



Extending Our Lines to Your Desktop

User's Manual | Version 4.0.7



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Welcome to SAG10® Software

What is SAG10 Software?

Who Can Use SAG10 Software?

SAG10 Highlights

Installation Technical Support

1 Welcome to SAG10® Software

1.1 What is SAG10 Software?

Southwire's SAG10 software is a PC-based program that automates execution of the Alcoa Graphic Method of sag-tension calculations for overhead conductors. The Alcoa Graphic Method has been the standard for sag and tension calculations for almost 90 years. SAG10® is a registered trademark of Southwire Company in the United States.

1.2 Who Can Use SAG10 Software?

Southwire intends the SAG10 program to be used by qualified engineers and designers who have a foundation of knowledge about overhead power transmission and distribution lines, and the performance of conductors used in those lines. When using the SAG10 program, a qualified engineer should review the parameters input for the calculations, and the resulting calculated data, and verify that they are correct for the specific application.

1.3 SAG10 Highlights

1.3.1 SAG10 Features

SAG10 calculation features include:

- Alcoa Graphic Method for Sag and Tension Calculations for ACSR and Other Conductors
- Sag and tension with creep
- Elevated temperature creep
- Inclined span calculation
- Stringing sag calculation
- Graphic output of galloping ellipses and sag curves
- Offset clipping calculation
- Clash module for calculating clearance between conductors and ADSS conductor
- Galloping calculations
- Ruling span variation calculations

Other SAG10 features include:

- Easy-to-use menu-driven interface
- Create, save, and open project files
- Automatic creep check
- Easily create, save, and edit Custom conductors
- Add attachments and supported loads to conductors

Data furnished includes:

- Stress-strain coefficients
- Standard load tables
- Conductor database including:
 - AAC
 - AAC/TW
 - AAAC
 - ACAR
 - Hard Drawn Copper
 - ACSR
 - ACSR/AW
 - ACSR/TW
 - ACSR/TW/AW
 - ACSR/SD
 - ACSS
 - ACSS/AW
 - ACSS/TW
 - ACSS/TW/AW
 - ZTACCR/TW/C7
 - ACCS/TW/C7
 - ACCR
 - ACCR/TW
 - Covered Line Wire
 - Multiplex
 - Alumoweld
 - OPGW
 - Copperweld
 - Copperweld-Copper
 - Steel
 - AAC British
 - AAAC British
 - ACSR British

1.3.2 What's New in SAG10® Version 4.0?

- Full Compatibility with the Windows® XP and higher operating systems. **Windows® is a registered trademark of Microsoft Corporation in the United States and other countries.*
- Updated conductor data
- Automated stress-strain chart selection using logic algorithms
- Updated U.S./Metric units and conversions
- Calculation optimization - Rounding only for displayed values, unit conversions made only for display)
- °C/°F unit selection in Edit Loading Table screen
- °C and °F units in sag-tension reports
- Automated software and data updates
- Flexible licensing options
- Easily export Power Line Systems, Inc. (PLS-CADD™) files. *PLS-CADD™ is a registered trademark of Power Line Systems, Inc. in the United States.*
- Conductor Types in drop-down format and better grouped for easy selection
- Added loading limits table in reports
- Corrected VR2® (Twisted Pair) calculations
- Enhanced Loading Table Editor, including simplified loading limit entry
- Edit and save Glazed and Rime Ice Densities
- Updated load tables per the NESC C2-2017 and RUS 2009
- Save ADSS conductors to Custom and in project files
- Improved performance and reliability
- View graphs of stress-strain charts

1.3.3 History of SAG10 Software and the Graphic Method

The Alcoa Graphic Method of sag-tension calculations was developed in 1926 by H.H. Rodee. The Alcoa Graphic Method is based on analysis of the stress-strain behavior of the complete conductor and its component parts. The method is useful for composite conductors such as ACSR and ACSS, as well as conductors composed of a single metal such as aluminum, copper, or steel.

In 1963, a mainframe-based program named SAGTEN became available to automate execution of the extensive calculations required by the Alcoa Graphic Method. In 1994, developers released the SAG10 program, a PC-based enhancement of the original mainframe-based SAGTEN.

In 2008, Southwire Company acquired ownership of the SAG10 program. In Version 3.10, Southwire completely redesigned the SAG10 user interface to simplify use of the program. Southwire also made many other enhancements to improve the accuracy and reliability of the SAG10 program. Version 4.0 includes many enhancements, notably the Compatibility with all current Windows® operating systems.

Release History:

1992, SAG10 Version 5 and SAGPLOT Version 1
 1994, SAG10 Program for Windows
 1997, SAG10 Version 1.1 for Windows
 1998, SAG10 Version 2.0 for Windows
 2001, SAG10 Version 3.0 for Windows
 2008, Southwire's SAG10 Version 3.10 for Windows
 2013, Southwire's SAG10 Version 4.0 for Windows

1.3.4 Future Direction for SAG10 Software

Southwire is proud to offer the SAG10 program to the Transmission and Distribution market, and we are committed to improving and expanding SAG10 usability and benefits. In keeping with that commitment, Southwire will periodically update the SAG10 software with new features, enhancements, and data based on feedback we receive from you. These updates will be made available through the automated update feature in Version 4.0, supported under the Maintenance Contract.

As a leading innovator in the industry, many Southwire developments have come through its partnership with its Transmission and Distribution customers. That's why we want to hear from you to help us grow and improve the SAG10 program even further.

Please visit <http://www.sag10.com/ContactUs.htm> and tell us what you like, what you dislike, and what you would like to see added to future releases. Help us to continue to provide you the best sag and tension tool possible.

1.4 Installation

1.4.1 Southwire's SAG10® Package Includes:

1. Product Key
2. Download link
3. Installation Instructions link
4. Documentation link
5. User's Manual link
6. Other helpful links

1.4.2 Minimum System Requirements

- Pentium 1.2 GHz or greater with at least 128 MB of RAM.
- The Windows® XP operating system or higher.
- Hard disk with at least 40 MB of free space (5 MB used by program for file storage).
- VGA or better monitor

NOTE

If you are upgrading from a previous version of the SAG10 program, any custom conductors and charts will have to be re-entered after installing the new version of the SAG10 program. You should print copies of any custom data before uninstalling any prior versions of the software that you wish to enter into the new version. It was necessary to change the way custom data is entered to correct some issues in prior versions of the SAG10 program.

NOTE

See the Installation Guide included with order delivery for detailed information on the installation process.

1.4.3 Installing the Application

1. After downloading the SAG10 installer, double click on the "SAG10_Installer.msi" file to begin installing the SAG10 software.
2. At the security prompt click **Run** or **Accept**.
3. Click **Next** on the "Welcome to the SAG10 Setup Wizard" window.
4. To continue the installation, read the License Agreement, check "I accept the terms in the License Agreement", and click on **Next**.
5. Information will be presented about this version of the SAG10 software. Read it and click Next.

6. By default, the SAG10 program will be installed under the "C:\Program Files (x86)\Southwire\SAG10" folder. A different location may be chosen by clicking on the **Change** button and selecting the preferred folder. Once completed, click **Next**.
7. A desktop shortcut will be added by default. Click **Next** to proceed.
8. To finalize the installation, click **Install**.
9. Click **Finish**.
10. To launch the SAG10 program, either double-click on the desktop shortcut OR navigate to the program by clicking on Start -> All Programs -> Southwire -> SAG10 ->SAG10.

1.4.4 Registering a License

The first time the SAG10 program is run, a valid product key will need to be entered to activate the software. Product keys are sent with order delivery emails after approval of orders. If the key cannot be located, call 1-877-797-2410.

1. Enter the Product Key in the space provided.
2. Choose the License Type as either *Network* or *Standalone*. All standard orders will be *Network* licenses.
3. By default, the License Source will be set to *Internet*. If a valid internet connection is not available, choose the *Email* option.
 - a) If *Internet* is chosen and proxy service IS NOT, proceed to Step 4 below.
 - b) If *Internet* and proxy service are chosen, check "Use Proxy Service" and click on Configure Proxy Service. Enter the proxy server address and click **Accept**. Proceed to *Step 4* below.
 - c) If *Email* is chosen, a license will need to be requested.
 - i. Begin by checking "I Accept the Licensing Terms".
 - ii. Click **Agree** on the License Agreement window that appears.
 - iii. Click on the Request button.
 - iv. Select a folder to save the license request file (for example a file name LicenseRequest.YYYY-MM-DD.xml will be generated).
 - v. Click **OK**.
 - vi. A window will appear with instructions on where to e-mail the previously generated license request file.

When the license file is received, load the application and use the **Process** button to apply it to the SAG10® software. Navigate to the folder where the license file is located (Ex: test_license.lic) and click **Open**. If successful, proceed to *Step 7*.

4. Check "I Accept the License Terms"
5. Click **Checkout**.
6. A prompt containing the License Agreement will appear. Choose Agree or Do NOT Agree.
7. Once a license is successfully checked out, the *Status* section of *License Information* will be updated to say "**Licensed**" with a **GREEN** background.
8. Click **Close** and the SAG10 software will appear as seen below.

1.4.5 Troubleshooting

ERROR: Could not acquire license. FAILED! NO [CONCURRENT] LICENSES AVAILABLE.

Possible issues:

- (1) A Product Key was entered, but the License Type was selected as *Network* instead of *Standalone*.
 1. Click the OK button on the error message
 2. Change the License Type from *Network* to *Standalone*
 3. Check "I Accept the License Terms"
 4. Click the **Checkout** button
- (2) There are no available seats. You must wait for a seat to become available, or call 1-877-797-2410.

ERROR: Could not acquire license. FAILED! NO [PERMANENT] LICENSES AVAILABLE

Possible issues:

- (1) A Product Key was entered, but the License Type was selected as *Standalone* instead of *Network*.
 1. Click the OK button on the error message
 2. Change the License Type from *Standalone* to *Network*
 3. Check the box beside "I Accept the License Terms"
 4. Click the **Checkout** button
- (2) This license has already been registered as *Standalone*. Call 1-877-797-2410 for support.

ERROR: Could not acquire license. FAILED! INVALID LICENSE HOLDER [license #].

An incorrect product key has been entered. Click the **OK** button and enter a valid Product Key.

ERROR: Could not acquire license. FAILED! MACHINE ALREADY HAS ANOTHER TYPE OF LICENSE ASSOCIATED WITH LICENSE CODE [license #]. CONTACT TECHNICAL SUPPORT.

A license has already been registered to this machine. Call 1-877-797-2410.

ERROR: Could not checkin license. FAILED! UNABLE TO CHECKIN LICENSE (NOT FOUND).

To resolve, check out the license by going to Help -> View License. Then the license may be checked back in.

ERROR: Could not checkin license. FAILED! ATTEMPTING TO CHECKIN LICENSE WITH PERMANENT ACTIVATION.

A permanent license may not be checked in. Doing so is not necessary, but if this is desired, you will need to contact Technical Support at 1-877-797-2410 to have the account checked in manually.

1.4.6 Automated Updating

If a software or data update is available for SAG10 Version 4.0, you will be prompted to incorporate the updates if: (1) you currently hold a maintenance contract and (2) the computer you are using is connected to the internet. The process for installing software updates will be similar to the installation process. Data updates will be automatic.

1.5 Technical Support

See Appendix B: Error Messages for a list of common error messages in the SAG10 program and explanations for their appearance. For further assistance, contact SAG10 technical support at 1-877-SWSAG10 (1-877-797-2410) or visit us on the web at www.sag10.com/ContactUs.htm.

Getting Started with the SAG10® Program

Creating a SAG10 Project

Select the Conductor

Enter the Ice/Wind Load and Tension Limits

Enter the Ruling Span Lengths

Calculate Sag and Tension

2 Getting Started with the SAG10® Program

There are five basic steps to creating a sag and tension report.

Each of these steps has multiple options, and each step may be affected by options you select for the entire project.

- Enter a project title and description, if desired
- Select the conductor for the project
- Enter the ice/wind load and tension limits for the project
- Enter the ruling span lengths
- Save as a project file
- Calculate sag and tension

Within some steps, you can either use standard data, or you can edit and save custom data.

2.1 Creating a SAG10 Project

To begin using the SAG10 program, click on the SAG10 icon. The SAG10 banner will display briefly, then the SAG10 **Main Menu** screen will appear.

- Enter the project title or number in the **Title** box.
- Enter descriptive information in the **Description** box.
- You can edit this information at any time.

NOTE

The **Tools→Options** menu in the SAG10 Main Menu screen toolbar offers many important project option choices. For Options details, refer to the section of the Main Menu chapter on the **Tools – Options** menu.

2.2 Select the Conductor

In the *Conductor Selection* panel of the **Main Menu** screen, click on the **Select** button. The **Conductor Selection** screen will open.

Select a conductor construction from the *Conductor Type* drop-down list. For this example, choose ACSR. A list of available ACSR conductors will open in the **Conductor or Messenger** drop-down list. Select a conductor, and data for that conductor will automatically be loaded. Buttons in the *Data* and *Conductor Options* panels of the **Conductor Selection** screen let you customize conductor construction data to suit

your application. You can save custom conductor constructions or use and save them only with the current project (See below). Any conductor options you select will be saved with the project.

When you have completed your conductor selection and any conductor data edits you want, click on the **Accept** button in the **Conductor Selection** screen to return to the **Main Menu**.

Conductor Selection Screen Details

For more details on conductor selection, refer to the chapter on the **Conductor Selection Screen**.

Conductor Selection

Sort Options

Conductor Type: Chart Type: Legacy

Conductor or Messenger:

Data		
Alum. Area:	0.0000	in ²
Total Area:	0.0000	in ²
Diameter:	0.000	in
Alum. Weight:	0.000	lb/ft
Total Weight:	0.000	lb/ft
RBS:	0	lb
Chart:		

AC Resistances:

	0.0000	Ohm/mi
	0.0000	Ohm/mi

Notes:

Conductor Options

- None
- VR2 (Twisted Pair)
- Use as a Messenger
- Marker Balls
- PLP Spoiler

EDIT DATA VIEW CHART GENERATE WIR CANCEL

2.3 Enter the Ice/Wind Load and Tension Limits

The *Load Selection* panel of the **Main Menu** contains a list of industry-standard load configurations. Choosing the NESC (Unloaded Limits) loading conditions will limit the initial and final without external loading tensions at conductor temperatures of 0.0°F, 15.0°F, or 30.0°F depending on the selected loading district. Choosing the NESC loading conditions will limit only the initial loaded tension at a conductor temperature of 60.0°F. The RUS 1724E-200 Table 9-3 loads and tensions are the equivalent to the old REA/Alcoa loads and tensions. You can select a standard load table, create a custom load table, or open a saved load table. For the purposes of this example, select **NESC (Unloaded Limits) Medium**.

To view or modify a load table, click on the **Edit Load Table** button in the Load Selection panel. The **Edit Load Table** screen will appear preloaded with any selection you have made in the *Load Selection* panel of the Main Menu. In our example, this screen should open preloaded with the **NESC (Unloaded Limits) Medium** values since we previously selected **NESC (Unloaded Limits) Medium** from the *Load Selection* panel of the **Main Menu**.

For the purposes of this example, click on the **Accept Loadings** button to return to the **Main Menu**.

Load Selection Details

For more details on load selection, refer to the **Edit Loading Table** chapter.

Load Selection

NESC

Light

Medium

Heavy

NESC (Unloaded Limits)

Light

Medium

Heavy

RUS 1724E-200 Table 9-3

Light

Medium

Heavy

California

Light

Heavy

Custom Load Table

Use Existing Load Table

EDIT LOAD TABLE

Edit Loading Table

File

Loading Table

* Cond. Temp	in	lb/ft ²	Limit	Type	Usage
15.0	0.25	4.00	60.0	%	Initial
32.0	0.25				
0.0					
15.0			35.0	%	Initial
15.0			25.0	%	Final/NL
15.0					
30.0					
60.0					Creep
90.0					
120.0					
167.0					
212.0					

°C °F

* Right click on a row button to Insert or Delete a row

OPEN **CLEAR** **SAVE AS**

File

LOAD SELECTION

NESC

Light

Medium

Heavy

NESC (Unloaded Limits)

Light

Medium

Heavy

RUS 1724E-200 Table 9-3

Light

Medium

Heavy

California

Light

Heavy

Custom Load Table

NESC K

New

Old

Old (Steel & Cu)

Zero (ignore K)

ADD GALLOP LOAD

ADD CREEP LOAD

LOADING TABLE NOTES

U.S. Imperial Units

USAGE MEANING

Initial – Initial Tension or Sag Limit

Final – Final Tension or Sag Limit

ET – Elevated Temperature Point

Creep – 10 Year Creep Check

CP – Common Point Load

Final/NL – Final No Load (w/o External Loading)

Notes:

- LIMIT ENTRY: Limit may be entered as either tension in %RBS or pounds, or sag in feet

- ICE TYPE: A negative value for Ice indicates Rime Ice (positive is Glazed Ice)

- WIND ENTRY: A negative value for Wind is used for Weight in lb/ft (positive is wind press in lb/ft²)

- RUS LOAD REDUCTION: Current RUS standards recommend reducing unloaded tensions by 5% (defaults are traditional values)

Ice Density

Glazed: 57.0 lb/ft³ **SAVE TO DEFAULTS** **RESTORE DEFAULTS**

Rime: 37.0 lb/ft³ **SAVE TO DEFAULTS** **RESTORE DEFAULTS**

ACCEPT LOADINGS **CANCEL**

2.4 Enter the Ruling Span Lengths

You can enter up to 50 ruling spans in the *Ruling Spans* panel of the **Main Menu**.

- You can enter spans individually
- You can create a series of spans.
- Accept each entry by pressing the Enter key.
- Units are Feet or Meters, depending on the option selected in the SAG10® Main

Menu toolbar→**Tools**→**Options** screen.

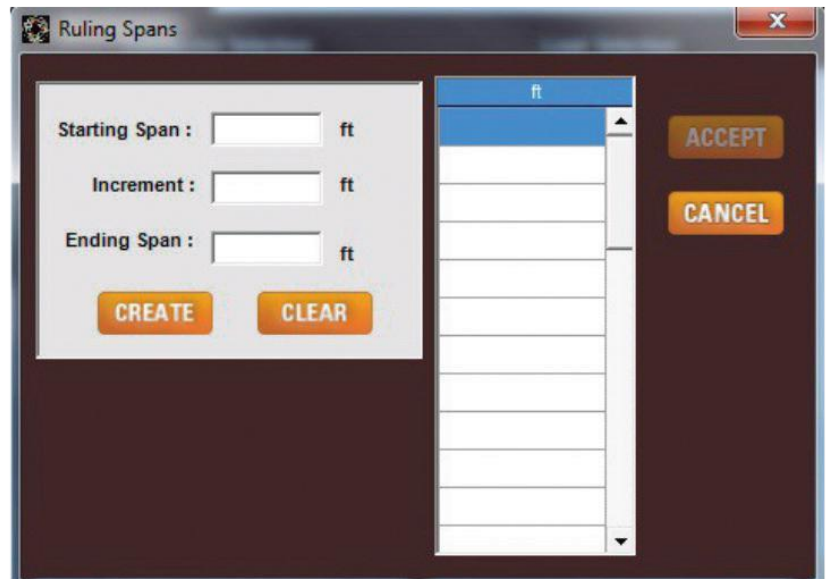
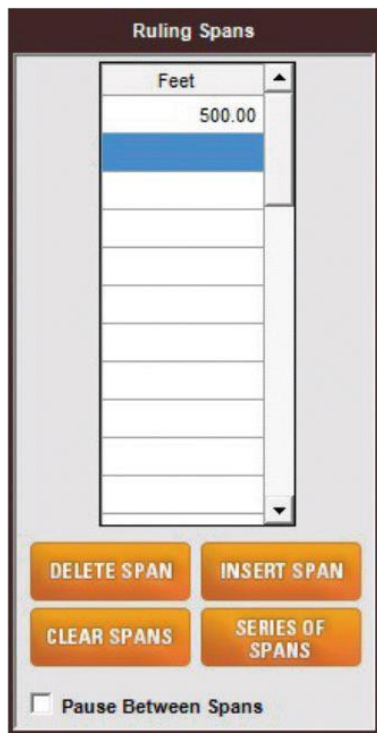
For our example, type in a value of 500 feet, and press the **Enter** key.

Menu let you edit the ruling spans list. You can:

- **Insert Span** will insert a span above the currently selected span.
- **Delete Span** will delete the selected span.
- **Clear Spans** will clear all of the spans in the table.
- **Series of Spans** opens the Ruling Spans window to create a series of spans.

To create a list of multiple ruling spans, equally spaced, simply enter a starting span length, the length you want to increment the spans by, and an ending span length. Click on the **Create** button, and the table will be filled in. Click on the **Accept** button, and these values will appear in the **Ruling Spans** table on the **Main Menu**.

The buttons in the *Ruling Spans* panel of the **Main**



2.5 Calculate Sag and Tension

NOTE

Before calculating sag and tension, be sure to:

1. Select a conductor
 2. Specify load conditions
 3. Enter a ruling span or spans
-

You can initiate sag and tension calculations in two ways:

- Click on the **Calculate Sag & Tension** button at the bottom of the SAG10® **Main Menu**
- Select **Main Menu** toolbar→**Run**→**Sag & Tension**.

Either way, the SAG10 program will generate a **Sag & Tension Data** screen that can be viewed, saved to a file, or printed.

Sag and Tension Output Details

For more details on sag and tension outputs, refer to the **Sag & Tension Data Screen** chapter.

NOTE

The **Tools**→**Options** menu in the toolbar of the SAG10 Main Menu offers many important project option choices. For Options details, refer to the section of the Main Menu chapter on the **Tools – Options** menu.

Main Menu Toolbar Controls

File Menu

Run Menu

Tools - Options Menu

Tools - Chart Explorer

Setup Menu

Help Menu

3 Main Menu Toolbar Controls

The Main Menu toolbar is located at the top of the SAG10® **Main Menu**.

3.1 File Menu

3.1.1 New

Select **New** to clear all previous project file data.

3.1.2 Open

Select **Open** to browse for an existing project file and open it. Loading a file will clear all current project file data.

3.1.3 Save

Select **Save** to save a newly created file, or to save an existing project file. This selection is active only after you have selected a conductor, load parameters, and ruling span data. Save SAG10 project files with an .s10 extension.

3.1.4 Save As

Select **Save As** to save a project file under a new name. This selection is active only after you have selected a conductor, load parameters, and ruling span data. Save SAG10 project files with a .S10Proj extension.

3.1.5 Exit

Select **Exit** to close the SAG10 program and return to Windows®.

3.1.6 Exit and Check-In License

Select **Exit** and **Check-In License** in order to close the SAG10 program and check in the license seat for use by another user.

3.2 Run Menu

3.2.1 Sag & Tension

The SAG10 **Main Menu** toolbar→**Run**→**Sag & Tension** selection executes the sag and tension calculations. Choose this selection only after selecting a conductor, load parameters, and ruling span, and any options in the SAG10 **Main Menu** toolbar **Tools**→**Options** screen.

Sag and Tension Output Details

For more details on sag and tension outputs, refer to the **Output Screen** chapter

3.2.2 Pause Between Spans

If you select the **Main Menu** toolbar→**Run**→**Pause between Spans** option, or the **Pause between Spans** checkbox in the *Ruling Spans* panel of the **Main Menu**, a **Next Span** option will be displayed in the toolbar of the **Sag & Tension Data** screen. Selecting **Next Span** will step through the sag and tension calculation for each ruling span entered.

If there is only one span to run, then this option does not affect the output.

If you enter a large number of spans and a *Warning Message* is received during calculation that indicates *Out of Memory* or *Output Exceeds Buffer Size*, then you may have to either:

- Use the Pause between Spans option, or
- Reduce the number of ruling spans.

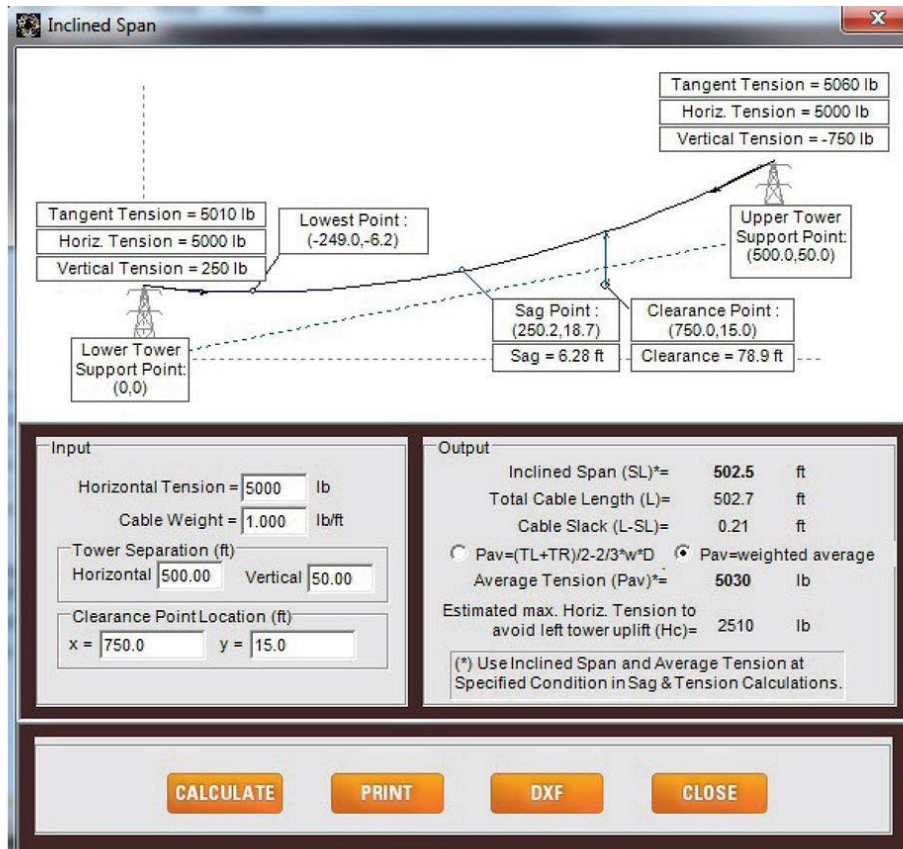
If these messages are displayed, the screen output will be incomplete, but the **Print to File** output will not be affected.

3.2.3 Inclined Spans

If you select the **Main Menu** toolbar→**Run**→**Inclined Spans** option, the **Inclined Span** screen will open.

Stringing sags generated by the graphic-method are for level ground spans and are based on the average tension (P_{av}) of the conductor. There are times when the combination of a long span and difference in elevation creates difficulties in sagging conductor

Depending on the span length and difference in elevation, the lowest point of sag may fall beyond the lower support (indicated by a negative value for the x-coordinate in the **Lowest Point** box) or the vertical tension at the lower tower may become positive. If either of these conditions occurs, this indicates that there may be an up-lift problem at the lower support attachment point. To correct this, enter a lower value for the **Horizontal Tension**.



Sag Calculation Temperature

The SAG10® Inclined Span option calculates the proper inclined Span Length (SL) and average tension (Pav) to be used based on the **Horizontal Tension** input. Therefore, as tension varies with conductor temperature, the sags and clearances resulting from the inclined span calculations are only valid at the conductor temperature associated with the **Horizontal Tension** input. For example, if the horizontal tension is an initial tension at 60.0°F, the resulting sag and clearance values are valid only for the 60.0°F initial condition.

Inclined Span Control Buttons

- **Calculate** will re-calculate the inclined catenary after changing any data.
- **DXF** will save the inclined catenary as a .DXF file to a location you specify. A DXF file can be imported into most CAD programs. Typical uses would be to generate a sag template, or to import the sag curve into a drawing containing some ground profile for structure spotting.
- **Print** will send the inclined span results to the printer.
- **Close** will close the **Inclined Span** screen and return you to the **Main Menu** screen.

3.2.4 Ruling Span Calculation

If you select the **Main Menu** toolbar→**Run**→**Ruling Span Calculation** option, the **Calculate Ruling Span** screen will open. This SAG10 utility calculates a ruling span from a list of spans.

Enter a list of spans within a line section into the table and click on the **Calculate** button. The resulting ruling span calculation shows in the box below the **Calculate** button.

Calculate Ruling Spans Control Buttons

- **Append** will append the calculated ruling span to the bottom of the ruling span list in the *Ruling Spans* panel of the **Main Menu** screen.
- **Replace** will remove any existing ruling spans from the ruling span list in the *Ruling Spans* panel of the **Main Menu** screen and replace them with the calculated ruling span.
- **Save Span File** saves the span file to a location you specify as a .SPN file type.
- **Open Span File** retrieves an existing span file.

Saved span lists can also be recalled and used when creating stringing sag tables. For more information, refer to the **Stringing Module** section in the **Output Screen** Chapter.



3.3 Tools – Options Menu

You can adjust key project option settings by selecting **Main Menu** toolbar→**Tools**→**Options**. The Option Settings screen will open.

Options you set are saved as part of the current project file. When you are finished selecting options, you can:

- Click on the **Save as Defaults** button, and the selected options will become the defaults when you load the program, or
- Click on the **Accept** button, which saves your selections for the current session only.

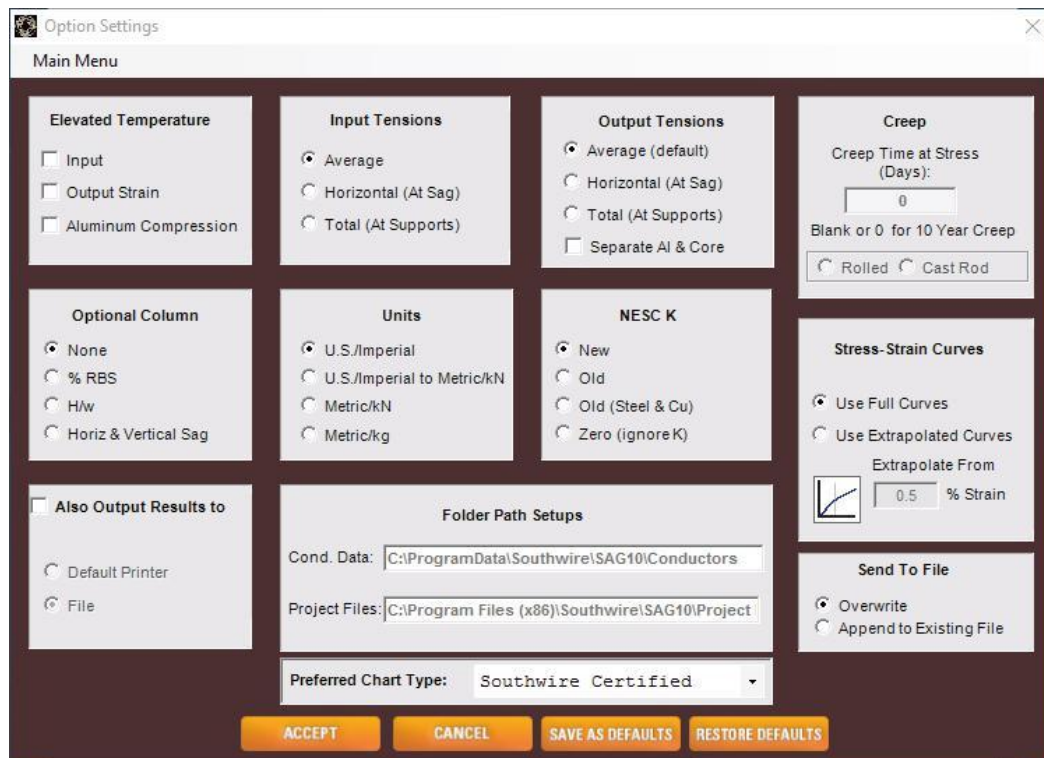
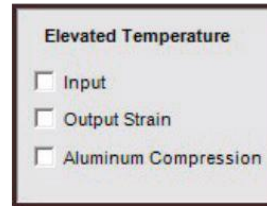
3.3.1 Elevated Temperature

The **Elevated Temperature** options are provided for you to include additional non-recoverable strain due to operation of conductors at elevated temperatures. These options should not be used for ACSS conductors, which are designed for high operating temperatures.

Input

This option will cause the sag-tension calculations to include the effects of additional non-recoverable strain due to operating a conductor at elevated temperatures. The default selection for this option is unchecked. When you check the **Input** box, the **Elevated Temperature Creep** screen opens. When working with elevated temperature calculations, the SAG10® program will modify the LoadTable before calculating sag and tension. For each conductor temperature in the Elevated Creep Table at or above 16.0°C

(60.0°F), an additional row will be created in the LoadTable with ET in the Usage column to designate the row as an Elevated Temperature Point. Conductor temperatures less than 16.0°C (60.0°F) will be ignored since they do not contribute to elevated temperature creep.



The screenshot shows a dialog box titled 'Elevated Temperature Creep'. It contains a table with two columns: 'Hours' and 'Deg C'. To the right of the table are five buttons: 'INSERT ROW', 'DELETE ROW', 'CLEAR TABLE', 'OK', and 'CANCEL'. At the bottom, there are two radio buttons: 'Rolled' and 'Cast Rod'. Below the radio buttons is a note: 'Note - Elevated temperature points require Usage = ET in the Loading Table'.

Enter the total time for which the conductor is expected to experience elevated temperatures over the life of the line. Entries are in hours and °C.

Elevated temperature creep is considered for all-aluminum conductors (AAC, AAAC, ACAR) and ACSR conductors with less than 7.5% steel by area. Elevated temperature creep of ACSRs with more than 7.5% steel by area is less than room temperature creep and can be ignored. If you have chosen an ACSR with more than 7.5% steel, the program will issue a warning message, uncheck the **Elevated Temperature Input** box, and bypass the **Elevated Temperature Creep** table.

Finally, click on either the **Rolled** or **Cast Rod** option, whichever is appropriate for the conductor being modeled. Rolled rod tends to creep more than cast rod, so the formulas are different.

The sag-tension output will include a pound (#) sign by the elevated temperature rows.

Output Strain

This option is considered only if the Elevated Temperature Input box is checked. If both boxes are checked, the sag and tension output will include a line of data at the first elevated

temp creep point, indicating normal creep (E_c) and elevated temperature creep (E_{crp}). E_c will represent the normal non-recoverable strain seen in the conductor over ten years, in parts per million. E_{crp} will represent the non-recoverable strain seen in the conductor due to operation at elevated temperatures, in parts per million.

Creep is a function of time and temperature. The SAG10® program will select the time/temperature that will cause the maximum micro-strain increase in elongation and convert it to a temperature differential. This means the E_{crp} value will not be a sum of the micro-strains but simply the micro-strain from one time/temperature case.

For more background on elevated temperature creep, research the following papers:

- J. R. Harvey, R. E. Larson - Use of Elevated Temperature Creep Data in Sag-Tension Calculations, IEEE Paper 69TP 674-PWR.
- J. R. Harvey, R. E. Larson - Creep Equations of Conductors for Sag-Tension Calculations, IEEE Paper C 72 190-2.
- J. R. Harvey, R. E. Larson - Technique to Include Elevated Temperature Creep in Sag-tension Calculations, IEEE T and D Conference and Exposition April 1-9, 1979.
- W. B. Zollars - Aluminum Conductor Elevated Temperature Considerations, Seminar sponsored by Georgia Power Co., the Aluminum Association, and EPRI on the Effects of Elevated Temperature Operation on Overhead Conductors and Accessories - May 20, 1986, Atlanta Georgia.

Aluminum Compression

ACSR conductors are composed of two materials, steel and 1350-H19 hardened aluminum. These materials expand at different rates when heated. The coefficient of linear thermal expansion for aluminum is approximately twice that of steel, so as an ACSR conductor is heated, the aluminum will attempt to expand more than the steel core. Since the aluminum and steel are connected together at various points along the line, the steel prevents the aluminum from elongating as much as it wants to. Under these conditions, the helical path of the aluminum grows and a compressive force builds in the aluminum, similar to a compressed spring.

This is not a problem in the normal operating temperature range of ACSR, which is below 100°C. However, at elevated operating temperatures, the amount of growth in the aluminum is much more than the growth in the steel. Since they are connected together, the aluminum “spring” pushes against the steel core as it grows. This extra force on the steel is not part of the normal sag and tension calculations. It causes the steel to elongate more, and thus the conductor to sag more, than the standard calculations predict. Selecting the **Aluminum Compression** option will cause the SAG10® program to take into consideration the additional expansive force imparted to the steel by the aluminum.

This option will cause the **Aluminum Compression Variables** screen to appear. The screen will automatically populate the input boxes with values from the database. These values may be edited if needed.



Aluminum Compression Variables

Built in Aluminum Stress: 1500 psi
(1500 = default value)

Aluminum Area : 0.86
(as fraction of total area)

of Aluminum Layers : 2

of Aluminum Strands: 26

of Core Strands : 7

Chart NOT found. Enter data at left manually.

Stranding Lay Ratios

Outer Layer 0 11 Inner Layer

ASTM Recommended Lay Ratios		
Min	10	10
Preferred	11	13
Max	13	16

OK CANCEL

The **Built in Aluminum Stress** has a default value of 1500 psi. This is the stress from the aluminum compression acting on the steel core.

The **Aluminum Area** is the ratio of the aluminum area to the total area.

The **# of Aluminum Layers, # of Aluminum Strands, and # of Core Strands** may be changed if the data is incorrect.

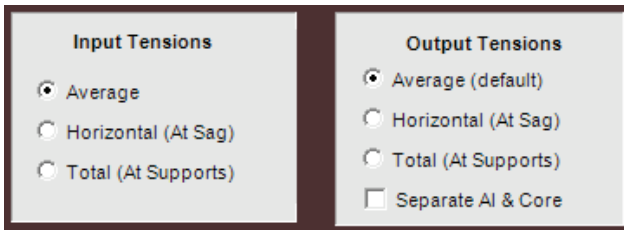
The **Stranding Lay Ratios** are the lay ratios (lay length divided by layer diameter) of the layers of aluminum. The input boxes go from the **Outer Layer** to the **Inner Layer** starting left and proceeding right.

Note: This only applies to ACSR, ACCR, and ZTACR conductors. This is not an issue in ACSS conductors due to the use of fully annealed 1350-O aluminum, which yields more readily than hardened 1350-H19 aluminum. For this reason, compressive forces do not build in the aluminum to a level high enough to affect the steel core.

For details, refer to “Theory of Compressive Stress in Aluminum of ACSR” and “Some Effects of Mill Practice on the Stress Strain Behavior of ACSR” by C. B. Rawlins. The Rawlins paper attributes the additional sag at high temperatures in ACSR to mill practices. Regardless of the cause, compressive stress is created in ACSR that causes additional sag.

3.3.2 Input and Output Tensions

A tension value may mean several things. It can describe horizontal tensions, total tensions (tension magnitude at support points) or average tensions (an in-between value representing the tension state of the entire span).



When you fill in the **Load Table**, you may require a limit based on a particular tension type. Conversely, in the sag and tension data output, you may want to display a different type of tension. The SAG10® program lets you specify input and output tension types separately in the *Input Tensions* and *Output Tensions* panels of the

Options Settings window. In addition, the *Output Tensions* panel has a box that lets you select a display that separates the tension components attributed to steel and aluminum. (See below for details.)

Average Tension

The default used for tension is the average value.

Horizontal Tension (At Sag)

The horizontal tension is at the belly of the sag. At this point, the horizontal tension equals the total tension in the conductor. Horizontal tension is used in offset clipping and inclined span calculations. Formulas used for level spans are as follows:

$$T_H = 2T_{avg} - T_S$$

Where: T_H = Horizontal, lb

T_{avg} = Average tension, lb

T_S = Total tension (at supports), lb

Total Tension (At Supports)

The total tension is the total tension at the supports. It includes the weight of the wire. The tension at the supports is used in tower-design calculations. Formulas used for level spans are as follows:

$$T_S = T_H + wD$$

Where: T_S = Total tension at supports, lb

w = Conductor weight, lb/ft

D = Conductor sag, ft

Separate Aluminum and Core Tension

The basis for the Alcoa Graphic Method of sag and tension is stress-strain testing. When stress-strain tests are performed on steel core conductors, both composite (aluminum combined with steel) and single (that of the steel only) data are generated. When dealing with steel core conductors, the Graphic Method derives the stress-strain data of the aluminum portion by subtracting the available steel data from that of the composite.

At each conductor temperature specified in the **Load Table**, the calculations are performed using the stress-strain data from the components, which are then added to form the composite. The **Separate Aluminum and Core Tensions** option will cause the tensions in each of the components to be displayed, as well as the total tension in the conductor. The ability to view the separate tensions can be a valuable tool when evaluating operation of ACSRs at high temperatures, or when calculation pre-tensioning for ACSS conductors.

3.3.3 Optional Columns in Output

These option boxes add columns to the sag and tension output for final and initial tension.

- **None** – no added columns
- **% RBS** – Percentage of Rated Breaking Strength
- **H/w** – Horizontal Tension divided by Weight. This is often referred to as the “Catenary Constant” or “C” value
- **Horizontal and Vertical Sag** – displays the resultant sag as horizontal and vertical components

3.3.4 Units

There are four options available for Units:

- **U.S./Imperial** - Both the input and output are in pounds per foot, pounds, and feet
- **U.S./Imperial to Metric/kN** - U.S./Imperial input and Metric/kN output in Newtons per meter, Kilonewtons, and meters
- **Metric/kN** - Both input and output are in Newtons per meter, Kilonewtons, and meters
- **Metric/kg** - Both input and output are in Kilograms per meter, Kilograms, and meters

All bare overhead conductor designs, including calculations of weight and RBS, are per ASTM International, regardless of the unit selection made. CSA and IEC designs are not currently supported. See the chapter on Editing conductor data for information on how to edit the data in order to conform to other standards.

NOTE: If you have any information on ways to improve our Metric use, please contact us via the SAG10® website.

3.3.5 NESC K

Occasionally it is necessary to distinguish between NESC 5th or 6th Edition and the

- **New** – Designates NESC 7th edition
- **Old** – Designates NESC 5th or 6th edition
- **Old (Steel and Cu)** – Match calculations for steel or copper cable for the older NESC manuals
- **Zero** – Ignore K

3.3.6 Also Output Results to

Default Printer

Automatically sends the results shown in the sag and tension calculation output screen to the default printer specified in the Print Setup section of this manual.

File

Automatically sends the results shown in the sag and tension calculation output screen to a specified file. The SAG10® program will prompt you for a file name to save the output when you run the sag and tension calculation.

3.3.7 Creep (Time Selection)

THIS FEATURE IS BROKEN AND WILL BE FIXED IN AN UPDATE.

The SAG10® program calculates final sag and tension data assuming 10 years of conductor creep.

Entering a number in Creep Time at Stress (Days) lets you calculate the conductor creep that would result from a longer or shorter time period. A shorter time period may be

helpful in evaluating conductors that have been under tension less than 10 years. A longer time period may be helpful to see if any additional creep may occur past 10 years. Blank or "0" will default to 10 years.

3.3.8 Folder Path Setups

Conductor Data

Browse or specify a path to a default folder containing conductor data.

Project Files

Browse or specify a path to a default folder containing project file data.

3.3.9 Stress-Strain Curves

Typically, the SAG10 program uses the full stress strain curves. These return the stress level at ANY strain value as calculated using the polynomial coefficients from the stress- strain charts. The default for this option is **Use Full Curves** and Southwire recommends that you do not change this. The **Threshold Strain** is now set to 0.5%.

There are times, especially when large mechanical loadings are placed on a conductor, particularly in longer spans, that very large strains are encountered. The SAG10 program may have to estimate, to the best of its ability, the stress-strain curve in these situations to complete the calculation. However, you should be aware that this is occurring as it may affect the accuracy of the results. If this occurs, a message will display on your output indicating that the calculations used an extrapolated curve.

3.3.10 Send To File

Overwrite

When you check this box, the data sent to a specified file will overwrite the existing data.

Append to Existing File

When you check this box, the data sent to a specified file will be appended to the existing data.

3.3.11 Chart Type

This drop-down lets you select a default stress-strain chart type. The options are:

- *Legacy* – This is historical data based on averages of older individual stress-strain test data and calculated data. Stress-strain tests run on these conductors were built using various standards. Therefore, your conductor manufacturer should be consulted for stress-strain data that is representative of your conductor.
- *Southwire Certified* – This option will become available as Southwire releases verified stress-strain data. Southwire has instituted a stress-strain testing program in order to provide accurate data for new production Southwire conductor for the SAG10® software.
- *Manufacturer Verified* – This option is for charts representing conductor types either not manufactured by Southwire or charts vetted but not yet certified by Southwire. These charts have been verified as representative of the conductor by the manufacturer specified under the chart number.
- *Custom* – These charts are custom selections by the user. A custom chart could include any chart from the Chart Explorer database or one added by the user. If the chart selected logically by the SAG10 program is changed, it becomes a *Custom* selection.

3.4 Tools – Chart Explorer

The stress-strain chart database is comprised of legacy charts which are the culmination of historical data based on averages of older individual stress-strain test and calculated data. Since a single stress-strain test cannot be concluded as accurate and representative of a conductor, many of the charts are the average of multiple tests. As new data becomes available by way of testing at Southwire, new charts will be added to the database that will be representative of Southwire conductor.

Selecting **Main Menu** toolbar→**Tools**→**Chart Explorer** will open the Chart Explorer screen. This screen shows a list of conductor detail charts, sorted by chart number. The chart explorer lets you quickly view any available charts, including those you create. Charts that are *Locked* cannot be edited.

Add

The **Add** button allows you to create a custom chart. Clicking on this button will open a blank **Chart Details** screen for you to fill in.

The **Chart Code** should be a custom chart number, either 6-### or 6-####.

The **Ref. Temp.** should be the conductor temperature measured during stress-strain testing.

The **Outer Area Fraction** is the percent by area of the outer material. The Cable Class is the conductor type.

The **Chart Coefficients** should be filled in using the 4th Order Polynomials gathered from stress-strain testing. The **Initial K0-K4** values should be representative of the initial curve with 1-hour creep, in units of psi/100. The **Creep K0-K4** values should represent the initial curve with 10-year creep added, in units of psi/100. The last column has boxes for **Elasticity** and **Thermal**. The Elasticity is the final modulus of elasticity, in units of psi/100. The Thermal is the thermal coefficient of expansion, in units of %/°F. The **Outer Components** and **Core Components** will need to be added for steel or composite core conductors. Only the **Outer Components** will be needed for homogeneous conductors.

Chart	Conductor Type	Stranding	%Alum	Locked	Notes
1-1009	ACSR	54/19	88.8	X	Type 13 ACSR (54/19). C...
1-1010	AAC			X	61 Strand AAC/1350-H1...
1-1019	ACSR	45/7	93.5	X	Type 7 ACSR (45/7), larg...
1-1020	ACSR	84/19	92.5	X	Type 8 ACSR (84/19). Co...
1-1021	ACSR	48/7	91.9	X	Type 9 ACSR (48/7). Con...
1-1023	ACSR	6/1	85.9	X	Type 17 ACSR (6/1), #2 ...
1-1032	AAC			X	127 Strand AAC/1350-H...
1-1049	AAC			X	37 Strand AAC/1350-H1...
1-1053	ACSR	72/7	95.9	X	Type 4 ACSR (72/7). Con...
1-1056	AAAC			X	19 Strand AAAC/6201-T...
1-1068	AAAC			X	7 Strand AAAC/6201-T8...
1-1099	-----			X	Contact your conductor ...
1-1105	ACSR			X	54/37 ACSR Contact yo...

The **Stranding Information** is optional and will only be used for **Aluminum Compression** calculations. See the section on **Aluminum Compression** for more information.

Delete

This will delete the currently selected chart from the database.

Details

This will open the **Chart Details** screen for the selected chart.

If you select a chart in the **Chart Explorer** screen and click on the **Details** button, a **Chart Details** window will open.

The **Copy** and **Paste** buttons allow you to move data to and from a Microsoft Excel spreadsheet. The **Graph** button will open a graph of the stress-strain chart including a creep curve. For composite conductors, the aluminum, core, and composite curves will be graphed along with the composite creep curve.

Chart Details

General Information

Chart Code: 1-537 Ref. Temp: 70 °F Outer Area Fraction: 86 % Conductor Type: ACSR Locked for Editing

Chart Coefficients

		Outer Components					
	K0	K1	K2	K3	K4		
Initial	-1213	44308.1	-14004.4	-37618	30676	64000 Elasticity	
Creep	-544.8	21426.8	-18842.2	5495	0	0.00128 Thermal	

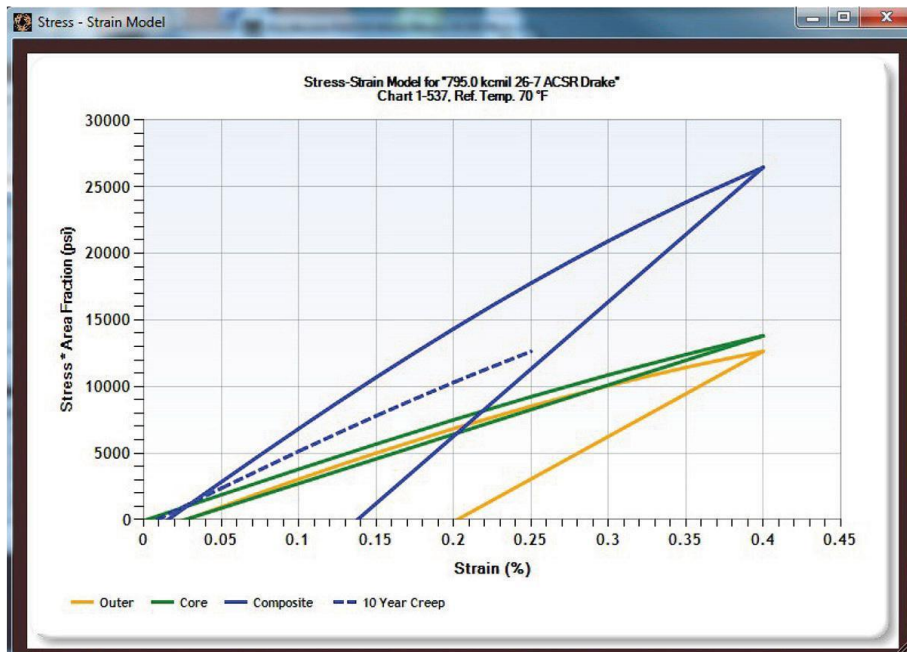
		Core Components					
	K0	K1	K2	K3	K4		
Initial	-69.3	38629	3998.1	-45713	27892	37000 Elasticity	
Creep	47.1	36211.3	12201.4	-72392	46338	0.00064 Thermal	

Stranding Information

ASTM Lay Ratio Limits (comma separated values for each layer) 3 Layer Example:

Strand	Layer	Minimum:	Preferred:	Maximum:
Outer: 26	2	10, 10	11, 13	13, 16, 17
Core: 7	1			

NOTES: Type 16 ACSR (26/7), larger than 762.8 kcmil. Contact your conductor manufacturer to v



3.5 Tools – Export PLS-CADD™ WIR Files (for Concurrent Licenses Only)

Selecting **Main Menu** toolbar→**Tools**→**Export PLS-CADD WIR Files** will open the **Export PLS-CADD Files** screen. This screen will allow you to check off any conductor type for which you would like to create a PLS-CADD file directory. Once you have chosen all the conductor types you wish, click **Generate**. The **Browse for Folder** screen will appear. From there, select the directory you would like to store the PLS-CADD files. If many conductor types are chosen for export, the export process may yield a busy cursor and say “Not Responding”. This is no cause for concern. Please allow the export to go through fully before attempting to resume computer activity.

Please see Section 4.3.3 on **Generating a WIR file** for information about creating single PLS-CADD files.

Note: Not all conductor types allow PLS-CADD file creation.

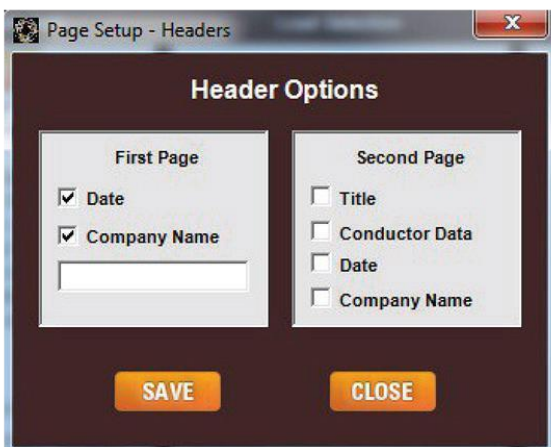
3.6 Setup Menu

3.6.1 Print Setup

Selecting **Main Menu** toolbar→**Setup**→**Print Setup** displays the standard Windows® printer setup and selection window. Refer to the Windows User’s Guide for details on use of Print Setup.

3.6.2 Page Setup

Selecting **Main Menu** toolbar→**Setup**→**Page Setup** opens the SAG10® Page Setup screen where you can set page header options.



First Page

These header options will appear on the first page of the output only.

- The **Date** is checked by default. Uncheck it if you do not wish the date to appear on the output.
- **Company Name** is a feature that allows you have your company name appear on the output. Check the **Company Name** checkbox and enter your company name in the text box.

Second Page

These header options will appear on any subsequent pages of output.

- Checking **Title** will cause the text entered in the **Title** field of the **Main Menu** to appear on subsequent pages. Note that the **Title** and **Description** entered on the **Main Menu** always appear on the first page.
- Checking **Conductor Data** will cause the description for the conductor to appear on all subsequent pages.
- Checking **Date** will cause the date to appear on all subsequent pages.
- **Company Name** can only be selected if it is selected in the *First Page* header options.

3.6.3 Fonts

Selecting **Main Menu** toolbar→**Setup**→**Fonts** opens the SAG10 Font window. Only Fixed Pitch Fonts may be selected. The SAG10 program requires that the **Courier New** font be loaded into Windows. If the proper fonts are not currently installed on your computer, refer to the Windows® Control Panel, Fonts for information on loading additional fonts.

3.7 Help Menu

Selecting **Main Menu** toolbar→**Help** in the SAG10® Main Menu tool bar will open a submenu with these options:

- Contents
- Search for Help On ...
- Tech Support
- View License
- About SAG10 [Software]

All of the material in this manual is available in SAG10 **Help**.

3.7.1 Help→Contents→Function Tabs

Contents

This tab gives access to a list of SAG10 User's Manual topics organized in Table of Contents order.

Index

This tab gives access to the standard Microsoft index feature.

Find

This tab gives access to the standard Microsoft word or phrase search feature.

3.7.2 Help→Search for Help On ...

This tab gives you direct access to the standard Microsoft index feature.

3.7.3 Help→Tech Support

This menu item displays contact information for Southwire's SAG10 technical support.

3.7.4 Help→View License

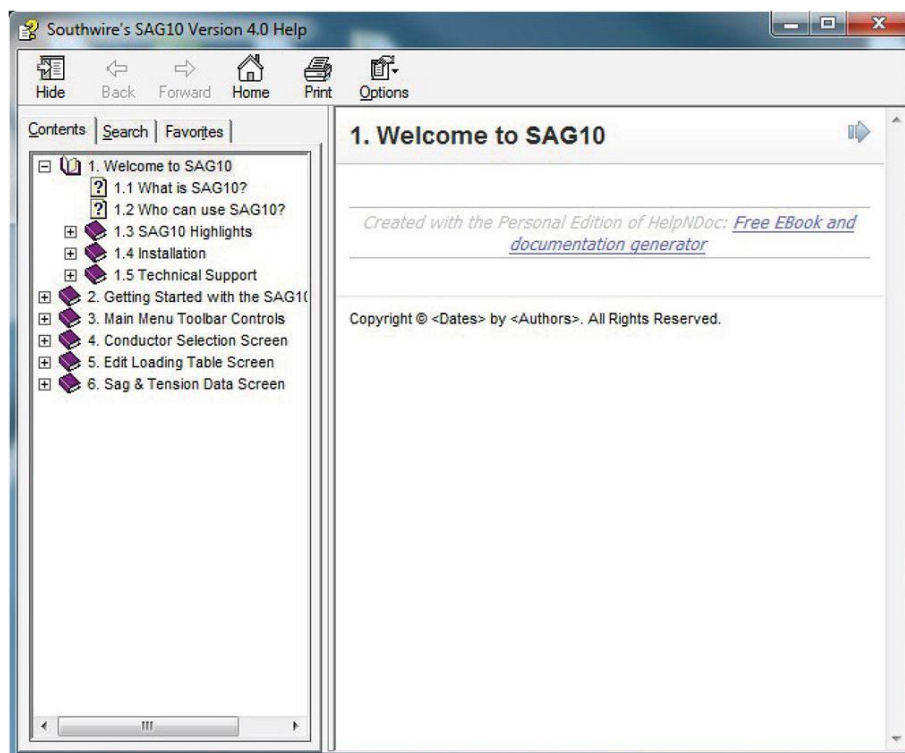
This menu item displays selected licensing information and other information about Southwire's SAG10 software.

3.7.5 Help→About SAG10 [Software]

This menu item displays the version number and registration number of the current SAG10 program installation.

3.7.6 Help→Maintenance Agreement

This menu item displays the Maintenance Agreement if you currently hold a Maintenance Contract.



Conductor Selection Screen

What is SAG10® Software?

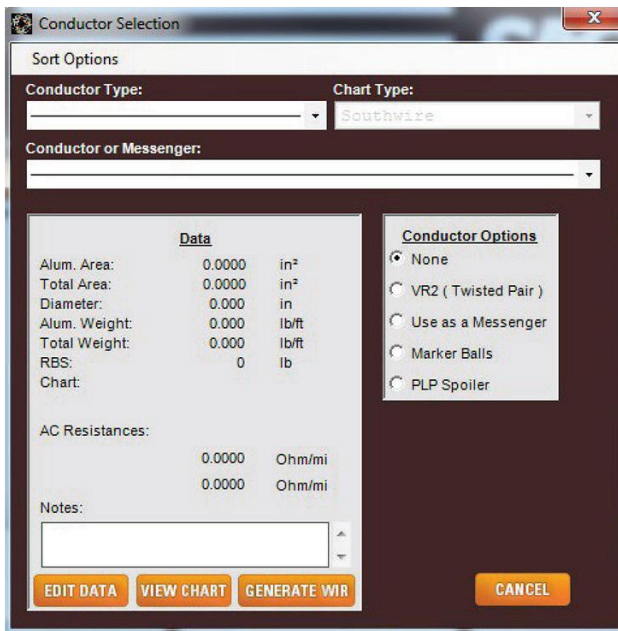
Who Can Use SAG10 Software?

SAG10 Highlights

Installation Technical Support

4 Conductor Selection Screen

To access the **Conductor Selection** screen, click the **Select** button in the *Conductor Selection* panel of the SAG10® **Main Menu** screen.

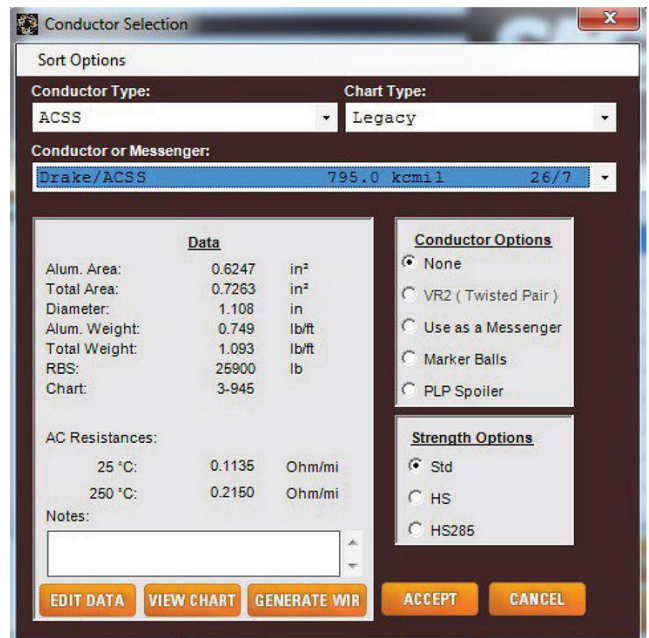


The **Conductor Selection** screen has five main components:

- The *Conductor Type* box, where a drop-down menu lets you choose the type of conductor to use.
- The **Conductor or Messenger** box, where a drop-down menu lets you select a specific conductor or support messenger.
- The *Data* panel, which shows a data summary for the specific conductor you have chosen.
- The *Conductor Options* panel, where you can select options for the specific conductor you have chosen. Not all options are available for some conductor types.
- The **Sort Options** menu toolbar which allows you to change the sort options for the drop-down list for the **Conductor or Messenger** box. You can sort **By Size** or **By Codeword**.

In addition to these five main panels, other panels may appear with additional information for a specific conductor type. For example,

ACSS conductors are available in three different strength options. When you choose an ACSS conductor, a *Strength Options* panel appears, with the available strength options. When you click on a strength option, the **RBS** value in the *Data* panel automatically updates.



4.1 Conductor Type

This drop-down menu lets you select a construction type. When you choose a general construction type, the **Conductor or Messenger** drop-down menu will display specific conductors of that type. Southwire has updated the conductor tables to match current ASTM standards, where standards exist.

Some data has been provided by other manufacturers, or is based on legacy values from the Alcoa version of the software. Data for these conductors is provided as-is, and should be verified as accurate for your particular conductor.

Note
Standards and manufacturing methods have changed over the years and older conductor designs may not exactly match the values in use today.

Custom Conductor Types

Any custom conductor types you build and save are stored in a central file that you can access by selecting the **Custom** type in the *Conductor Selection* drop-down menu. For details on creating custom conductors, refer to the **Editing Conductor Data** section, below.

4.2 Conductor or Messenger

This is where you select the specific conductor to use, either as a conductor or as a support messenger for an assembly. The drop-down list automatically opens when a **Conductor Type** is selected, or you can open the drop-down at any time by clicking on the drop-down arrow on the right side of the box.

4.3 Chart Type

This drop-down lets you select a stress-strain chart type. The options are:

- **Legacy** – This is historical data based on averages of older individual stress-strain test data and calculated data. Stress-strain tests run on these conductors were built using various standards. Therefore, your conductor manufacturer should be consulted for stress-strain data that is representative of your conductor.
- **Southwire Certified** – This option will become available as Southwire releases verified stress-strain data. Southwire has instituted a stress-strain testing program in order to provide accurate data for new production Southwire conductor for the SAG10® software.
- **Manufacturer Verified** – This option is for charts representing conductor types either not manufactured by Southwire or charts vetted but not yet certified by Southwire. These charts have been verified as representative of the conductor by the manufacturer specified under the chart number.
- **Custom** – These charts are custom selections by the user. A custom chart could include any chart from the Chart Explorer database or one added by the user. If the chart selected logically by the SAG10 program is changed, it becomes a *Custom* selection.

4.4 Data Panel

Once you select a specific conductor, the data for that conductor will automatically load into the conductor *Data* panel. You will notice there is extra data in SAG10 Version 4.0 when compared to previous versions. This data is crucial for the application to create the PLS-CADD™ files available for export. The Chart number specified in the *Data* panel of the screen is the stress-strain chart found by the SAG10® software using the logic in Appendix A: Chart Logic.

<u>Data</u>		
Alum. Area:	0.6247	in ²
Total Area:	0.7263	in ²
Diameter:	1.108	in
Alum. Weight:	0.749	lb/ft
Total Weight:	1.093	lb/ft
RBS:	25900	lb
Chart:	3-945	
AC Resistances:		
25 °C:	0.1135	Ohm/mi
250 °C:	0.2150	Ohm/mi
Notes:		
<input type="text"/>		
<input type="button" value="EDIT DATA"/> <input type="button" value="VIEW CHART"/> <input type="button" value="GENERATE WIR"/>		

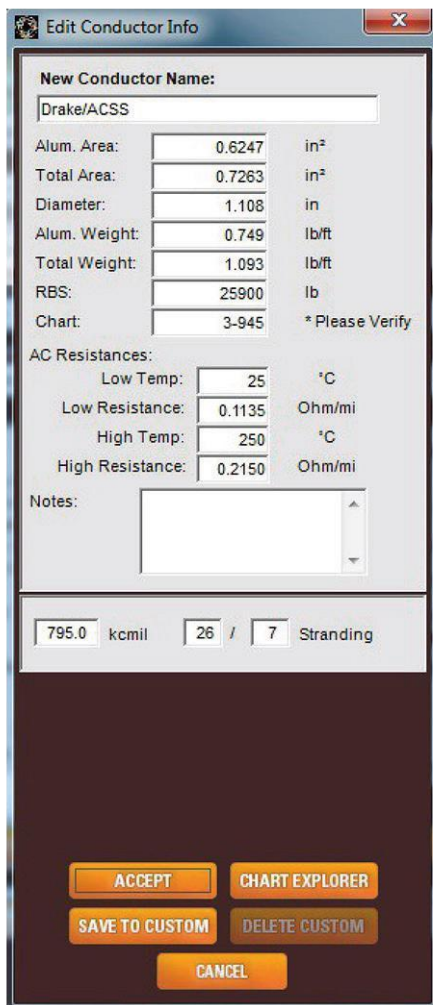
If this is the conductor you want, choose any conductor options you need, then simply click the **Accept** button at the bottom of the **Conductor Selection** screen to return to the **Main Menu** screen. There are three other buttons in the *Data* panel that allow you to 1) view the stress-strain chart associated with the conductor, 2) edit the conductor data and create a custom conductor, or 3) generate a PLS-CADD WIR file for the selected conductor (for Concurrent licenses only).

4.4.1 View Chart

The **View Chart** button in the *Data* panel will take you to the **Chart Details** screen and show you the stress-strain data assigned to the selected conductor. A unique chart number identifies each chart.

4.4.2 Editing Conductor Data

The **Edit Data** button in the *Data* panel opens the **Edit Conductor Info** screen, shown below, where you can create a custom conductor by modifying the name and characteristics of the conductor you're working with. Conductors that conform to CSA/IEC standards may be designed by editing the weights, RBS, and resistances. Note that the contents of this screen will change based on the conductor type selected.



As you edit the data in the Edit Conductor Info screen, the Chart number will change per the logic in Appendix A: Chart Logic. If no chart is found using the logic, the Chart field will be left blank, whereupon you must fill in this field. Make sure to edit the chart number **LAST**, as the SAG10® program will attempt to find a chart number as you change other data fields. You can create a custom conductor by editing the conductor data, then clicking Save to Custom.

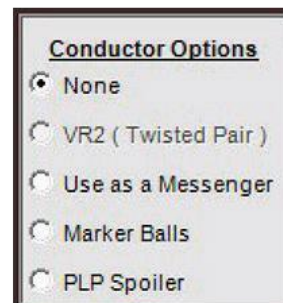
- The **Accept** button will close the screen and retain the modified values for this project file only – it will not save them to the conductor database. When re-opening the project file, this conductor will be available for use in calculations but will not be available in the **Conductor Selection** screen. A Custom conductor must be created for this conductor to be available in the **Conductor Selection** screen.
- To save your modified values as a **Custom** conductor, click on the **Save to Custom** button.
- The **Delete Custom** button lets you remove custom conductors.
- The **Chart Explorer** button takes you to the Chart Explorer screen. Here you can review available charts or create a new stress-strain chart. For more details, refer to the **Tools→Chart Explorer** section of the **Main Menu** chapter.

4.4.3 Generating a WIR file (For Concurrent Licenses Only)

The Generate WIR button exports a PLS-CADD™ WIR file to the directory you choose. Note that all WIR files generated by the SAG10 program are in U.S./Imperial units, regardless of the unit selected in the **Tools→Options** menu.

4.5 Conductor Options

The **Conductor Options** box lets you add special features to your conductor selection:



- VR2® (Twisted Pair)
- Use as a Messenger
- Marker Balls
- PLP Spoiler

Conductor options that are not available for the selected **Conductor Type** will appear in gray, as is the **VR2 (Twisted Pair)** option in the example above.

4.5.1 VR2® (Twisted Pair) Option

Any of the AAC, AAAC, ACSR, ACSR/AW, ACSR/TW, ACSR/TW/AW, AAC British, AAAC British, or ACSR British conductors may be modeled as a twisted pair conductor. If you select the VR2 (Twisted Pair) option, the conductor description will indicate use of VR2 by appending the "/VR2" suffix to the codeword.

VR2 Equivalent Values		
Cond. Area:	1.2494	in ²
Total Area:	1.4526	in ²
Diameter:	1.813	in
Cond. Weight:	1.498	lb/ft
Total Weight:	2.186	lb/ft
RBS:	63000	lb
Chart:	1-537	
AC Resistances:		
25 °C	0.0615	Ohm/mi
75 °C	0.0723	Ohm/mi

Since VR2 is simply two conductors twisted together, the weights, strength, and areas of the wire are doubled. The diameter is considered to be 1.6366 times larger than the single conductor for wind and ice calculations. This is due to the cross-section that varies along the axis of the line. When this option is selected, a *VR2 Equivalent Values* panel appears with the resulting data to be used.

4.5.2 Use as a Messenger

This option allows you to add several non-supporting cables to a supporting conductor or messenger. Each of the non-supporting cables must be of equal diameter and weight.

In the **Additional Weight** entry, you can add the weight of additional hardware, such as hangers, as an evenly distributed weight. Enter it in lb/ft (kg/m or N/m for Metric). Do this by manually summing the total weight of additional attachments, and dividing by the total span length.

Supported Cable Information

Non-Supporting Cable and Hanger Data

Number of Cables :

Diameter of Each Cable : in

Weight of Each Cable : lb/ft

Additional Weight (Hangers) : lb/ft

Hanger Ice Load Factor :

Apply the NESC K Factor :

Only to Messenger

Each Cable and Messenger

Design Limits Apply :

Before Attachment

After Attachment

CLEAR

Hanger Ice Load Factor is a factor added to account for ice buildup on the hangers. Determination of the amount of ice is left to the design engineer. The number that has traditionally been used, based on 0.50 inches of ice buildup on the hanger, is a value of 1.8. Southwire does not endorse or recommend this number. For other ice buildup thicknesses, enter your calculated value.

The SAG10® program multiplies the weight of a cable by the quantity of cables and adds that to the total weight. This total weight is evenly distributed over the span length. Radial ice is applied as a uniform layer over each of the cables, as well as the supporting messenger. Wind pressure is applied over the cross-sectional area of the cables and messenger. Radial ice will increase all cable and messenger diameters, and resulting wind areas, by twice the radial ice thickness.

Apply the NESC K Factor

The NESC K factor can be applied in two ways: **Only to Messenger** or to **Each Cable and Messenger**. The NESC manual does not clearly define whether the K factor should be applied to the messenger only, or to each of the cables and the messenger, so both options have been offered to allow for your discretion.

Design Limits Apply

The design limits for messenger-supported assemblies can be applied **Before Attachment** or **After Attachment**. If you want to apply the design limits to the complete assembly, click on the **After Attachment** button. This will ensure that the design conditions are met after installation of cables and additional weights. This approach is best used for new lines.

You may also design messenger-supported systems by applying the design limits to the messenger only. If you want to apply the design limits to the messenger only, click on the **Before Attachment** button. The sag and tension output will then display two calculations per span, the first with the design limits applied to the messenger only, the second to showing the effect on the total assembly. This approach allows cables and additional weights to be added and analysis to be done for a line that has been up for some time. Note that when **Before Attachment** is used, the NESC limits may be exceeded due to the added weight. In some cases, it may be necessary to restring the line.

WARNING!

When you select the **Before Attachment** option, pay special attention to the two calculations per span. It is possible for the first, where the limits are applied to the messenger only, to meet all of the design limits, and the second, showing the effect on the total assembly, to exceed the bare wire design limits. This method should only be used with qualified engineering supervision.

The **Supported Cable Information** options do **NOT** apply to the following designs:

- Any non-supporting cable in direct contact with the messenger, such as figure-8 cable or lashed cable.
- Any pre-assembled non-supporting cable that is strung at the same time as the messenger, such as figure-8 cable. Calculations for these situations are explained below.

4.5.3 Non-Supporting Cable, Pre-Assembled or Lashed

Use this calculation method for non-supporting cables pre-assembled to a messenger prior to stringing.

1. Determine basic information for the messenger, such as area, diameter, weight (per foot, or unit of measure), RBS and chart number.
2. Determine the diameter and weight (per foot, or unit of measure) of the cable(s) being supported.
3. In the Conductor Selection screen, select a Conductor Type for the messenger, then a specific conductor to be used as the messenger.
4. Click Edit Data in the Data panel and enter the Area of the messenger. Enter the Weight (per foot, or unit of measure) of the messenger plus cables. For the Diameter, enter the assembly diameter exposed to the wind. Enter the RBS of the messenger cable and Chart number for the messenger.
5. Click Accept or Save to Custom.
6. You can now use this selection for your sag and tension calculations.

If the cables are in direct contact, such as with lashed cable, the actual amount of combined ice build-up will vary depending on the configuration, quantities and diameter of the attached cable(s). As a result, all calculations assume the most conservative situation: that each cable will be covered with a uniform layer of the radial ice specified in the loadings table. If this is too conservative, it is up to the user to calculate an appropriate reduction of ice, and then reduce the radial ice indicated in the loadings table accordingly.

4.5.4 Marker Balls

This option allows you to add marker balls to a conductor. Each of the marker balls must be of equal diameter and weight.

Data Input for Attachment of Marker Balls

Calculations Apply for a Single Span or Multiple Adjacent Spans
All Spans Must be Within the Current Ruling Span

Span Length With Marker Balls : ft

Quantity of Marker Balls :

Diameter of Ball : in

Weight of Ball : lb

Total Additional Weight (i.e. Dampers) : lb

Design Limits Apply :

Before Attachment After Attachment

CLEAR

The SAG10[®] program multiplies the **Weight of Ball** by the quantity of balls and adds that to the total weight. This total weight is evenly distributed over the span length. Radial ice is applied as a uniform layer over the balls, as well as over the conductor. Wind pressure is applied over the cross-sectional area of the balls and conductor. Radial ice will increase all diameters, and resulting wind areas, by twice the radial ice thickness.

If marker balls are placed on all the spans within a ruling span, and their weight is evenly distributed among all spans, then the results may be obtained using this method. Fill in the **Data Input for Attachment of Marker Balls** prompt screen, using the ruling span length, total quantity of marker balls, their individual diameter and weight, and any additional weight you may have.

If the marker balls are on a single span within the ruling span, meaning the span is not dead-ended on either side, then additional calculations must be performed to determine the sag and tension information within that span. For details, refer to Appendices C and D in the **Appendix** section or at www.sag10.com/support/Documentation.htm.

When you have selected the **Marker Ball** option, the marker ball data appears in the middle of the

sag and tension run, serving as a break between the sag and tension data before and after the balls are installed. The second line indicates the quantity of balls, span, diameter and weight of one ball, and the additional weight (such as total weight of the vibration dampers) as the last item.

Design Limits Apply

The design limits for marker balls can be applied **Before Attachment** or **After Attachment**. If you want to apply the design limits to the complete assembly, click on the **After Attachment** button. This will ensure that the design conditions are met after installation of marker balls and additional weights. This approach is best used for new lines.

You may also design systems by applying the design limits to the conductor only. If you want to apply the design limits to the conductor only, click on the **Before Attachment** button. The sag and tension output will then display two calculations per span, the first with the design limits applied to the conductor only, the second showing the effect on the total assembly. This approach allows marker balls to be added and analysis to be done for a line that has been up for some time. Note that when **Before Attachment** is used, the NESC limits may be exceeded due to the added weight. In some cases, it may be necessary to restring the line.

WARNING!

When you select the **Before Attachment** option, pay special attention to the two calculations per span. It is possible for the first, where the limits are applied to the conductor only, to meet all of the design limits, and the second, showing the effect on the total assembly, to exceed the bare wire design limits. This method should only be used with qualified engineering supervision.

Stringing Sag Table Output for Marker Balls

If you are running a Stringing Sag Table for a line with marker balls, the SAG10[®] program will generate output with the Initial data prior to adding balls, Final data with balls attached, and Final loaded data with balls attached. For more information, refer to the Stringing Module entry in the section on Output Screen toolbar controls.

4.5.5 PLP Spoiler

Click on the **PLP Spoiler** button in the *Conductor Options* panel if you want the calculations to account for the horizontal and vertical loading created by PLP Spoilers.

The **Weight/Spoiler** is the weight of each spoiler in the span.

The **Increase in Cond. Diameter** is the approximate % increase in the conductor diameter due to addition of the spoilers.

Once the requested data is filled in, click on the **Accept** button at the bottom of the **Conductor Selection** screen to return to the **Main Menu** screen. When you run sag and tension calculations, the output will show the added spoilers and the conductor weight for each load condition will include the additional loads created by the spoilers.

Design Limits Apply

The design limits for PLP spoilers can be applied **Before Attachment** or **After Attachment**. If you want to apply the design limits to the complete assembly, click on the **After Attachment** button. This will ensure that the design conditions are met after installation of PLP spoilers. This approach is best used for new lines.

You may also design systems by applying the design limits to the conductor only. If you want to apply the design limits to the conductor only, click on the **Before Attachment** button. The sag and tension output will then display two calculations per span, the first with the design limits applied to the conductor only, the second showing the effect on the total assembly. This approach allows PLP spoilers to be added and analysis to be done for a line that has been up for some time. Note that when **Before Attachment** is used, the NESC limits may be exceeded due to the added weight. In some cases, it may be necessary to restring the line.

WARNING!

When you select the **Before Attachment** option, pay special attention to the two calculations per span. It is possible for the first, where the limits are applied to the conductor only, to meet all of the design limits, and the second, showing the effect on the total assembly, to exceed the bare wire design limits. This method should only be used with qualified engineering supervision.

4.5.6 ADSS Cable

The SAG10® *Conductor Selection* panel of the **Main Menu** includes a selection for **ADSS** (All Dielectric Self Supporting) cable. This feature was written specifically for cable manufactured by AFL Global. As such, it requires data that is not typically supplied by other cable manufacturers. There are no standard conductor designs available for this conductor type. Contact your ADSS cable manufacturer to obtain the information you need for this feature.

In order to perform **ADSS** calculations, first choose ADSS from the *Conductor Type* panel. The *Data* panel will load with no values, so click on the **Edit Data** button if it does not pop up itself, and type in the proper values requested on the screen. These values may be obtained from your ADSS cable manufacturer for your particular cable. Currently, the ability to store custom ADSS cable designs is not available.

The **MRCL** stands for Maximum Rated Conductor Limit and **RBS** stands for Rated Breaking Strength, which is the same as Rated Tensile Strength. It is important that both **MRCL** and **RBS** values be accurate in order to allow stringing the cable to the proper design tensions.

The SAG10 program obtains the allowed percentage of RBS by dividing the MRCL by the RBS. This percentage is often 50%, but may range from 45% to 63+%, depending on the particular cable. The allowable percentage is increasing as new designs are developed.

NOTE: For the breakdown of the sag and tension calculations for an ADSS conductor, refer to the paper titled, "ADSS Sag & Tension."

4.5.7 OPGW Cable

The SAG10 **Conductor Selection** list includes the **OPGW** (Optical Ground Wire) type. The standard OPGW constructions listed are provided, as is, courtesy of Alcoa Fujikura Ltd. (AFL). For information and values for OPGW, contact your OPGW manufacturer.

4.5.8 AAAC Conductor

The SAG10 **Conductor Selection** list includes the **AAAC** (All-Aluminum Alloy Conductor) type. The standard conductor tables supplied are for AAAC made from 6201-T81 aluminum alloy. There are other alloy types that have been, and are currently, being used, most notably 5005 alloy. However, 6201-T81 is the only aluminum alloy recognized by ASTM for AAAC at this time.

4.5.9 ACSR/TW Codewords

Previous versions of the software identify diameter equivalent trap-wire constructions using a TWD suffix rather than the correct codeword. The codewords for the diameter equivalent ACSR/TW conductors have been updated to the new Aluminum Association codewords, where they exist.

4.6 Sort Options

Once a conductor type has been selected, you can change the sort order for the selections in the **Conductor** or **Messenger** box drop-down menu from the Sort menu selection on the screen toolbar.

- **By Size** will cause the SAG10 program to arrange the conductor choices by size, from smallest to largest.
- **By Codeword** will cause the SAG10 program to arrange the conductor choices alphabetically based on the codeword, or the concatenated description for products without codewords.

Edit Loading Table Screen

Load Table Fields

Load Selections

Add Gallop Load

Add Creep Load

Extra Heavy Loads

Use of the Common Point

Printing the Load Table

5 Edit Loading Table Screen

In the *Load Selection* panel of the **Main Menu** screen, you can choose from a list of industry-standard loading configurations. You should always check these values to be sure they are still valid, as standards can change.

If you are using the standard table values, all you have to do is click on a selection in the *Load Selection* panel on the **Main Menu** screen. However, if you would like to view or modify the Load Table, click on the **Edit Load Table** button in the *Load Selection* panel. The *Edit Loading Table* screen will appear and, if you have selected one of the standard loadings, will pre-load those values into the loading table. If you have selected **Custom Load Table** on the **Main Menu** screen, a blank table will preload with a single row, 60.0°F, and Creep in the Usage column for a creep check. Table units and headings are based on your selection of **Units** in the **Main Menu**→**Tools**→**Options** screen.

The figure below shows a load table with **NESC (Unloaded Limits) Medium** values selected. You can make up to a total of 50 additional entries. Once you click **Accept Loadings**, the SAG10® program will automatically sort your entries based on conductor temperature. Thus, you can just add them to the bottom of the table.

You can create custom loading tables with the **Save As** button. Once created, custom load files can be selected on the **Main Menu** screen by checking the **Use Existing Load Table** box. This lets you create a standard load table with the temperatures you need and select it, without having to return to this screen each time you want to use those loading conditions.

The screenshot shows the 'Edit Loading Table' window with the following components:

- Loading Table:** A table with columns: Cond. Temp (°F), Ice (in), Wind (lb/ft²), Limit, Type, and Usage. The first row is selected with Cond. Temp: 15.0, Ice: 0.25, Wind: 4.00, Limit: 60.0, Type: %, Usage: Initial.
- Load Selection:**
 - NESC:** Radio buttons for Light, Medium (selected), and Heavy.
 - NESC (Unloaded Limits):** Radio buttons for Light, Medium (selected), and Heavy.
 - RUS 1724E-200 Table 9-3:** Radio buttons for Light, Medium, and Heavy.
 - California:** Radio buttons for Light, Medium, and Heavy.
 - Custom Load Table:** Radio button.
 - NESC K:** Radio buttons for New (selected), Old, Old (Steel & Cu), and Zero (ignore K).
- Loading Table Notes:**
 - U.S./Imperial Units:** Section header.
 - USAGE MEANING:** Initial – Initial Tension or Sag Limit, Final – Final Tension or Sag Limit, ET – Elevated Temperature Point, Creep – 10 Year Creep Check, CP – Common Point Load, Final/NL – Final No Load (w/o External Loading).
 - Notes:**
 - LIMIT ENTRY: Limit may be entered as either tension in %RBS or pounds, or sag in feet
 - ICE TYPE: A negative value for Ice indicates Rime Ice (positive is Glazed Ice)
 - WIND ENTRY: A negative value for Wind is used for Weight in lb/ft (positive is wind press in lb/ft²)
 - RUS LOAD REDUCTION: Current RUS standards recommend reducing unloaded tensions by 5% (defaults are traditional values)
- Buttons:** OPEN, CLEAR, SAVE AS, ADD GALLOP LOAD, ADD CREEP LOAD, ACCEPT LOADINGS, CANCEL.
- Ice Density:** Glazed: 57.0 lb/ft³, Rime: 37.0 lb/ft³. Includes SAVE TO DEFAULTS and RESTORE DEFAULTS buttons.

5.1 Load Table Fields

The Load Table fields (columns) are:

- **Conductor Temperature** (°F or °C)
- **Radial thickness of ice** (inches or mm). The default ice density is 57.0 lb/ft³ for glazed ice, per the NESC. Entering a negative value will cause the calculations to use the ice density for rime ice (or wet snow). The default density for rime ice is 37.0 lb/ft³. Both the glazed and rime ice densities can be modified in the *Ice Density* panel on the **Edit Loading Table** screen. The *Ice Density* panel has input boxes, **Save to Defaults** buttons for permanent use of edited densities, and a **Restore Defaults** button.
- **Horizontal wind load** (lb/ft², kg/m², or N/m²). Negative wind values are used as total weight per unit length. Negative wind values should not be used when the **Marker Balls** or **Use as a Messenger** options are selected on the **Conductor Selection** screen.
- **Limit** (lb, kg, kN, ft, m, or %RBS). If a negative value is entered, the calculations will use the number as a sag limit. Unlike previous versions of the SAG10[®] program, if the limit is in %RBS, the number should be input in percentage form, not decimal form; e.g. for 33.3 %RBS, you would enter 33.3 instead of 0.333. For Metric input, enter this **AFTER** you switch the **Type** because the value converts based on the **Type**.
- **Type** (lb, kg, kN, ft, m, %RBS). The field specifies the unit for the **Limit** used.
- **Usage** indicates when a condition or limit is to be applied. Options are:
 - Initial = Initial Tension or Sag Limit
 - Final = Final Tension or Sag Limit
 - ET = Elevated Temperature Point
 - Creep = 10-Year Creep Check
 - CP = Common Point Load
 - Final/NL = Final without External Loading Tension or Sag Limit

NOTE

The bare weights in the outputs are from the conductor database or a customconductor you create. Loaded weights are calculated by adding the bare weight plus the effect of the wind and ice as defined in the load table.

5.2 Load Selections

You can quickly load a standard table using the loadings listed in the *Load Selection* panel. Selecting from this list will cause any values currently in the load table to be deleted, and the new values loaded.

It is left to you to determine if these values are appropriate and sufficient for the conductor selected and the operating conditions. For example, these limits and loads may

need to be modified for all-aluminum conductors to prevent vibration, or loading conditions may be modified for operating conditions such as extreme ice and wind loads.

5.2.1 NESC

The 2017 NESC (National Electric Safety Code) Light, Medium, and Heavy loadings for overhead conductors are shown in the tables below. Tension limits indicate the maximum tensions allowed by the NESC. The 2017 revision to the NESC removed the unloaded tension limits if one of the following vibration mitigation methods is used: vibration control devices, stress-reduction devices, self-damping conductors, or vibration-resistant conductors. You should verify these tables, as they may change as the NESC code is revised.

You should be familiar with the NESC standard, as there are exceptions and cases where it may be inappropriate to apply these limits.

Note that AFL recommends that NESC Limits be reduced to 50.0% for ADSS cables.

NESC																	
Light						Medium						Heavy					
Cond. Temp °F	Ice in	Wind lb/ft ²	Limit %RBS	Type %	Usage	Cond. Temp °F	Ice in	Wind lb/ft ²	Limit %RBS	Type %	Usage	Cond. Temp °F	Ice in	Wind lb/ft ²	Limit %RBS	Type %	Usage
30.0		9.00	60.0	%	Initial	15.0	0.25	4.00	60.0	%	Initial	0.0	0.50	4.00	60.0	%	Initial
30.0						32.0	0.25					32.0	0.50				
60.0					Creep	0.0						-20.0					
90.0						30.0						0.0					
120.0						60.0					Creep	30.0					
167.0						90.0						60.0					Creep
212.0						120.0						90.0					
						167.0						120.0					
						212.0						167.0					
												212.0					

5.2.2 NESC (Unloaded Limits)

Where none of the aforementioned vibration mitigation methods are used, the 2017 NESC requires application of unloaded tension limits of 35% RBS initial and 25% RBS final without external loading, at a temperature dependent on the loading district. Final tension in this application is the tension that exists after long-term (10-year or normal) creep and prior to ice and wind loading. The SAG10[®] database includes alternative loading tables for these designs, as shown below:

NESC (Unloaded Limits)																	
Light						Medium						Heavy					
Cond. Temp °F	Ice in	Wind lb/ft ²	Limit %RBS	Type %	Usage	Cond. Temp °F	Ice in	Wind lb/ft ²	Limit %RBS	Type %	Usage	Cond. Temp °F	Ice in	Wind lb/ft ²	Limit %RBS	Type %	Usage
30.0		9.00	60.0	%	Initial	15.0	0.25	4.00	60.0	%	Initial	0.0	0.50	4.00	60.0	%	Initial
30.0						32.0	0.25					32.0	0.50				
60.0			35.0	%	Initial	0.0						-20.0					
60.0			25.0	%	Final/NL	15.0						0.0					
60.0					Creep	30.0						30.0					
90.0						60.0			35.0	%	Initial	60.0			35.0	%	Initial
120.0						60.0			25.0	%	Final/NL	60.0			25.0	%	Final/NL
167.0						60.0					Creep	60.0					Creep
212.0						90.0						90.0					
						120.0						120.0					
						167.0						167.0					
						212.0						212.0					

5.2.3 RUS 1724E-200 Table 9-3

The loading limits specified by the Rural Utilities Service (RUS) are shown in the table below. They are more conservative than the NESC limits. If you are designing to RUS standards, they should verify what values are correct per the latest RUS documents.

RUS 1724E-200 Table 9-3																	
Light						Medium						Heavy					
Cond. Temp °F	Ice in	Wind lb/ft ²	Limit %RBS	Type %	Usage	Cond. Temp °F	Ice in	Wind lb/ft ²	Limit %RBS	Type %	Usage	Cond. Temp °F	Ice in	Wind lb/ft ²	Limit %RBS	Type %	Usage
30.0		9.00	50.0	%	Initial	15.0	0.25	4.00	50.0	%	Initial	0.0	0.50	4.00	50.0	%	Initial
30.0			33.3	%	Initial	32.0	0.25					32.0	0.50				
30.0			25.0	%	Final	0.0						-20.0					
30.0						15.0			33.3	%	Initial	0.0			33.3	%	Initial
60.0					Creep	15.0			25.0	%	Final	0.0			25.0	%	Final
90.0						15.0						0.0					
120.0						30.0						30.0					
167.0						60.0					Creep	60.0					Creep
212.0						90.0						90.0					
						120.0						120.0					
						167.0						167.0					
						212.0						212.0					

5.2.4 California

The California Heavy and Light Loadings for Overhead Conductors are shown in the tables below. If you are designing to California standards, they should verify what values are correct per the latest California standards documents.

California											
Light						Heavy					
Cond. Temp °F	Ice in	Wind lb/ft ²	Limit %RBS	Type %	Usage	Cond. Temp °F	Ice in	Wind lb/ft ²	Limit %RBS	Type %	Usage
25.0		8.00	50.0	%	Initial	0.0	0.50	6.00	50.0	%	Initial
25.0						32.0	0.50				
60.0					Creep	-20.0					
90.0						0.0					
120.0						30.0					
167.0						60.0					Creep
212.0						90.0					
						120.0					
						130.0					
						167.0					
						212.0					

5.3 Add Gallop Load

Clicking on the **Add Gallop Load** button in the *Load Selection* panel in the Edit Loading Table screen will insert the loads shown below into the Load Table. These are required to calculate the Galloping Ellipses.

Gallop Load					
Cond. Temp °F	Ice in	Wind lb/ft ²	Limit %RBS	Type %	Usage
32.0	0.50				
30.0					

NOTE

The NESC, RUS and California Heavy loads already include the gallop load conditions.

Refer to the Gallop module section in the Sag & Tension Data screen chapter for more information on galloping calculations.

5.4 Add Creep Load

To make a standard check for creep, click on the **Add Creep Load** button in the *Load Selection* panel. The SAG10® program will add a Load Table entry of:

Creep Load					
Cond. Temp °F	Ice in	Wind lb/ft ²	Limit %RBS	Type	Usage
60.0					Creep

Any row with Creep in the **Usage** column will allow the program to check for creep. If all such entries are removed, creep will not be checked, and incorrect data may result. In such a case, the output will also read **Creep is NOT CONSIDERED**.

If the final sag is controlled by creep, the output will read **Creep governs the final sag**. If the final sag is controlled by the ice and wind from one of the load cases, the output will read **Loading conditions govern the final sag**.

5.5 Extra Heavy Loads

Extra heavy loads, or loads greater than the NESC load, are oftentimes needed for consideration in sag-tension calculations. For instance, a utility may want to use a more accurate load than the NESC load, or maybe a 1% (once per hundred years) load needs to be considered. Whatever the case, these extra heavy loads need to be properly considered. When you add an extra heavy load, you want to make sure the structure limits are not exceeded. You will need to add a tension limit similar to the one below.

Extra Heavy Load					
Cond. Temp °F	Ice in	Wind lb/ft ²	Limit %RBS	Type	Usage
0.0			15,000	lb	Initial

The extra heavy load tension limit will be the Design Condition unless one of the standard tension limits is reached first.

5.6 Use of the Common Point

A Common Point is used to calculate the sag and tension at an extra heavy load without affecting the final sag-tension calculations. This can allow engineers to forecast a 1% (once per one hundred years) load without the final sags and tensions taking into account the non-recoverable strain from that load, which could potentially create larger sags.

A Common Point may be used at any loading condition by specifying CP in the Usage column of the **Edit Loading Table** screen. If a Common Point needs to be added, but the condition already has the Usage column filled, another line may be added with the same loading conditions.

Placing a Common Point at a specific loading condition forces the final sag and tension calculations to consider **ONLY** non-recoverable strain from two conditions: the Common Point load and creep. That means the non-recoverable strain from all other mechanical loads will be ignored, regardless of whether the load is greater or lesser. The non-recoverable strain at the Common Point loading condition will govern the final sags and tensions unless creep yields more strain.

If the calculation uses ACSS conductor, the Common Point condition will always govern because ACSS is assumed not to creep.

5.7 Printing the Load Table

Saved Loading Table files with a .LOD extension can be opened with a word processor, such as Microsoft WordPad or Microsoft Word. Highlight the text and select a fixed pitch font such as Courier New. If you want the table headings, you will have to type them in manually. When you have chosen your font and headings, print from the word processor.

Sag & Tension Data Screen

Data Screen

Creep Messages in the Data Screen

Data Screen Upper Toolbar Controls

Data Screen Lower Toolbar Controls

6 Sag & Tension Data Screen

NOTE

The toolbar in the SAG10® Sag & Tension Data screen offers many important project calculation choices. For details, refer to the Data Screen toolbar controls section below.

6.1 Data Screen

When you run sag and tension calculations, either from the **Calculate Sag & Tension** button on the **Main Menu** screen, or from the **Main Menu** toolbar→**Run** menu, the SAG10 program generates a **Sag & Tension Data** screen to display the output. You can use the scroll bars to view data that extends off the screen.

If you selected the **Pause between Spans** option, either in the *Ruling Spans* panel of the **Main Menu** screen, or in the **Main Menu** toolbar→**Run** menu, the toolbar at the top of the **Sag & Tension Data** screen will contain the **Next Span** option. Clicking on **Next Span** will allow the SAG10 program to calculate each span until the last span is displayed.

The SAG10 Main Menu screen toolbar→**Tools**→**Options**→*Also Output Results* to panel lets you send sag and tension output to either a printer, or a file, as well as the **Sag & Tension Data** screen when a calculation is run. If you select this, the output of calculations for the modules listed in the **Sag & Tension Data** screen toolbar→**Modules** menu selection: **Stringing**, **Offset Clip**, **RS Variation**, **Gallop** and **Clash** are also sent to the printer or file.

Refer to the SAG10 **Main Menu** screen toolbar→**Page Setup** menu selection for options such as adding your Company name and date to the page header.

6.2 Creep Messages in the Data Screen

6.2.1 Extrapolated Curve Message

If your output indicates that the SAG10 program has had to extrapolate a stress-strain curve beyond the point where it may be valid, this message will appear. This may happen anytime large mechanical loadings are placed on a conductor, particularly in longer spans, and very large strains are encountered. The SAG10 program estimates the stress-strain curve in these situations to the best of its ability and completes the calculation. However, you should be aware that this is occurring as it may affect the accuracy of your results.

6.2.2 Creep Messages and Critical Tension

- If your output indicates that **Normal creep determines the final sag**, it means that final sag and tension are controlled by the non-recoverable strain caused by the long-term creep of the conductor.
- If your output indicates that **High tension loading determines the final sag**, it means that final sag and tension are controlled by the non-recoverable strain caused by one of the loaded conditions.
- If your output indicates that **Creep is NOT CONSIDERED**, it means that you have bypassed the normal creep check by leaving out Creep in the Usage column of a temperature case in the Loading Table and that the output is therefore potentially incorrect. To add the creep creep, you can click Add Creep Load in the Edit Loading Table screen.

For hotter climates, the normal creep check condition at 60.0°F may be changed to a higher conductor temperature, such as 70.0°F. Likewise, for a colder climate, the normal creep check condition may be changed to a lower conductor temperature, such as 50.0°F. The 10-year creep load will be applied at the highest conductor temperature in the loading table with a no load, no tension limit and Creep in the Usage column. The critical tension (Tcr) is the tension corresponding to the intersection between final modulus curve and 10-year creep curve in the conductor stress-strain chart.

If $T > T_{cr}$, then the 10-year creep curve strain is greater than the final modulus curve strain, and the final sag and tension will be based on the 10-year creep curve. The Data Screen message will read: **Normal creep determines the final sag.**

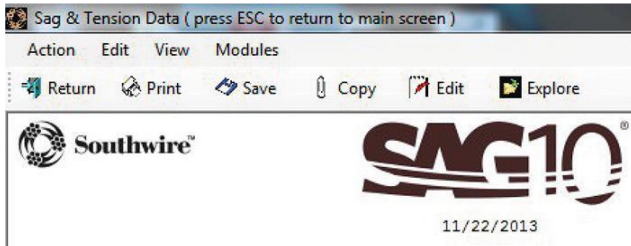
If $T < T_{cr}$, then the 10-year creep curve strain is less than the final modulus curve strain, and the Final sag and tension will be based on the final modulus curve. The **Data Screen** message will read: **High tension loading determines the final sag.**

6.2.3 Loading Limits Table

The limits defined in the loading table will be reported in the output. Limits can include tension (directly or in %RBS) or sag. The table will also include any conditions you set such as: ET (Elevated Temperature Point), Creep, or CP (Common Point Load). This table can allow you to accurately recalculate sag-tension using only this report.

Loading Limits						
Cond. Temp °F	Temp °C	Ice in	Wind lb/ft ²	K lb/ft	Limit	Usage
15.0	-9.4	0.25G	4.00	0.20	60.0 %	Initial
15.0	-9.4	0.00	0.00	0.00	35.0 %	Initial
15.0	-9.4	0.00	0.00	0.00	25.0 %*	Final/NL
60.0	15.6	0.00	0.00	0.00		Creep

6.3 Data Screen Upper Toolbar Controls



6.3.1 Action

Export to Printer

This menu item displays the standard Windows® printer setup and selection window.

Export to File

This menu item saves the report file to a location you specify.

Set Up Fonts

This menu item opens the SAG10® Font window. For details, refer to the **Main Menu** screen toolbar→**Setup** menu section.

Explore Folder

This menu item lets you browse for a file or folder location you specify.

Exit to Main Screen

This menu item closes the **Sag and Tension Data** screen and returns you to the SAG10 **Main Menu** screen.

6.3.2 Edit

Cut, Copy, Paste to Clipboard

These menu items implement the standard Microsoft Word commands.

Edit with Wordpad

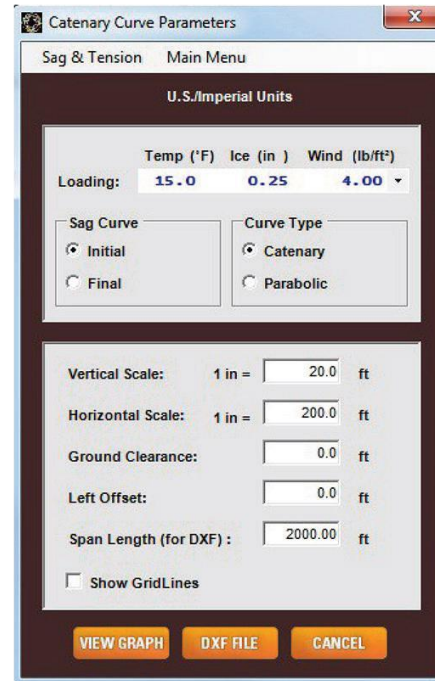
This menu item opens Microsoft Word and loads the output report for editing.

6.3.3 View

Sag Curves

This menu item opens the **Catenary Curve Parameters** window.

This window lets you set parameters for the sag curve display.



Catenary Curve Parameter Window Controls

- **Sag Curve** settings for **Initial** or **Final** sag
- **Curve Type** settings for **Catenary** or **Parabolic** curve.
- Adjustable **Horizontal** and **Vertical** scales
- You can specify a **Ground Clearance** for the sag curve. If you enter a value of 0, no ground clearance will be shown with the sag curve
- Set a **Left Offset** for the sag curve to allow better viewing of flatter sag curves.
- Checking the **Show Gridlines** box will put gridlines on the screen, printed and DXF output. This may aid in alignment of the sag curves with your own grid system.
- You can specify a custom **Span Length** for the DXF output.
- The **View Graph** button opens the **Catenary Curve** screen. You can print or plot the image directly, or transfer it to a graphics program for further **editing**. **Toolbar options in the Catenary Curve screen toolbar**:
 - o **Save as BMP file** saves the curve to a .BMP file.
 - o **Print/Plot** will send the curve to the default printer or plotting device.
 - o **Page Setup** allows you select print options such as portrait or landscape print orientation in a standard Microsoft Word printer setup window.
 - o **Return** takes you back to the **Catenary Curve Parameter** screen.

- The **DXF File** button saves the sag file as a .DXF file in a location you specify. A DXF file can be imported into most CAD programs. Typical uses would be to generate a sag template overlaid with other conductors, or to import the sag curve into a drawing containing some ground profile for structure spotting.
- The Cancel button closes the Catenary Curve Parameters screen and returns you to the Sag & Tension Data screen.

6.3.4 Stringing Module

The Stringing Module may be used to make calculations for pulling conductor up to sagging tension during installation. The calculation results are the sags for the individual spans in a tension section. Selecting this option from the **Sag & Tension Data** screen toolbar **Modules** list will open the **Stringing Temperatures** screen.

Stringing Spans

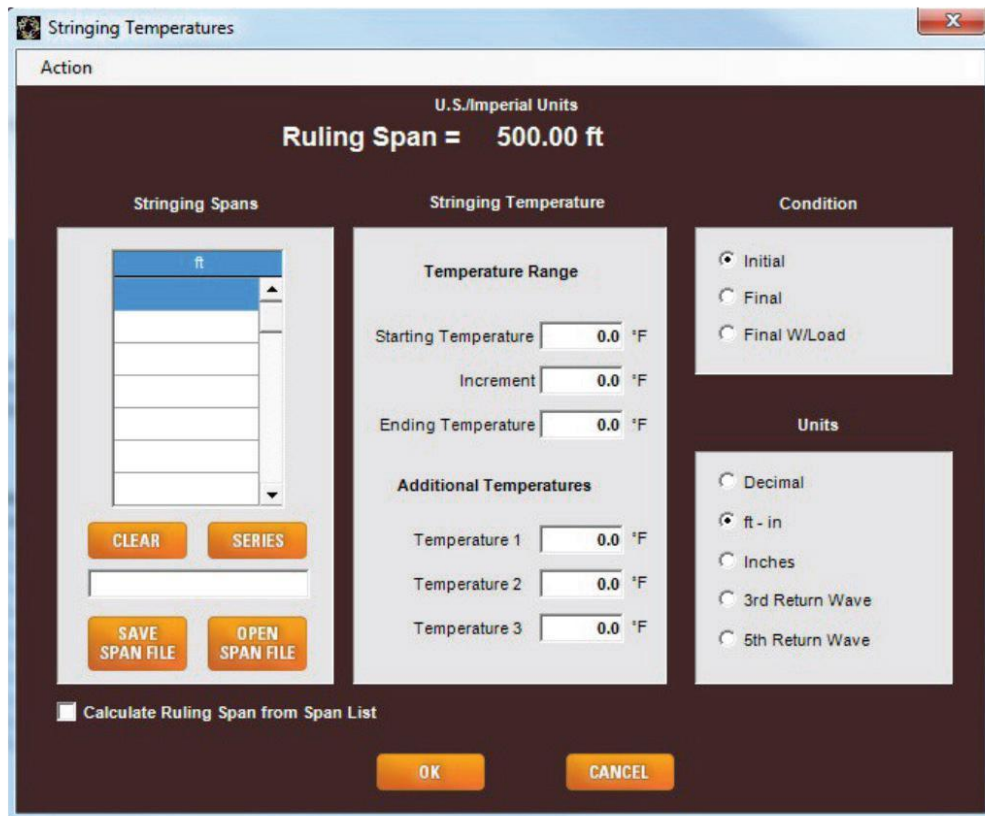
You can enter multiple spans within the ruling span, or select up to 40 individual spans. The number of spans times the number of conductor temperatures may not exceed a total of 1880.

Calculate Ruling Span from Span List

You can also retrieve a span list from a .spn file created and saved in the **Ruling Span Calculation** screen (Refer to the **Main Menu** toolbar→**Run** menu section). If this box is checked, the SAG10® program will calculate a ruling span for the list of spans used.

Stringing Temperatures

The stringing temperatures should be chosen as all the possible conductor temperatures on the day of sagging. The appropriate stringing temperature may be found using a conductor thermometer on the day of sagging. You can enter up to 30 stringing temperatures. The stringing temperatures you enter are independent of the conductor temperatures you selected for the normal sag and tension calculation.



The stringing temperatures you enter will be retained for the entire SAG10® session, and are saved with the project file.

Condition

Selecting the **Initial** condition will calculate initial sags, and selecting **Final** will calculate the final sags. **Final W/Load** calculates the final loaded sags.

If you have chosen **Marker balls** or **Use as a Messenger** in the **Conductor Selection** screen (For more details, refer to the **Conductor Selection Screen** chapter.), **Initial** will calculate without balls or cables, and **Final** will calculate with balls or cables attached. This will let you string the bare wire before attaching balls and cables, and then check the final sag after attachment.

If you are stringing pre-assembled aerial cable, enter the data without balls or cables. The Stringing Sag Table will be output as Initial Sag with the attached cable load. (For more details, refer to the **Conductor Selection Screen** chapter.)

Final W/Load will calculate with balls attached. This selection will generate stringing sag tables using all of the temperatures with ice or wind loading.

Horizontal tensions are, by definition, the same in all spans within a ruling span section. The SAG10 program calculates and stores the horizontal tension for each conductor temperature needed in constructing a stringing chart. Stringing sag tables are not available when running elevated temperature creep.

Units

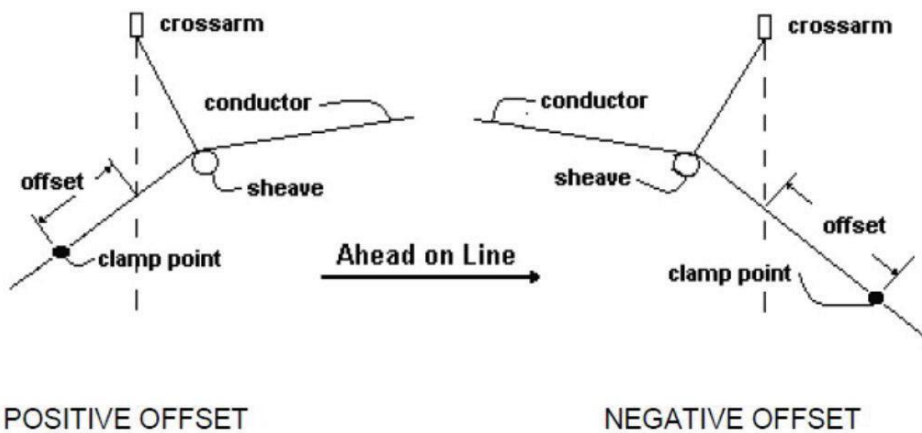
- The default stringing sag output is **ft-in** for U.S./Imperial Units. ft-in allows the output to be shown in feet and inches. Inches shows the output in inches only.
- The setting will default to Decimal for Metric Units. Decimal units are feet for U.S./Imperial and meters for Metric.
- 3rd and 5th Return Wave will generate stringing sag output as the time in seconds for sagging done by stopwatch.

For a more concentrated look at the formulas and methods used for stringing calculations, go to <http://www.southwire.com/transmission/OCM.htm> to obtain a copy of the Southwire Overhead Conductor Manual.

6.3.5 Offset Clip Module

When conductor is strung on steep hillsides it will “run downhill”. As a result, the lower spans will have more than chart sag and the upper spans will have less than chart sag. This difference between chart sag and sag in sheaves can be computed and is given below as “sag correction”. This sag correction is to be added (+) or subtracted (-) from chart sag to obtain the “sag in sheaves”.

Using the “sag correction” to obtain the “sag in sheaves”, the conductor is strung between dead-ends or snubbing stations. The correct length of conductor exists between the two end points but not in each individual span. The “clipping offset” given below is the length of conductor that must be pulled from each span into an adjacent span in order to have the correct length at chart sag in all spans.



All offsets are measured from the intersection of the conductor and a vertical line through the point of attachment of the insulator string in its final position. If the structure is leaning, the vertical line must be projected from the base of the structure. All offsets must be measured before any "clipping in". When the conductor is in suspension clamps, all insulator strings will swing plumb. Positive offsets (+) are measured in the direction of the first structure, thus the conductor moves ahead on line. Conversely, negative offsets (-) are measured in a direction away from the first structure in the sagging section.

The SAG10® offset clipping program uses techniques presented in AIEE Paper 59-900, "Sag-Tension Computations and Field Measurements of Bonneville Power Administration" by Paul F. Winkelman.

Required Data

You will need to know the following factors: ruling span, horizontal stringing tension, stringing temperature, maximum design tension, loading-ice, wind, conductor temperature, bare weight, area and modulus. Many of these factors are already part of the SAG10 program.

The program asks for elevation, station and structure number. You must also know the direction of pull. The printout produces positive or negative insulator offsets and sag corrections by structure number.

Create a File

You will need to create a file in a text editor that has ASCII output. Set the file extension to .CLP. In the file, each structure will have its own line with the following information, in this order, separated by commas:

- Elevation
- Station back
- Station ahead (Set to 0 if there is no equation station.)
- Structure identification, enclosed in single quote marks

A sample file called SAMPLE.CLP appears below. The example shows the pull from Structure 1-1 to 1-12. Structure 1-6 is a sample of an equation station.

Sample Clipping Data File (sample.clp)

1951,107253,0,'Str # 1-1'	
1851,107353,0,'Str # 1-2'	
1941,107453,0,'Str # 1-3'	COLUMN 1 - Elevation
1851,107553,0,'Str # 1-4'	
1051,107653,0,'Str # 1-5'	COLUMN 2 - Station Back
1921,107753,107783,'Str # 1-6'	
1971,107853,0,'Str # 1-7'	COLUMN 3 - Station Ahead
1981,107953,0,'Str # 1-8'	(Greater than zero if equation station)
1955,108053,0,'Str # 1-9'	
2051,108153,0,'Str # 1-10'	COLUMN 4 - Structure Number
1651,108253,0,'Str # 1-11'	
1451,108353,0,'Str # 1-12'	

Offset Clipping Run Procedure

1. Create a .clp file as described above.
2. Create and execute a sag and tension run for the ruling span in which the offset clipping will be used.
3. In the **Sag and Tension Data** screen toolbar, select **Modules→Offset Clipping**.
4. A standard **Open File** window will appear. Select the file you created in step #1.
5. When you click on **Open** in the **Open File** window, the **Offset Clipping** screen will appear.

The most recently calculated Ruling Span is displayed as the first input. If you choose that Ruling Span and a stringing temperature from the most recent Sag and Tension run, then the correct Horizontal Tension will be offered as the third input.

6. Click on the **OK** button. The Offsets will appear on the **Sag & Tension Data** screen.

6.3.6 Ruling Span Variation Module

This module calculates the variation in sags and tensions when spans of differing lengths see large temperature excursions.

Causes of Sag and Tension Variations

Between dead-end structures, there are typically a variety of different span lengths. The ruling span is a mathematical number that represents a best approximation of the average characteristics that will occur within each of those spans. At initial stringing temperature, the horizontal tension is the same for all of the spans, assuming the conductor is pulled in evenly across the various spans. However, the further the conductor

temperature deviates from the stringing temperature, and the further a span length varies from the ruling span, the greater the variation in sag and tension.

These variations are normally small enough to fall within the safety margin allowed in line design. However, at elevated or cold temperatures and with large span variations, these variations may be large enough that they should be considered during line design. This section allows you to become aware that certain spans may have more sag and other spans may have more tension than was calculated by the ruling span sag and tension data – and to quantify those differences.

Calculations are Limited to Suspension Insulators

These calculations apply only for suspension insulator systems, where the insulators are free to swing, limited only by gravity. Fixed insulators, such as post insulators, would have less change in sag and tension and are not calculated here. Calculating the exact stiffness of the support structure would be required, numbers that would be difficult to obtain.

Running Ruling Span Variations

To use this module:

1. Select **Modules**→**RS Variation** in the **Sag & Tension Data** screen toolbar. A standard **Open File** window will open. Select either a .SPN file created in **Ruling Span Calculations** screen or a .CLP file from clipping offset calculations. When you click on **Open** in the **Open File** window, the **Variations in Ruling Span Data** screen will appear.
2. Select the correct stringing temperature from the **Stringing Temp** drop-down menu.
3. Select the conductor temperature to compare with in the **Temp/Load to Compare** drop-down menu. You can view the extreme variations by selecting an elevated temperature, a cold temperature, or an ice load condition for comparison.
4. Set the comparison condition by clicking on **Initial** (for cold temperature or ice load comparison) or on **Final** (for elevated temperature comparison).
5. Enter the **length** and **weight** of the entire string of suspension insulators.
6. Click on the **OK** button, and the Variations in Ruling Span calculations will appear on the **Sag & Tension Data Screen**.

6.3.7 Gallop Module

The SAG10[®] program will calculate galloping by three methods, the two common methods of Davison and Toye, and calculations by C.B. Rawlins, based upon his IEEE paper.

Conductor Galloping Phenomenon

Galloping has been a problem to operators of overhead lines for decades. Its occurrence is largely limited to areas subject to icing of conductors at times when the wind is mainly crosswise to the line; more specifically, it is limited to periods of freezing rain when the temperature is about 30.0°F. On double circuit lines, it has occasionally been noted that the conductors on the leeward side galloped violently, while those on the windward side were calm. A few observations have been reported of galloping that occurred on bare (free-of-ice) conductors.

The hazards presented by galloping conductors are: contact between phases, contact between phase conductors and ground wires, possible mechanical damage at supports, and damage to supporting structures. Mechanical damage at supports is due to the violent gyrations of the conductors. Conductor damage can occur at supports due to contact with suspension clamps. Conductor damage or trip-outs can occur from contact between phases or with ground wires.

During galloping, the conductors oscillate almost vertically in one or two loops per span. The path of the conductor at its antinode is usually an ellipse whose major axis is tipped at a small angle to the vertical. In the case of single loops, studies indicate that the major axis can be somewhat larger than the sag in the span under loaded conditions, and the minor axis can be up to about 40% of this value. It has been noted that single-loop galloping rarely occurs in spans over 600 to 700 ft. This is fortunate, since it would be impractical to provide clearances large enough in long spans to prevent the possibility of contact between phases.

Observations indicate that in longer spans, galloping usually takes place with two loops per span, with the maximum motion of the conductor taking place at the quarter points of the span.

The elliptical path of a conductor galloping in a single loop has been studied by A. E. Davison, formerly of the Hydroelectric Power Commission of Ontario. Davison's diagram shown in the figure below indicates that the elliptical path has a major axis inclined to the vertical at a slight angle, and that the entire elliptical path is displaced leeward of the point of conductor support. This path of a conductor galloping in a single loop is defined by the equations under the diagram.

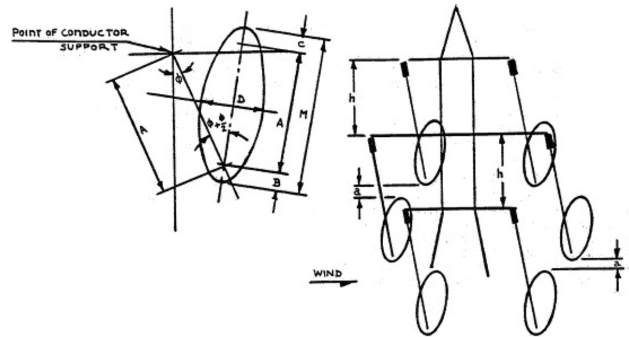


Fig. 32 - Schematic representations and equations of the elliptical paths of a conductor-in a single loop and in two loops per span.

Elliptical path of conductor when dancing in single loop. (A.E. Davison)

$$\Phi = \tan^{-1} \left(\frac{2 P s f \text{ Wind Load on } 1/2" \text{ Ice}}{Wt \text{ of Conductor } + 1/2" \text{ Ice}} \right)$$

$$A = \text{Sag @ } 1/2" \text{ ice, No Wind at } 32 \text{ Deg F, Final}$$

$$B = A/4$$

$$C = 1 Ft$$

$$D = \text{Minor axis} = .4 * M \text{ (Major axis)}$$

$$M = B + A + C$$

Ellipse is the possible envelope of conductor travel during "dancing".

Elliptical path and clearance diagram for conductor dancing in two loops per span. (L.W. Toye)

$$M = \sqrt{\frac{3x \left(\left(\frac{L}{2} \right)^2 + S^2 \right) x \left(L + \frac{8xS^2}{3xL} - 2x \sqrt{\left(\frac{L}{2} \right)^2 + S^2} \right)}{8}}$$

$$K = \sqrt{(M+1)^2 - (M-1)^2} = \text{Minor axis of ellipse}$$

M = Major Axis of Ellipse

L = Span length between towers

S = Sag of conductor

$$h = (M + a - 1) \text{ Cos } (\theta)$$

a = design clearance

theta = angle of swing of conductor

The elliptical paths and a diagram of the clearances for conductors galloping in two loops per span have been developed by L. W. Toye, of the Public Service Electric and Gas Company of New Jersey. The equations showing parameters of the clearance diagrams for the galloping conductors of such spans are given in the right-hand column of the figure above.

Since actual galloping of conductors on transmission lines occurs so infrequently and usually under bad weather conditions, field observations are scarce, even though the phenomenon has been known for a long time. Personal observations have been recorded

occasionally, and motion pictures have been obtained, but these have not been particularly helpful in the physical study of the prevention or cure of galloping.

Many attempts have been made to apply simulated ice buildups so that normal winds might produce consistent galloping effects and the system could be studied at will, but here, too, results have been limited.

Stockbridge dampers, known for their ability to control the frequencies encountered with Aeolian vibration, are not considered helpful in controlling galloping conductors; the dampers may, in fact, be damaged by the galloping. Other methods - most of them requiring expensive or impractical devices - have been tried or described, but no effective means of prevention is as yet available

Add Gallop Loads

Before you can do galloping calculations, you must have gallop load entries in your load file:

- One line showing 30°F, no ice, no wind
- One line showing 32°F, 0.50" ice, no wind

Clicking on the **Add Gallop Load** button in the *Load Selection* panel of the **Edit Load Table** screen will add these entries to the load table automatically.

Running Gallop Calculations

Select **Modules**→**Gallop** in the **Sag and Tension Data** screen toolbar and the **Galloping Data Entry** screen will open.

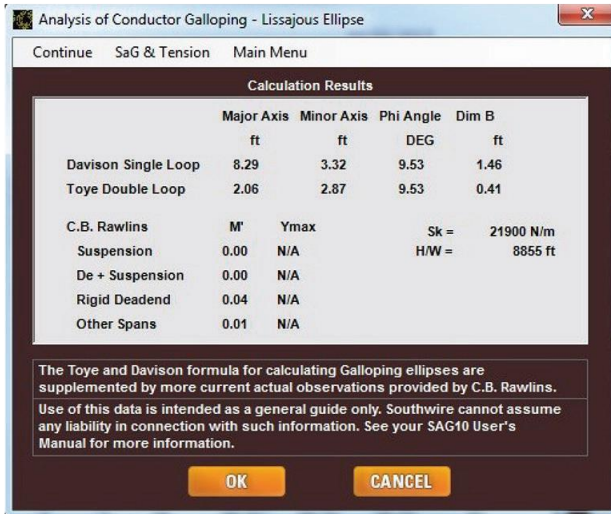
The **Galloping Data Entry** screen displays current conductor information, applicable sag and tension calculation results, and prompts for additional information.

Horizontal Span: The displayed value defaults to the current ruling span. This may be made larger or smaller, to match specific span lengths within the ruling span.

Suspension Insulator Length: If this value is greater than zero, the Rawlins calculations will create a Ymax (peak to peak amplitude) result for suspension structures, and an insulator length will be shown in the graphical display.

Structure Spring Constant: This value is used in calculating the Ymax value in the Rawlins calculations. The value will vary from the sample entry of 21900 and should be determined specifically for your structures. For more details, refer to "Analysis of Conductor Galloping Field Observations – Single Conductors" by C. B. Rawlins. The Davison and Toye formulas give ellipse dimensions recommended for use in design, based on observations available at the time they were published. These dimensions have been widely applied in designing clearances for galloping. A more recent, larger collection of field observations provides the basis for the Ymax values.

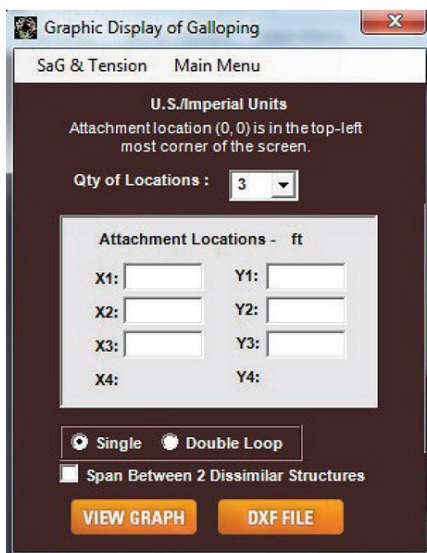
Designers are cautioned that a wide variety of ellipse orientations and eccentricities occur in practice. Refer to Fig. 4-6 of EPRI's Transmission Line Reference Book, "Wind Induced Conductor Motion" for information on the ranges of variation.



When you click on the **OK** button in the **Galloping Data Entry** screen, the **Analysis of Conductor Galloping** screen opens. This window shows the results of the Davison, Toye and Rawlins galloping calculations.

If suspension insulator length prompted for in the **Galloping Data Entry** screen is set to zero, the Rawlins results for suspension insulators will show N/A. If M' has a value, but Ymax indicates N/A, it means that the value for Ymax is outside of the range of test data available in the galloping study in Rawlins IEEE paper. No input is required for this screen.

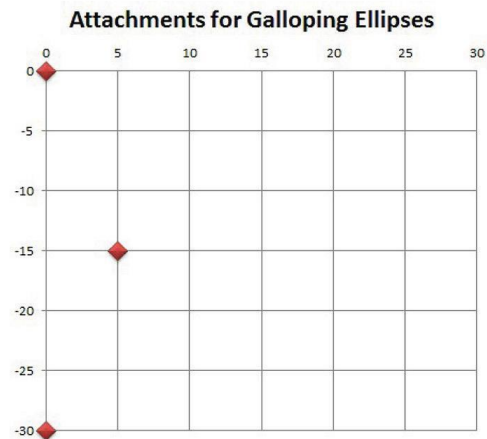
If you click on the **OK** button in the **Analysis of Conductor Galloping** screen, the **Graphic Display of Galloping** screen will open.



To display a graphical layout of the galloping ellipses, you will need to enter two- dimensional Cartesian coordinates for conductor attachment points. Click on the arrow to the right of the **Qty of Locations** box to select a display of 1 to 4 conductors. An equal number of pairs of attachment point boxes will be displayed, (X1,Y1) thru (X4,Y4).

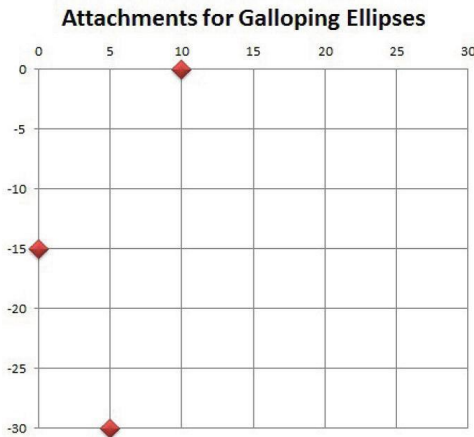
The attachment point furthest to the left and highest in elevation should be considered the baseline value of (0, 0). The other attachments are then measured from this point. This is to ensure the display is viewable. For optimal scaling, use the Print Scale feature.

An example of properly selecting attachment locations is shown below.



Above is a plot of the following attachment locations: (0,0) (5,-15) (0,-30).

If there is no attachment point that meets the criteria of being in the upper left-hand corner, then a layout similar to that shown below should be used.



Above is a plot of the following attachment locations: (0,-15) (5,-30) (10,0). This layout is typical for a 3-phase system on a single pole davit arm or post insulator.

Galloping loops may be graphed as either Single Loop (Davison) or Double Loop (Toye).

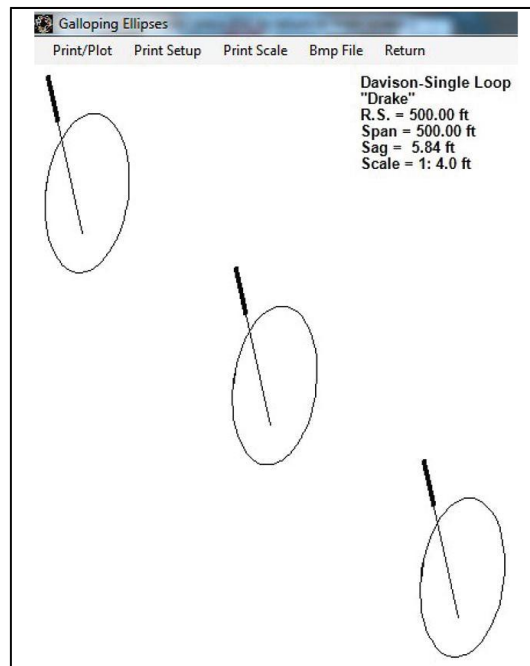
Clicking on the **DXF File** button will open a standard **Save As** window where you can browse for a location to save a DXF file that can be imported into most CAD programs. A typical use for this would be to overlay the Galloping Ellipses from more than one conductor with the image of a power line structure.

Another use would be for viewing the proximity of ellipses between the conductor and OHGW, or to other circuits on the same structure with different conductor or sag characteristics. In this case, it is necessary to run sag & tension calculations for each conductor or OHGW separately, and generate a separate DXF file for each wire. Each DXF file is then imported to a CAD program for overlay upon each other and/or a structure drawing.

If you have two dissimilar structures, such as a suspension tangent and a dead-end structure, or a horizontal phase layout that rolls into a vertical layout, and you want to determine the midspan galloping performance, check the **Span Between 2 Dissimilar Structures** box. The **2nd Structure Attachment Points** screen will be added to the **Graphic Display of Galloping** screen.

In the example shown above, the first structure is horizontal suspension and the second is a vertical dead-end structure. The resulting graphic output is equivalent to two structures with attachment points that are an average of the X and Y coordinates of the two structures, and an average of the attachment point suspension lengths.

When you click on the **View Graph** button, the graphic display of the galloping ellipses is created.



You can print or plot this image directly, or transfer it to a graphics program for further customizing, such as adding to or removing part of the image, setting margins, and/or rescaling before printing/plotting.

Galloping Graphic Display Toolbar Controls

Print/Plot will send the graphic image to the printer or plotter selected in Print Setup.

Print Setup opens a standard printer setup and selection window. You can select the printer or plotter you want to use here.

NOTE

When returning to the **Sag & Tension Data** screen, the output will continue to print in the direction that was most recently set. **Be sure to reset the print direction prior to leaving this area to whatever direction may be required for the next print operation.**

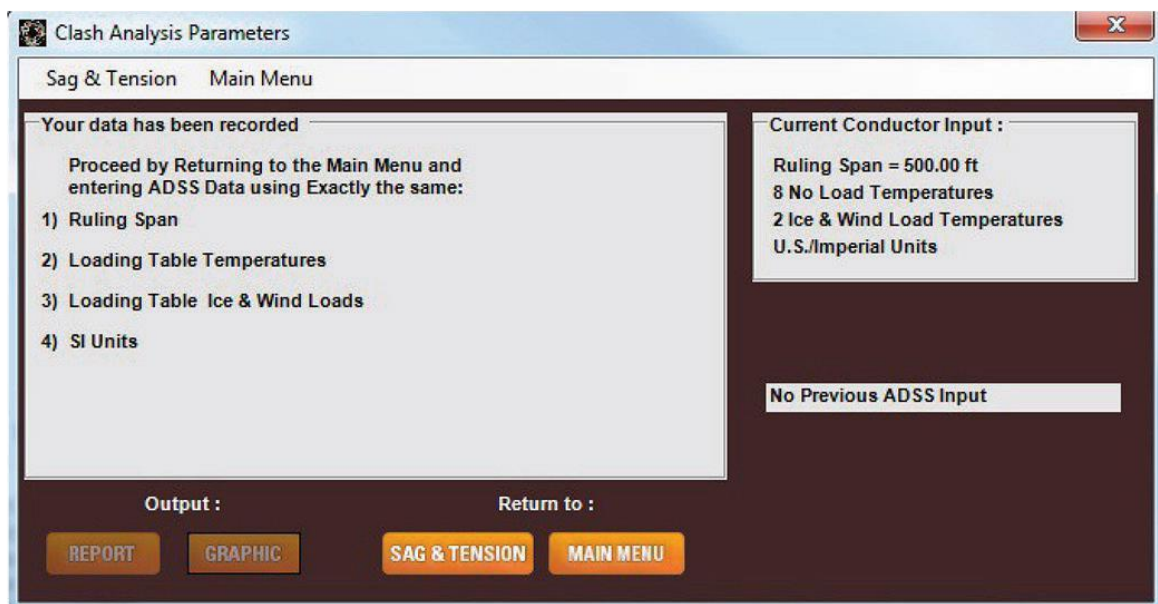
Print Scale opens a window that shows the smallest ratio that will fit on the currently selected printer/plotter paper. A larger number creates a smaller image. Try a scale such as 80:1 for Portrait and 60:1 for Landscape mode for the example shown.

BMP will generate a .BMP file of the graphic screen and open a browser window where you can select a file name and a storage location.

6.3.8 Clash Module

Clash Analysis refers to the loaded and unloaded swing and static clearances between your chosen conductor and ADSS supported on the same structure, for both initial and final state. Conductor suspension insulator string length is taken in consideration. The steps required are:

- 1) Create or Open a project file for the chosen conductor with all the appropriate loads and ruling span.
- 2) Save the Project.
- 3) In the **Main Menu** toolbar, select **Run→Sag & Tension**.
- 4) In the **Sag & Tension Data** screen toolbar, select **Modules→Clash**.
- 5) The **Clash Analysis Parameters** screen will appear indicating that your data has been recorded. Click on the **Main Menu** button to return to return to the **Main Menu** screen to enter the ADSS cable data.



- 6) In the **Main Menu**, click on the **Conductor Selection** button. Select the **ADSS** conductor type and click on the **Edit Data** button in the *Data* panel. Enter the ADSS cable information and click **Accept**.
- 7) Change the Loading Limits (tension or sag) in the **Load Table** if appropriate but **leave all loading conditions, both unloaded and loaded, exactly the same**.
- 8) In the **Main Menu** toolbar, select **Run→Sag & Tension**.
- 9) In the **Sag & Tension Data** screen toolbar, select **Modules→Clash** for a second time. A **Clash Analysis Parameters** screen with spaces for data entry will appear.

- 10) Adjust the parameters shown on the screen as needed. Be sure to fill in **Insulator Length** if **Suspension** is selected, and the **Horizontal** and **Vertical** offsets between the two cables
- 11) In the **Clash Analysis Parameters** window, click on the **Report** button to view the loading cases, cable swing angles, offsets, and conductor to ADSS



Southwire Conductor Accessories, Adss-Conductor Clash Analysis (U.S./Imperial Units)

Clash Span = 500.00 ft Ruling Span = 500.00 ft

Conductor: 795.0 kcmil 26/7 ACSR "Drake"
Suspension Insulators, Length = 5.0 ft

Initial Sag

'EDS Still Air'* Case: No Ice, No Wind:

Temp °F	Ice in	Wind lb/ft²	K lb/ft	Weight lb/ft	H-Sag ft	V-Sag ft	R-Sag ft	Swing Angle Degrees
-20.0	0.00	0.00	0.00	1.093	0.00	2.44	2.44	0.00

Loading Case: Ice & Wind or Wind Alone:

Temp °F	Ice in	Wind lb/ft²	K lb/ft	Weight lb/ft	H-Sag ft	V-Sag ft	R-Sag ft	Swing Angle Degrees
0.0	0.50	4.00	0.30	2.508	1.74	5.19	5.47	18.56

Conductor: ADSS Cable, Moduli = 792/600/900 kpsi, Thermal Coef of Expansion = 5.84e-6/°F

Coordinates of ADSS relative to Conductor (0,0): X= 0.0 ft Y= 20.0 ft

'EDS Still Air'* Case: No Ice, No Wind:

Temp °F	Ice in	Wind lb/ft²	K lb/ft	Weight lb/ft	H-Sag ft	V-Sag ft	R-Sag ft	Swing Angle Degrees
-20.0	0.00	0.00	0.00	0.263	0.00	2.79	2.79	0.00

Loading Case: Ice & Wind or Wind Alone:

Temp °F	Ice in	Wind lb/ft²	K lb/ft	Weight lb/ft	H-Sag ft	V-Sag ft	R-Sag ft	Swing Angle Degrees
0.0	0.50	4.00	0.30	1.580	6.47	11.57	13.25	29.21

Transverse View: ADSS-Conductor Clearance=19.6 ft 'EDS Still Air'* Case: No Ice, No Wind
Transverse View: ADSS-Conductor Clearance=13.7 ft Loading Case: Ice & Wind or Wind Alone

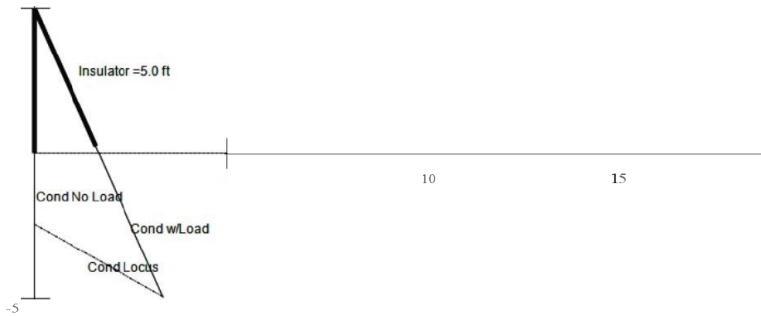
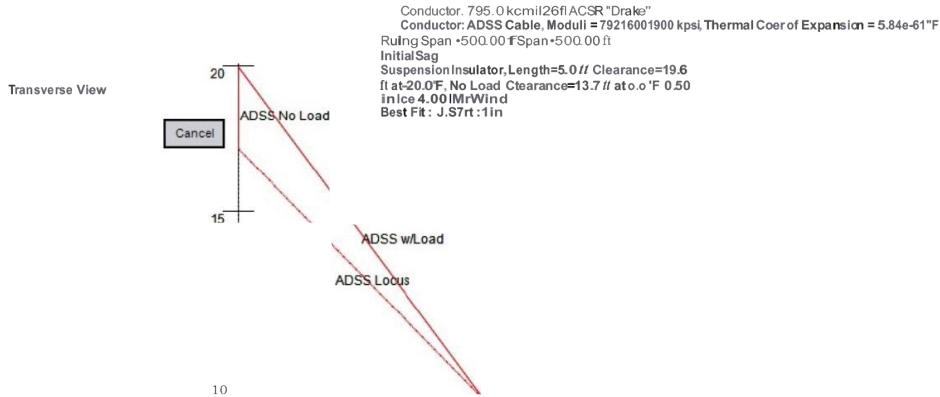
Assumptions:

- Conductor coordinates: (0,0) : represent the attachment point of the conductor to the insulator string end, and not the attachment point of the insulator string to the structure cross-arm, therefore there are 2 separate cases:
 - conductor attached to a tension insulator string : when the wind blows, the tension insulator string is fixed, so only the conductor will have a swing angle, having as fixed rotation point the point of coordinates:(0,0).
 - conductor attached to a suspension insulator string : when the wind blows, the suspension insulator string will swing together with the conductor, having as a rotation point the point of coordinates:(0,L), where L=suspension insulator string length.
- Line Angle=0 ; if line angle>0, the angle pull due to line angle has to be considered in the calculation of the swing angle of the suspension insulator string at structure.
- No difference in elevation between the attachment points at the 2 structures, for both conductor and ADSS, therefore: wind span=weight span=basic span. Also, on each side of the 2 structures, the spans are equal with the basic span. If there is a difference in elevation, the weight span will be a function of the catenary constant (of that loading case) and the difference in elevation.

12) Click on the **Graphic** button to view the **Clash Diagram** screen. This screen displays the Transverse and Longitudinal clearances between the two conductors.

Clash Diagram

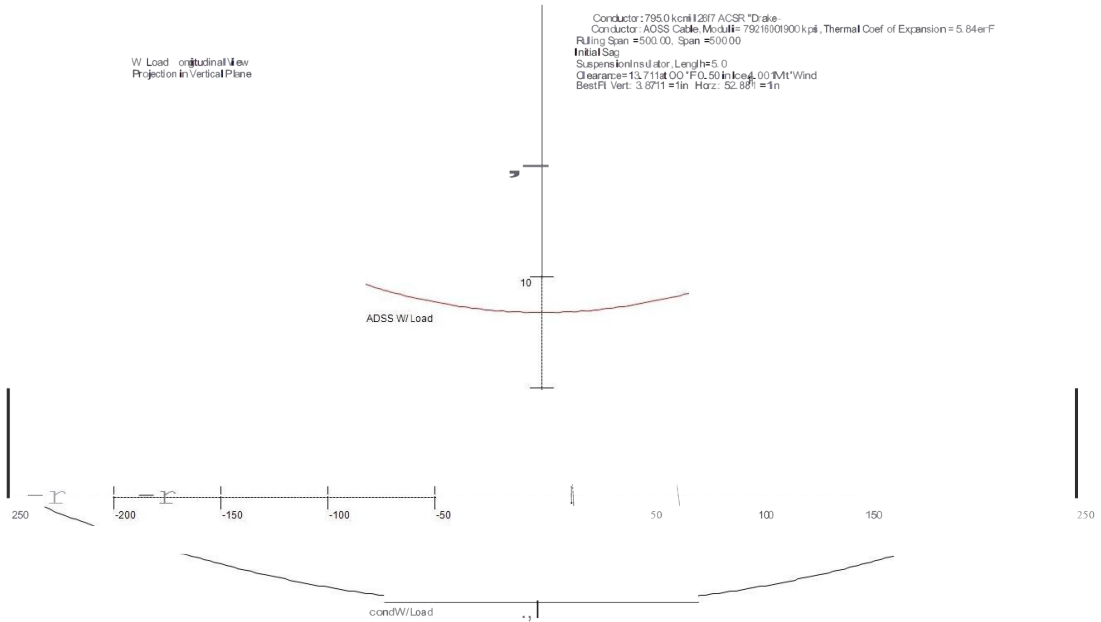
Output View BMP File Return



Clash Diagram

Output View BMP File Return

W Load longitudinal View Projection in Vertical Plane



Options available on the **Clash Diagram** screen toolbar are:

Output menu choices:

- **Output, Print/Plot** will send the image to the Printer or Plotter.
- **Output, Print Setup** brings up the Printer Dialog box allows the image to be rotated to Portrait or Landscape.
- **Output, Scale** allows the scale to be adjusted independently for printed output.

View menu choices:

- **View, Long No Load** displays a longitudinal view of the conductors under no load conditions.
- **View, Long W/Load** displays a longitudinal view of the conductors with ice and wind load conditions.
- **View, Transverse** displays a transverse view of the conductors under both loaded and unloaded conditions.
- **View, Scale** allows you to rescale the graphic image to an exact scale. The default is Best Fit, which is the largest size that will conveniently fit on the screen. The Longitudinal and Transverse Views are scaled separately.

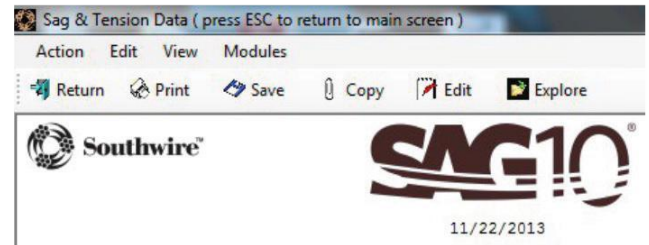
BMP file:

This will generate a .BMP file of the graphic screen. This graphic image may then be stored on disk and/or emailed or otherwise shared as a permanent object.

Return

This option will close the **Clash Diagram** screen and return you to the **Sag & Tension Data** screen.

6.4 Data Screen Lower Toolbar Controls



6.4.1 Return

The Return button closes the Sag & Tension Data screen and returns you to the SAG10® Main Menu screen.

6.4.2 Print

The Print button sends the sag and tension report to the default printer.

6.4.3 Save

The Save button opens a standard Save File window where you can choose a file name and a location to save the output report file.

6.4.4 Copy

The Copy button opens the default word processor and copies the output report to the word processor screen.

6.4.5 Edit

The Edit button opens the default word processor and copies the output report to the word processor screen for further editing.

6.4.6 Explore

The Explore button opens a browser window where you can select a file to open.

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8 Appendices – Reference Materials

Appendix A – Error Messages

Appendix B – Determining Sag-Tension on Single Span,
Original Design Known

Appendix C – Determining Sag-Tension on Single Span,
No Original Design

8.1 Appendix A – Error Messages

	Error Message	Explanation
1	You have NOT Included a Creep Check in Your Load Table. The Results May Be Incorrect ! Proceed Anyway ?	Include a Creep condition in the Usage column in the load table to allow a creep check.
2	Could not acquire license. FAILED! NO [CONCURRENT] LICENSES AVAILABLE.	The license you have input is either expired or has no available seats.
3	Could not acquire license. FAILED! INVALID LICENSE HOLDER [license #].	The license you have input is invalid. Please try a different product key.
4	Cannot Open Conductor DataFile	Check the path for the DATA.*files.
5	Cannot Red Conductor DataFile	The DATA.*files were successfully opened, but unable to be read.
6	Conductor Not Found in DataFile	The conductor is not available for the specified data type.
7	No ltype Match in Read Cond File	Call tech support.
8	Cannot Open Sag10.Pgm	Make sure that Sag10.Pgm is in the \Sag10 directory.
9	Cannot Read Sag10.Pgm	Sag10.Pgm was successfully opened, but unable to be read.
10	Cannot Find Chart #	The specified chart number is not in the Sag10.Pgm file.
11	Can't Open Project File (Open/Save)	There was an error in opening the .PRF file.
12	Cannot Read Project File	The .PRF file was successfully opened, but unable to be read.
13	Opsav is NOT set to 0 or 1	Call tech support.
14	ltype 13 in Old PRF File	The other type has been changed from 13 to 15 in the latest version. The project file should be resaved under Version 5.1 to update.

	Error Message	Explanation
15	S&T Output Buffer Full	Use the Pause Between Spans option (Main Menu), or decrease the number of spans in the project file in order to view and scroll the output. Does not affect printer or file output.
16	Cannot Open Report File	Check for disk space or disk error.
17	No Tension Limits	At least one condition must have a tension limit in the Loadings Table.
18	You have more than one Common Point	Only one Common Point is allowed in the Loadings Table.
19	SIG1 UNDEFINED	Initial tension is not defined.
20	SIG2 UNDEFINED	Final tension is not defined.
21	Can't do ElevTemp & Marker Balls	The program cannot calculate both Elevated Temp and Marker Balls options at the same time.
22	Cannot Open .CLP File	There was an error opening the .CLP file.
23	Cannot Read .CLP File	.CLP was successful in opening, but unable to be read.
24	This is the Maximum Number of Values Allowed	The limit has been reached for the item mentioned.
25	The MRCL/RTS ratio may never exceed 60% for ADSS. Check your Cable specifications before proceeding!	Be sure to use the proper cable specifications.
26	The Load Table tension values may NOT exceed the MRCL for ADSS Cable. Correct Load Table tension before proceeding!	Set the tension value to less than the cable MRCL.
27	Error NOT Listed	Please contact technical support.
28	Root#x Failure in Phase#y, where x = 1 to 12 and y = 1 to 12	The program may fail at any of 12 root calculations (1-12). A typical reason for failure is too much load or too big of a span for the strength of the conductor.

8.2 Appendix B – Determining Sag-Tension on Single Span, No Original Design

Situation: A section of line is currently in place, with no recorded data as to the ruling span, design limits, or stringing sags. It is necessary to determine the ruling span and design limits, in order to modify the line (such as adding marker balls, changing the supporting structure, etc.).

For this example, the following assumptions were made:

- Conductor: 795.0 kcmil 26/7 ACSR “Drake”
- Calculated Ruling Span: 1000.00 ft
- Loading District: NESC Heavy
- Measured Sag: 15.38 ft, 937.00 ft span, 60.0°F conductor temperature

Step #1

Calculate the ruling span using by inputting all the spans in the applicable tension section into the **Calculate Ruling Span** tool.

Step #2

Select the conductor in the **Conductor Selection** screen. Verify an accurate chart is selected.

Step #3

The sag at a given conductor temperature must be determined for at least one span. This can be accomplished by measuring the sag with survey methods, or by throwing a ding line over the wire and using the stopwatch method (Use proper safety procedures if the line is hot).

Step #4

Choose the applicable load selection in the Load Selection panel on the **Main Menu**. In the Edit Loading Table screen, remove all design limits except for the sag value obtained by survey, entered into the Limit column with the distance unit as the Type. Use the temperature at time of survey and Final in the Usage column if the line is assumed to be at final conditions.

* Cond. Temp	Ice	Wind	Limit	Type	Usage
0.0	0.50	4.00			
32.0	0.50				
-20.0					
0.0					
30.0					
60.0			15.38	ft	Final
60.0					Creep
90.0					
120.0					
167.0					
212.0					

°C °F
 * Right click on a row button to Insert or Delete a row

 File:

Step #5

Initially, the ruling span value used should match the single span for which the survey data was

Feet
 937.00

Pause Between Spans

obtained.

Step #6

Go to **Tools**→**Options** and change both the *Input Tensions* and *Output Tensions* to **Horizontal (At Sag)**.

Step #7

Click the Calculate **Sag & Tension** button. In the output, note the final tension at 60.0°F.

Span = 937.00 ft Special Load Zone
 Normal creep determines the final sag

Loading Limits					Limit	Usage
Cond. Temp °F	Temp °C	Ice in	Wind lb/ft ²	K lb/ft		
60.0	15.6	0.00	0.00	0.00	15.38 ft*	Final
60.0	15.6	0.00	0.00	0.00		Creep

Design Points					Weight lb/ft	Final		Final/No Load		Initial	
Cond. Temp °F	Temp °C	Ice in	Wind lb/ft ²	K lb/ft		Sag ft	Tension lb	Sag ft	Tension lb	Sag ft	Tension lb
0.0	-17.8	0.50G	4.00	0.30	2.508	18.58	14816	18.58	14816	18.31	15037
32.0	0.0	0.50G	0.00	0.00	2.093	18.59	12365	18.59	12365	17.39	13215
-20.0	-28.9	0.00	0.00	0.00	1.093	10.69	11219	10.69	11219	9.59	12515
0.0	-17.8	0.00	0.00	0.00	1.093	11.75	10212	11.75	10212	10.19	11777
30.0	-1.1	0.00	0.00	0.00	1.093	13.49	8892	13.49	8892	11.22	10692
60.0	15.6	0.00	0.00	0.00	1.093	15.38	7802	15.38	7802	12.42	9658
90.0	32.2	0.00	0.00	0.00	1.093	17.33	6923	17.33	6923	13.78	8704
120.0	48.9	0.00	0.00	0.00	1.093	19.30	6220	19.30	6220	15.29	7850
167.0	75.0	0.00	0.00	0.00	1.093	21.97	5463	21.97	5463	17.83	6732
212.0	100.0	0.00	0.00	0.00	1.093	23.26	5162	23.26	5162	20.35	5897

* Design Condition

Note: For NESC applications, please confirm compliance with NESC Rule 261H1.

G Glazed Ice Density of 57.0 lb/ft³

This will be your final design limit at 60.0°F in the ruling span sag & tension calculations.

Step #8

Create a new project file using the calculated ruling span. The only design limit should be the tension obtained in Step #7. Make sure to change the *Input Tensions* to **Horizontal (At Sag)**. When sag & tension are calculated, review the output to be sure that design conditions have not been exceeded.

The screenshot shows two panels from a software application. The 'Loading Table' panel on the left contains a table with columns for Cond. Temp (°F and °C), Ice (in), Wind (lb/ft²), Limit, Type, and Usage. The row for 60.0°F is highlighted, showing a Limit of 7802 lb and Usage of Final. The 'Ruling Spans' panel on the right shows a vertical list of spans with a value of 1000.00 Feet. Below the list are buttons for DELETE SPAN, INSERT SPAN, CLEAR SPANS, and SERIES OF SPANS. At the bottom of the interface are buttons for OPEN, CLEAR, and SAVE AS, along with a file input field.

8.3 Appendix C – Determining Sag-Tension on Single Span, Original Design Known

Situation: Sag & tension information is available for the original line, but more information is required for a single span within that ruling span, perhaps to modify the line (such as adding marker balls, changing the supporting structure, etc.).

For this example, the following assumptions were made:

- Conductor: 795.0 kcmil 26/7 ACSR “Drake”
- Ruling Span: 1000.00 ft
- Loading District: NESC Heavy

Step #1

Select the conductor in the **Conductor Selection** screen. Verify an accurate chart is selected.

Step #2

Enter the original design criteria into the loading table. Enter the actual ruling span for the line.

Loading Table

*	°F	in	lb/ft²	Limit	Type	Usage
	Cond. Temp	Ice	Wind			
▶	0.0	0.50	4.00	60.0	%	Initial
	32.0	0.50				
	-20.0					
	0.0					
	30.0					
	60.0			30.0	%	Initial
	60.0			25.0	%	Final
	60.0					Creep
	90.0					
	120.0					
	167.0					
	212.0					

°C °F

* Right click on a row button to Insert or Delete a row

OPEN
CLEAR
SAVE AS

File

Ruling Spans

Feet

1000.00

DELETE SPAN
INSERT SPAN

CLEAR SPANS
SERIES OF SPANS

Pause Between Spans

Step #3

Go to **Tools**→**Options** and change the *Output Tensions* to **Horizontal (At Sag)**.

Step #4

Click the **Calculate Sag & Tension** button. In the output, note the initial tension at 60.0°F. This will be your initial design limit at 60.0°F in the single span sag & tension calculations.

Design Points		Ice in	Wind lb/ft ²	K lb/ft	Weight lb/ft	Final		Final/No Load		Initial	
Cond. Temp °F	Temp °C					Sag ft	Tension lb	Sag ft	Tension lb	Sag ft	Tension lb
0.0	-17.8	0.50G	4.00	0.30	2.508	21.05	14899	21.05	14899	20.82	15066
32.0	0.0	0.50G	0.00	0.00	2.093	21.04	12440	21.04	12440	19.82	13207
-20.0	-28.9	0.00	0.00	0.00	1.093	12.57	10873	12.57	10873	11.23	12165
0.0	-17.8	0.00	0.00	0.00	1.093	13.74	9943	13.74	9943	11.93	11452
30.0	-1.1	0.00	0.00	0.00	1.093	15.65	8735	15.65	8735	13.12	10417
60.0	15.6	0.00	0.00	0.00	1.093	17.66	7741	17.66	7741	14.47	9445
90.0	32.2	0.00	0.00	0.00	1.093	19.71	6936	19.71	6936	15.97	8558
120.0	48.9	0.00	0.00	0.00	1.093	21.75	6286	21.75	6286	17.59	7769
167.0	75.0	0.00	0.00	0.00	1.093	24.67	5543	24.67	5543	20.28	6740
212.0	100.0	0.00	0.00	0.00	1.093	26.02	5256	26.02	5256	22.92	5966

* Design Condition

Note: For NESC applications, please confirm compliance with NESC Rule 261H1.

G Glazed Ice Density of 57.0 lb/ft³

Step #5

Create a new project file using the tension obtained above as the only design condition. Make sure to change the *Input Tensions* to **Horizontal (At Sag)**.

Loading Table

* Cond. Temp	°F	in Ice	lb/ft² Wind	Limit	Type	Usage
▶	0.0	0.50	4.00			
	32.0	0.50				
	-20.0					
	0.0					
	30.0					
	60.0			9445	lb	Initial
	60.0					Creep
	90.0					
	120.0					
	167.0					
	212.0					

°C °F
 * Right click on a row button to Insert or Delete a row

 File

Step #6

Use the span length for which further information is requested. For this example, 1134.00 ft will be used. The sag & tension output will be for the specific span in question, not for the ruling span.

Ruling Spans

Feet
1134.00

 Pause Between Spans

