{matrix}$$

It is known whether the conductors are co-planar if the determinant of the matrix is equal to zero.

(These calculations are performed for each conductor in combination with each other conductor, ie. Red-Yellow, Yellow-Blue and Blue-Red.)

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OVERHEAD DESIGN PROGRAMS
PHASE SEPARATION

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OVERHEAD DESIGN PROGRAMS
PHASE SEPARATION PROGRAM

The following equations are used in order to find the vertical and horizontal separations at mid span:

$$T = \frac{L_{ACT}}{2}$$

(These calculations are performed for each conductor individually.)

$$\Delta x = |x_1 - x_2|$$
$$\Delta y = |y_1 - y_2|$$
$$\Delta z = |z_1 - z_2|$$

(These calculations are performed for each conductor in combination with each other conductor, ie. Red-Yellow, Yellow-Blue and Blue-Red.)

Transverse Mid Span Separation $= \Delta y$
Vertical Mid Span Separation $= \Delta x$
Z at Mid Span $= z_1$

The Extra Clearance between the conductors is calculated in accordance with C(b)1 Guidelines for Design and Maintenance of Overhead Distribution and Transmission Lines, Clause 9.3.

$$\%Extra = \frac{\sqrt{\Delta y^2 + (1.2 \times \Delta x)^2}}{\frac{Voltage}{150} + 0.4 \times \sqrt{Sag + SuspensionInsulatorLength}} \times 100$$

(These calculations are performed for each conductor in combination with each other conductor, ie. Red-Yellow, Yellow-Blue and Blue-Red.)

For the construction to be suitable, the Extra Clearance as a percentage needs to be greater than 100%.

Also, if the value of $Cos\,\tau$ is equal to zero for two conductors then those conductors are normal to each other and if the values for *CosX*, *CosY* and *CosZ* are equal for two conductors then those conductors are parallel to each other. The angle between the conductors is equal to τ *(°)*.

If the situation is suitable, then a table containing the Transverse Mid Span Sparation, the Vertical Mid Span Separation, the Longitudinal Distance at Mid Span, the Extra Clearance and the Angle Between the Conductors will be displayed, as will indications as to whether the conductors are Co-planar, Normal and Parallel to each other.

If the situation is unsuitable, this will be displayed.

<u>To use the program</u>

- Select a Conductor by clicking the **Select Conductor** button.
- Select a **Stringing Tension** from the drop down list
- Enter the **Actual Span Length** in the corresponding textbox
- Enter the **Ruling Span** in the corresponding textbox
- Enter the **Conductor Voltage** in the corresponding textbox.
- Enter the **Suspension Insulator Length** in the corresponding textbox
- Enter the **Vertical Sag at 50°C** in the corresponding textbox.
- Alternatively, click **Calculate Vertical Sag** to allow the program to automatically propagate this value
- Select **Standard Construction** or **3 Conductor**. This will allow the choice of Ergon standard construction or a special construction.
- If **3 Conductor** is selected type the **X- and Y-Coordinates** for all conductors of Structures 1 and 2 in the corresponding spaces and press Enter. For information about positioning conductors on the crossarm, refer to the drawing below.
- Click the **Calculate** button to calculate and display the outcome.

OVERHEAD DESIGN PROGRAMS
CONDUCTOR SAGGING PROGRAM

Overview

The program is designed to calculate the vertical sag of a nominated conductor under specified conditions for a number of different temperatures ranging from 5°C to 40°C in 5° increments and also 50°C, 60°C, 75°C and 80°C and up to four actual span lengths. The tension under which this sag is calculated is also displayed.

The sag is calculated from the following equation:

$$S_V = \frac{W \times L^2}{8 \times T}$$

Where S_V = vertical sag at mid span (m)
W = weight of conductor (N/m)
L = actual span length (m)
T = final tension (N).

The tension under the operating conditions is calculated by solving the equation below for T_o:

$$\left(\frac{c_1 wl}{T}\right)^2 - T = \left(\frac{c_1 w_o l}{T_o}\right)^2 - T_o + c_2 t$$

Where $c_1 = \sqrt{\frac{EA}{24}}$ and $c_2 = \alpha EA$

l = ruling span (MES) (m)
T = tension under the initial conditions (N)
w = weight of conductor under initial conditions (N/m)
T_o = tension under the operating conditions (N)
w_o = weight of conductor under operating conditions (N/m)
t = temperature under initial conditions less the temperature under the operating conditions (°C)
E = final modulus of elasticity (Pa)
A = total sectional area of the conductor (m²)
a = co-efficient of linear expansion (/°C)

The conductor transition span, depending on the region selected is always taken into account. If the ruling span exceeds the transition span, the tension of the conductor under the selected conditions will be limited. In such instances, the limitation boundary is for limit state conditions applicable for the selected region instead of the selected stringing conditions.

The program has an allowance for temperature correction to allow for inelastic stretch, which applies to specific types of conductors. The Conductor Sag Enter Version requires this value to be entered; while the Conductor Sag Select Version requires the user to select whether or not temperature correction is to be allowed and it assigns the value based on the conductor type and stringing condition.

The program allows the conductor sag to be calculated either by selecting conditions from drop down lists or by entering all relevant data. This is contained in two separate programs. Either the **Select Version** or the **Enter Version** can be opened by pressing the appropriate button on the main menu.

OVERHEAD DESIGN PROGRAMS
CONDUCTOR SAGGING PROGRAM

<u>To use the program</u>

- Under Conductor Sagging on the main form choose the **Select** or **Enter** button.

Using Conductor Sagging Program (Select Version):

- Select a Conductor by clicking the **Select Conductor** button.
- Select the **Stringing Tension** from the drop down list. If an unlisted value is required type the **Stringing Tension** in the drop down list.
- Enter the **Ruling Span (MES)**, **Actual Span 1**, **Actual Span 2**, **Actual Span 3** and **Actual Span 4** in the corresponding text boxes.
- Select whether to allow for **Temperature Correction**.
- Select the **Region** in which the construction is situated.
- Click the **Calculate** button to calculate and display the Sag and Tension for the nominated conditions.

Using Conductor Sagging Program (Enter Version):

- Manually input the **Conductor Data**, consisting of **Overall Diameter**, **Total Sectional Area**, **Calculated Breaking Load**, **Unit Mass**, **Final Modulus of Elasticity** and **Coefficient of Linear Expansion** in the text boxes provided.
- Alternatively select a Conductor by clicking the **Select Conductor** button.
- Enter the **Span Details**, consisting of **Ruling Span (MES)**, **Actual Span 1**, **Actual Span 2**, **Actual Span 3** and **Actual Span 4**.
- Input the **Stringing Conditions**, consisting of the **Stringing Tension**, the **Wind Pressure** at 15°C and the **Conductor Type (LVABC or Bare Conductors)**.
- Input the **Temperature Correction to allow for inelastic stretch**.
- Click the **Calculate** button to calculate and display the Sag and Tension for the nominated conditions.

<u>Assumptions</u>

- The limit state conductor strength of bare conductors and LVABC used for the transition span check are 72% and 40% respectively as listed in the “Conductor Design” section of this manual.
- The temperature corrections to allow for inelastic stretch are as follows:

SC conductors:	0°C
AAC conductors:	10°C @ 20%EDT
	5°C @ 10%EDT
AAAC conductors:	15°C
ACSR conductors:	10°C
Copper conductors:	5°C
LV ABC conductors:	0°C

OVERHEAD DESIGN PROGRAMS
RESULTANT STAY LOAD PROGRAM

Overview

The program is designed to calculate the resultant horizontal load carried by a stay, the direction of the stay, the pole strength utilisation for up to ten loads on a specified pole and recommends the suitable stay type.

The program requires the input of relevent data and performs the following calculation, as described in the "Stays" section of this manual, to find the resultant load, direction and pole strength utilisation:

$$P = L \times \left(1 + \frac{3 \times b}{2 \times a}\right)$$

Where P = horizontal stay load
L = termination or deviation load
b = distance between L and P
a = distance between P and the ground

(Each load is treated individually to find a required horizontal stay load.)

These individual loads are added vectorially to give a resultant load. The wind pressure on the pole at the stay attachment height is also taken into account having the same direction as the resultant load for worst case condition. The equation is given below.

$$P_R = \sqrt{(\Sigma P \sin\alpha)^2 + (\Sigma P \cos\alpha)^2} + W$$

Where P_R = resultant horizontal load
P = individual horizontal stay loads
α = direction of load relative to 0°
W = wind pressure on the pole at the stay height

The direction of this load is calculated as follows:

$$\theta = Arc\tan\frac{\Sigma P \sin\alpha}{\Sigma P \cos\alpha}$$

with reference to the applicable quadrant that the loads are applied in. The direction of the ideal stay load is opposite to this, ie. θ + 180°.

The pole is checked in bending under limit state and long duration conditions using the following calculation, as described in the "Stays" section of this manual:

$$\sigma Z \geq \Sigma Lx + W_M$$

Where σ = maximum allowable bending stress in pole
Z = modulus of pole at stay attachment point
= $\pi D^3/32$
D = pole diameter at stay attachment point
L = horizontal load applied to pole
χ = distance from load centre to stay attachment
W_M = wind moment on pole
= Area of pole above stay attachment point x design wind pressure x $\chi/2$

The pole strength utilisation is found as a percentage as follows:

%Utilisation = Bending due to loads above the stay / Allowable Bending in the pole at the stay x 100 (under Limit State and Sustained load conditions)

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APPROVED	J. Brooks
DATE	26.06.01
PASSED	C. Noel
DRAWN	M. St John

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OVERHEAD DESIGN PROGRAMS
RESULTANT STAY LOAD

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OVERHEAD DESIGN PROGRAMS
RESULTANT STAY LOAD PROGRAM

To use the program

- Select the **Pole Length** from the drop down list.
- Select the **Pole Strength** from the drop down list.
- Select the **Pole Setting Depth** from the drop down list.
- Select the **Region** from the option list.
- Select **Unstabilised** or **Stabilised Backfill** from the options provided
- Select whether the pole is a **New Pole** or a pole already **In Service**
- If the pole already **In Service** then enter the **Calculated Pole Working Strength** and select either **No Change In Tip Load** or **Change In Tip Load**.
- Select the **Soil Type** from the options provided
- Select **Good to Medium Soil** or **Other Soils** from the options available.
- Select **Stay Type** from the drop down list.
- Select the **Stay Angle** from the options available. This option is only available for ground stay types.
- Enter the **stay position from pole tip.**
- Add **Limit State** and **Sustained** conductor loads using the **Tension Calculator**.
- Open the **Tension Calculator, Select a Conductor,** enter the **Initial Tension** of the conductor, enter a **Ruling Span,** select a **Wind Region** and enter the **Number of Conductors.**
- Click **Calculate** conductor load to display conductor tensions. Finally **Add Load** to the unstayed pole loads. Loads are entered in the first empty row.
- Enter the **Load Angle** and **Distance From Pole Tip** in the text boxes provided. Alternately, enter the details of each **Horizontal Load** for both **Limit State** and **Sustained** conditions including its angle and position relative to the top of the pole – **positive** for loads below the pole and **negative** for loads above the pole.
- Click **Display Load Info** to check all conductor loads are correct.
- Click **Calculate** to calculate the resultant stay load.

The Resultant Horizontal Stay Load, the Ideal Stay Direction and the Pole Strength Utilisation at Point of the Stay Attachment under Sustained and Limit State Load Conditions will be displayed. Check that the pole strength utilisation for the input condition (either sustained or limit state) is less than 100%.

If an available stay that can handle the calculated horizontal loads, the program will recommend the type of stay required.

Assumptions

- Where the RL from the pole top for the applied load is to be entered, it should be noted that in instances where the conductor is below the pole top a positive figure should be entered and in instances where the conductor is above the pole top a negative figure should be entered.
- The calculation of the resultant load, P_R, assumes that the bending moment occurring at a point one-third the height of the stay attachment above ground level is zero.
- The poles are of strength group S2 as the values for the pole tip diameter and the diameter 2m from the butt of the pole are that for poles of strength group S2.
- The Design Stress in bending is that for poles of strength group S2, as listed in the “Poles” section of this manual.
- The wind pressure on the pole is assumed to be in the same direction as the resultant conductor loads.

OVERHEAD DESIGN PROGRAMS
UNSTAYED POLE PROGRAM

Overview

The program is designed to calculate the load on the pole due to conductor tension and pole wind loading. The program has two parts. First it will calculate the net allowable pole tip load and secondly the resultant pole tip load. Compares the two values and decides whether the design meets C(b)1 Guidelines for Design and Maintenance of Overhead Distribution and Transmission Lines.

The program integrates the Net Allowable Pole Tip Loads program. It calculates the lower of the allowable tip loads determined by either the pole strength or the foundation strength after allowance for wind on the pole element. The limiting factor, either the pole or foundation strength, is displayed with the allowable pole tip load.

The allowable foundation loads are calculated based on C(b)1 Guidelines for Design and Maintenance of Overhead Distribution and Transmission Lines, Appendix C.

The allowable pole strengths are dependant on if the pole is new or existing:

- For a **new pole** the allowable pole strengths are based on the ultimate pole strength factored by 0.72 for Limit State and 0.2 for sustained loads.
- For an **existing pole with no change in tip load** the allowable pole strengths are based on the ultimate pole strength factored by 0.72 for Limit State and 0.2 for sustained loads.
- For an **existing pole with a change in tip load** the allowable pole strengths are based on the ultimate pole strength factored by 0.72 for Limit State and 0.2 for sustained loads

The relevant diameters are based on pole strength group S2. Knowing these diameters allow calculation for wind loading and foundation loads as provided by the following equations:

For Wind on Pole

Diameter at ground = $(D_B - D_T) / (H - 2) \times (2 - J) + D_B$

Pole Centroid = $((2 \times D_T + D_G) / (D_T + D_G) \times h) / 3$

Pole Taper = $(D_2 - D_T) / (H - 2)$

Area = $((D_T + D_G) \times h) / 2$

Wind on Pole (kN) = (Area x Wind Pressure) /1000

Wind on Pole refer to pole tip (kN) = (Wind on Pole x Pole Centroid) / h

For Foundation Loads

Average below ground Diameter = D_T + Pole Taper x (h + J/2)

Maximum Tip Load to avoid over turning

$$P_o \text{ (Limit State)} = (K \times 1.8 \times D \times J^3) / (12 \times (h + \tfrac{3}{4}J))$$

Maximum Tip Load to avoid overturning

$$P_o \text{ (Sustained)} = (K \times 0.5 \times D \times J^3) / (12 \times (h + \tfrac{3}{4}J))$$

Where
D_T = pole tip diameter (m)
D_G = diameter at ground level (m)
D_B = diameter 2m from butt (m)
D = average below ground diameter (m)
J = setting depth (m)
H = pole length (m)
h = pole height above ground (m)
K = passive soil reaction per unit depth (kPa/m)
P_o = maximum tip load to avoid overturning (kN)

OVERHEAD DESIGN PROGRAMS
UNSTAYED POLE PROGRAM

The limit state and sustained horizontal conductor loads entered are broken down into vector components. Each components are summed to give the total resultant horizontal loading referred to the pole tip. The formula below gives the equivalent horizontal pole tip load:

$$Load_{@\ poletip} = \frac{Load_{applied}\, xL_{point}}{H}$$

Where

- $Load_{applied}$ = limit state or sustained load entered
- L_{point} = distance from pole tip to application point
- H = pole height above ground

The formula given below vectorially adds each horizontal load to give the equivalent resultant load:

$$P_R = \sqrt{(\Sigma P \sin\alpha)^2 + (\Sigma P \cos\alpha)^2} + W$$

Where

- P_R = resultant horizontal load
- P = individual horizontal stay loads
- α = direction of load relative to 0°
- W = wind pressure on the pole at the stay height

The direction of this load is calculated using the formula below with respect to the applicable quadrant that the loads are applied in:

$$\theta = Arc \tan \frac{\Sigma P \sin\alpha}{\Sigma P \cos\alpha}$$

A sheet number is provided in each sheet for labelling purposes.

<u>**To use the program**</u>

- Select the **Pole Height** from the drop down list.
- Select the **Pole Strength** from the drop down list. (The pole strength is only used in the calculation of wind loads)
- Select the **Setting Depth** from the drop down list.
- Select the **Region** in which the pole is situated, either Regions A & B or Region C.
- Select **Unstabilised** or **Stabilised Backfill** from the options provided
- Select whether the pole is a **New Pole** or a pole already **In Service**
- If the pole already **In Service** then enter the **Calculated Pole Working Strength** and select either **No Change In Tip Load** or **Change In Tip Load**.
- Select the **Soil Type** from the options provided
- Add **Limit State** and **Sustained** conductor loads using the **Tension Calculator**.
- Open the **Tension Calculator, Select a Conductor,** enter the **Initial Tension** of the conductor, enter a **Ruling Span,** select a **Wind Region** and enter the **Number of Conductors.**
- Click **Calculate** conductor load to display conductor tensions. Finally **Add Load** to the unstayed pole loads. Loads are entered in the first empty row.
- Enter the **Load Angle** and **Distance From Pole Tip** in the text boxes provided.
- Alternatively, enter the details of each **Horizontal Load** for both **Limit State** and **Sustained** conditions including its angle and position relative to the top of the pole – **positive** for loads below the pole and **negative** for loads above the pole.
- Click the **Calculate Unstayed Pole Load** button to calculate, display the Allowable Pole Tip Load under limit state or sustained load conditions, the resultant horizontal load and direction of pole. A message will be displayed beside the calculated results stating if the design conditions according to the standards have been satisfied or not.
- Click **Display Load Info** to check all conductor loads are correct.

- To export the current scenario to the **Resultant Stay Load** Program. Click the **Export to Result. Stay Load** button.
- Alternatively, click the **Clear Loads** button to clear all the loads.

Assumptions

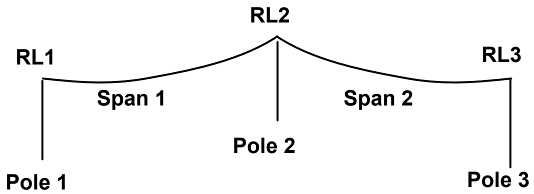
- The poles are of strength group S2 as the values for the pole tip diameter and the diameter 2m from the butt of the pole are that for poles of strength group S2. The allowable foundation loads for group S1 poles will be marginally less and the allowable foundation loads for group S3 poles will be marginally more.
- When the option of stabilised backfill is chosen, the average below ground diameter is increase by 0.1m to account for the stabilised backfill.
- As defined in Table C.1 of C(b)-1, “Good" soil is well compacted rock soil, hard clay and well bonded sand and gravel with good surface water drainage with a passive soil reaction per unit depth of 600kPa/m; "Medium" soil is compact medium clay, well bonded sandy loam, bonded sand and gravel with reasonable surface water drainage with a passive soil reaction per unit depth of 300kPa/m; "Poor" soil is soft clay, poorly compacted sand and soil that tend to absorb large amounts of water (excluding slush) with a passive soil reaction per unit depth of 150kPa/m.
- The Design Stress in bending is that for poles of strength group S2, as listed in the “Poles” section of this manual.

OVERHEAD DESIGN PROGRAMS
DEVIATION ANGLES PROGRAM

<u>Overview</u>

This program is designed to calculate the range of deviation angles allowable for **flying angle constructions**. The range is calculated under 100Pa and 500Pa wind conditions with the wind load being in both the same direction and opposite directions to the deviation angle load.

Assuming that the construction is similar to the following,



The following calculations are made and the equations are solved to find the range of allowable deviation angles based on the maximum allowable angle of swing for the given condition:

Straight Line RL at P3 = RL1 + (RL3 – RL1) x (L_1 / (L_1+L_2))
Distance Below Top of P2 = RL2 – Straight Line RL at P3
$C = T / W_C$
L_{Wind} (Pole 2) = (L_1 + L_2) / 2
L_{Weight} (Pole 2) = (1 + (2 x Distance Below Top of P2 x C) / (L_1 x L_2)) x L_{Wind} (Pole 2)

Transverse Deviation Angle Load on the Conductors = 2 x Sin ($\theta\pi/360$) x T
Transverse Wind Load on the Conductors = L_{Wind} x d x P
Weight due to Conductor and Insulator = L_{Weight} x W_C + 0.5 x W_I

θ = Arctan ((Transverse Wind Load on the Conductors ± Transverse Deviation Angle Load on the Conductors) / Weight due to Conductor and Insulator) x $180/\pi$
(The ± denotes that for the wind load and deviation angle load in the same direction + is used and for the wind load and deviation angle load in opposite directions – is used.)

where

L_1	= is the length of span 1 (m)
L_2	= is the length of span 2 (m)
C	= catenary constant (m)
T	= conductor tension (N)
W_C	= conductor weight (N/m)
L_{Wind}	= wind span (m)
L_{Weight}	= weight span (m)
θ	= deviation angle (°)
d	= conductor diameter (m)
P	= wind pressure (Pa)
W_I	= insulator weight (N)
ϕ	= swing angle (°)

The conductor transition span, depending on the operating conditions selected is always taken into account. If the ruling span exceeds the transition span, the tension of the conductor under the selected conditions will be limited. However, since this program calculates the range of allowable deviation loads under 100Pa and 500Pa wind conditions, the ruling span will not generally exceed the transition span. In such instances that it does, the initial conditions when performing the tension change operation are the allowable limit state conditions applicable instead of the selected stringing condition.

This program allows the range of allowable deviation angles to be calculated either by selecting conditions from drop down lists or entering all relevant data into the spaces provided. This is contained in two separate programs. Either the **Select Version** or the **Enter Version** can be opened by pressing the appropriate button on the main menu.

OVERHEAD DESIGN PROGRAMS
DEVIATION ANGLES PROGRAM

To use the program

- Under Deviation Angles on the main form choose the **Select** or **Enter** button.

Using Allowable Deviation Angles Program (Select Version):

- Select a Conductor by clicking the **Select Conductor** button.
- Select the **Line Voltage** of the conductor.
- Select the type of **Insulators** used from the drop down list.
- Select the **Stringing Condition** from the drop down list. If an unlisted value is required type the **Stringing Tension** in the drop down list.
- Enter the **Ruling Span (MES)** in the corresponding textbox.
- Enter the **Span 1** in the corresponding textbox.
- Enter the **Span 2** in the corresponding textbox.
- Enter the **Conductor RL for Pole 1** in the corresponding textbox.
- Enter the **Conductor RL for Pole 2** in the corresponding textbox.
- Enter the **Conductor RL for Pole 3** in the corresponding textbox.
- Click the **Calculate** button to calculate and display the range of allowable deviation angles and the governing wind conditions.

Using Allowable Deviation Angles Program (Enter Version):

- Manually input the **Conductor Data**, consisting of **Overall Diameter**, **Total Cross-sectional Area**, **Calculated Breaking Load**, **Unit Mass**, **Final Modulus of Elasticity** and **Coefficient of Linear Expansion** in the text boxes provided.
- Alternatively select a Conductor by clicking the **Select Conductor** button.
- Input the **Construction Details**, consisting of the **Voltage**, **Stringing Tension**, **Insulator Type** and **Insulator Weight**.
- Input the **Span Details**, consisting of the **Ruling Span (MES)**, **Wind Span** and **Weight Span** at 500Pa Wind Pressure and at 100Pa Wind Pressure.
- Click the **Calculate** button to calculate and display the range of allowable deviation angles and the governing wind conditions.

Assumptions

- The maximum allowable deviation angle for both 100Pa and 500Pa wind conditions is limited to 45°.
- The minimum allowable deviation angle for both 100Pa and 500Pa wind conditions is limited to 3°.
- The range of allowable deviation angles is the larger of the allowable deviation angles with the wind load and the deviation load in opposite directions under 100Pa and 500Pa wind conditions and the lesser of the allowable deviation angles with the wind load and the deviation load in the same direction under 100Pa and 500Pa wind conditions. The governing wind conditions relating the maximum and minimum of the range are displayed.
- The Weight Spans which need to be entered on the Deviation Angles Enter sheet can be calculated using the “Weight Span” program.
- Where a negative weight span is calculated or entered in the Deviation Angles sheets, the construction is deemed unsuitable for a flying angle construction as the allowable swing angles will be exceeded.
- The Deviation Angles Enter sheet does not take the transition span of the conductor into account.