

USER'S MANUAL
for the
Experimental Data Processing (EDP)
COMPUTER PROGRAM

Version 1.0

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1 Introduction

The primary role of an experiment is to extract information from the observed measurements. The main goal of the digital raw data processing is to remove outliers without changing the recorded data, perform a statistical analysis on the smoothed data, and analyze the results. There are two main ways to process data: filtering and curve fitting. The ultimate information derived from observed measurements is the stress-strain curve. Experimental Data Processing (EDP) features the ability to perform the full process necessary to gain a characteristic curve and values from raw data. A flow-chart of this process is shown below in Figure 1.

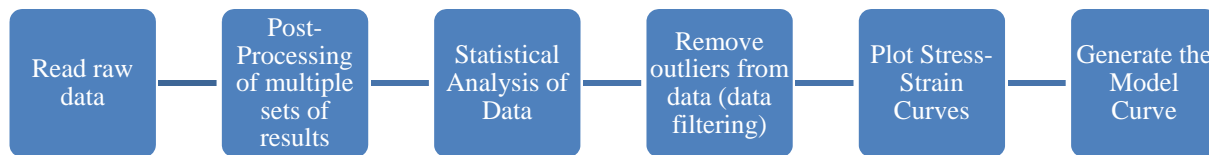


Figure 1: Flowchart of data processing

Reading raw data is done for each individual set of raw data using a single interface. This feature requires some user input related to the name, plotted columns, and number of header lines.

Post-Processing is done through a spreadsheet style interface allowing for columns of data to be modified through a single command. Removing outliers and data filtering is performed by zone for each individual data set. Several smoothing and fitting options are available to additionally process data as needed.

EDP also features the ability to plot data. If stress-strain data is generated through post-processing and smoothing of separate data sets, the spreadsheet interface may be used to create a new data set from existing smoothed or fitted data. Multiple stress-strain curves may be created and plotted.

Finally, EDP has the ability to generate a single representative curve from several input stress-strain curves.

1.1 Installation of EDP

Download the installation file “EDPV1-0setup.exe” and run it.

1.2 Organization of the Manual

This manual focuses on explaining each of the main functions of EDP, their uses, and their limitations in the context of creating a model curve from raw data. EDP features a function for each of the data processing steps. Each of these functions and their interfaces are discussed in detail in Chapter 2. An example is given in Chapter 3. More advanced features such as plotting options and Failure surface generation are discussed in Chapter 4.

2 EDP Features

This chapter details the interface options available for performing each of the 6 steps of data processing outlined in Figure 1. A complete example to generate a characteristic curve using these functions can be found in chapter 3. Additional features beyond generating the model curve are outlined in the Advanced Features section.

All dialogue boxes used in data processing and plotting are available along the top tool bar. Certain options are only available based on the number of data sets loaded and or plotted.

2.1 Read Raw Data

The read raw data interface is the first option available on the top tool bar accessible when launching the program. Figure 1 shows the location of the **Read raw data** dialogue button in the top tool bar.

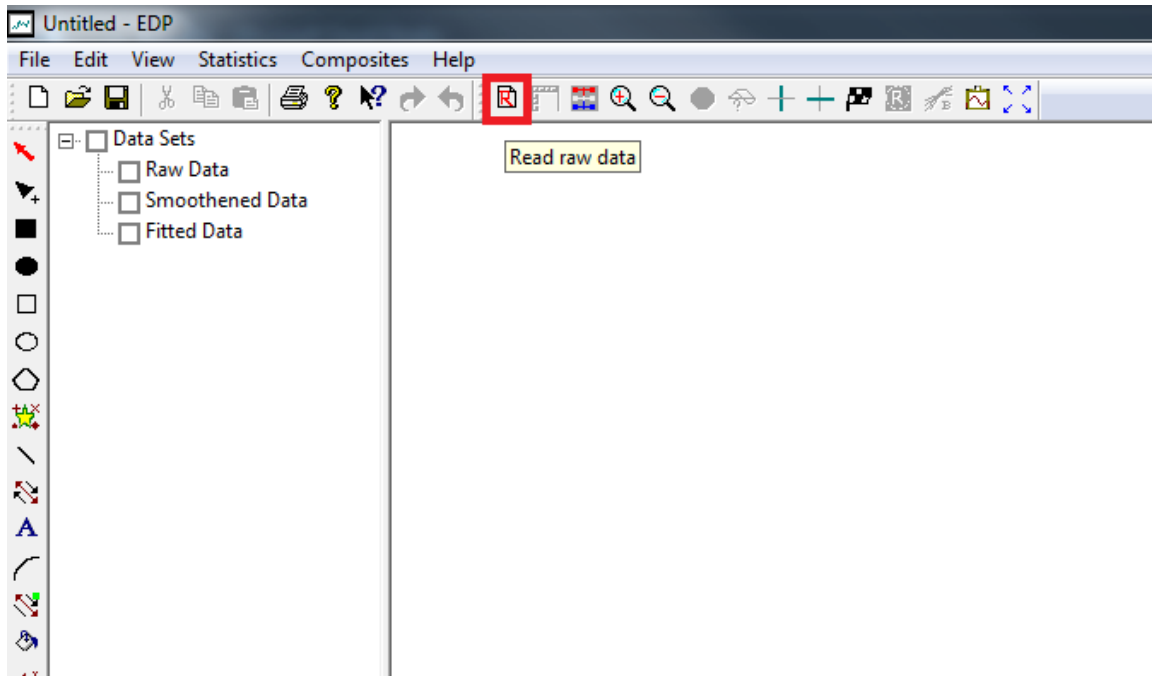


Figure 2. The Read raw data button (highlighted in red) is found at the top of the screen in the tool bar.

Upon opening, the Read Raw Data dialogue box appears, shown in Figure 3. This box features four areas of interest. In the upper right corner are the action buttons. **OK** and **Cancel** will close the dialogue. **Notepad** will open a new text file for entering notes or comments if necessary. The **Browse** button allows the user to select a csv, dat, or txt file containing the raw data. The raw data files have the following limitations: the data cannot be interrupted (i.e. a second header should not appear within the data) and the column headers must include two lines for column titles and units. Finally, **Apply** will read the raw data found using browse using the specifications defined in the Field Delimiter and Raw Data Details sections.

Reading raw data requires some user input. The upper left corner allows the user to indicate the delimiter used to separate values within each row. Blank space(s), Comma, and Tab are selected by default, but any character may be defined as a delimiter using the Other text box.

In the center of the dialogue is the Raw Data Details section. EDP requires the user to input the number of columns and the number of header lines. For the number of header lines, the last two lines must have the column headings and units, and comment lines (begin with \$) and blank lines are ignored by EDP. The user may also define the X and Y-data columns for plotting. Finally, the user may also define a Data ID (the name of the data set).

The final section at the bottom is a preview of the data. This does not show the data in a spreadsheet style. Instead, the first ten lines of the data are shown separated by line as text. This may be used to check which delimiter to use, the number of header lines, and the number of columns.

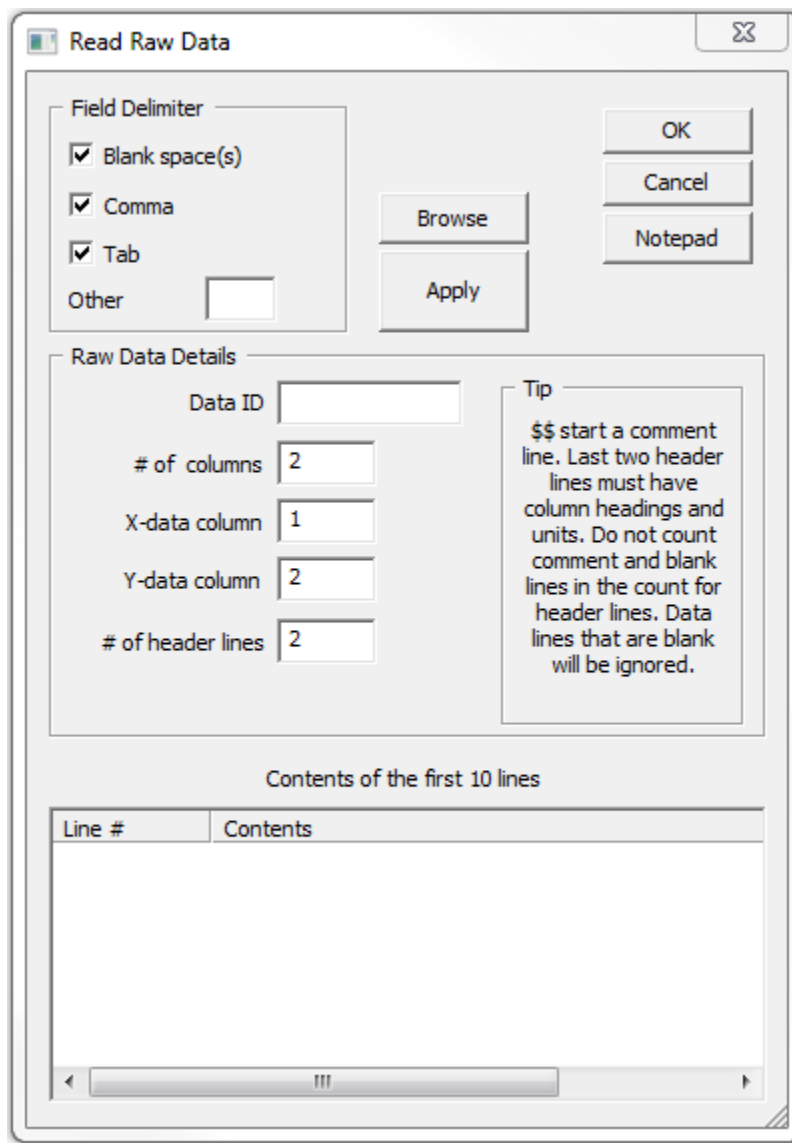


Figure 3. The Read Raw Data interface

Once a file, delimiters, and details are specified, **Apply** will read the data. A new file may then be read without closing the dialogue box. Once all data has been read, press **Ok** to return to the main screen.

2.2 Edit or View Data

Once raw data has been read into EDP, the **Edit or view data** button becomes available. Figure 4 shows the location of this button in the top tool bar. This interface allows for raw data to be edited. If data has been processed, this interface also allows for viewing of smoothed or fitted data as well.

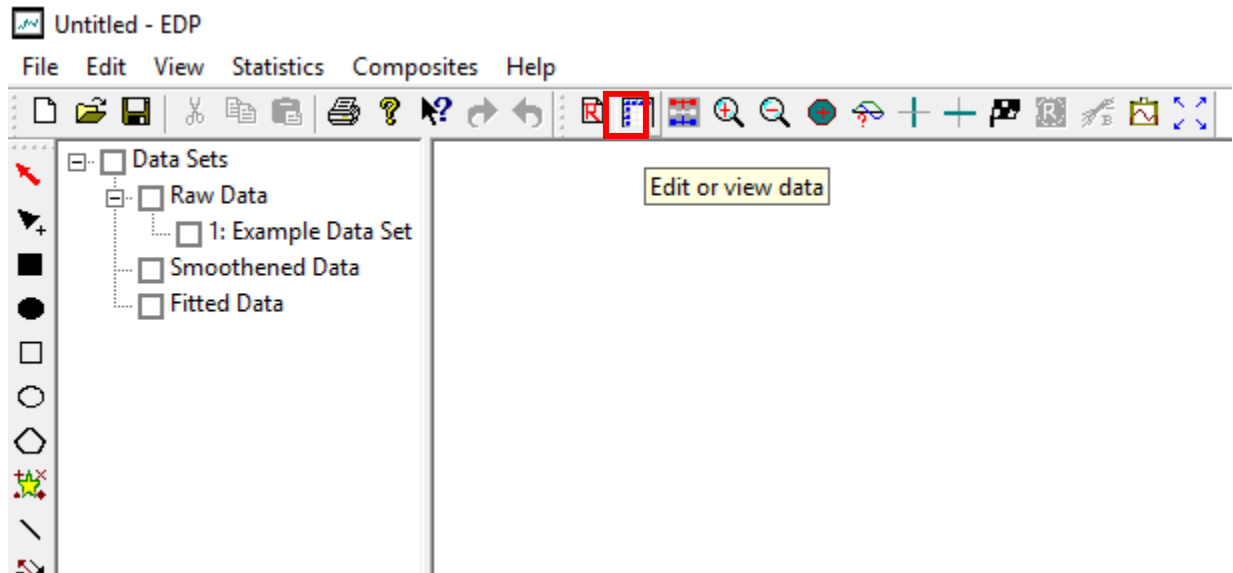


Figure 4. Edit or view data button location, highlighted in red.

Once pressed, the Edit Raw Data & View Smoothened and Fitted Data interface appears, as shown in Figure 5 with a sample set of data. This interface features four areas used for viewing and manipulating data.

The top section shows a table with details for each data set: the set number, set name, the number of points, the number of columns, the number of analysis zones, and the min and max values of the x and y columns.

In the bottom right of the window are the details of the current data set. Here, the data set and data type being displayed can be selected. The data set name, column headers, units, and x and y column numbers that were set when reading raw data may be changed here. To save any changes to these values, press the **Update** button. The x and y columns of the currently selected data set may also be exported by using the **Export** button. This exported file will contain four header lines (the last two of which are the column headers and column units) and the x and y data separated by commas.

The data from the currently selected data set is shown in the center of the screen in a spreadsheet style. The first column features the data tag for each row within the data set in the style ds#_r# (indicating the current data set and row). The first row shows the column titles, the second row shows the column units, and the third row shows the data tag for each column within the data set

in the style ds#_c#_type (indicating the current data set, column, and data type). The column ID's are used in the Cell Operations section of the interface to edit entire columns. In the spreadsheet, columns and rows may be deleted. To delete a row or column, first select the row(s) or column(s) by clicking the ID, the right click to open the data editing menu. Within this menu are also commands to insert new rows and columns. When changing the value within a cell, **Update** must be pressed to save the change.

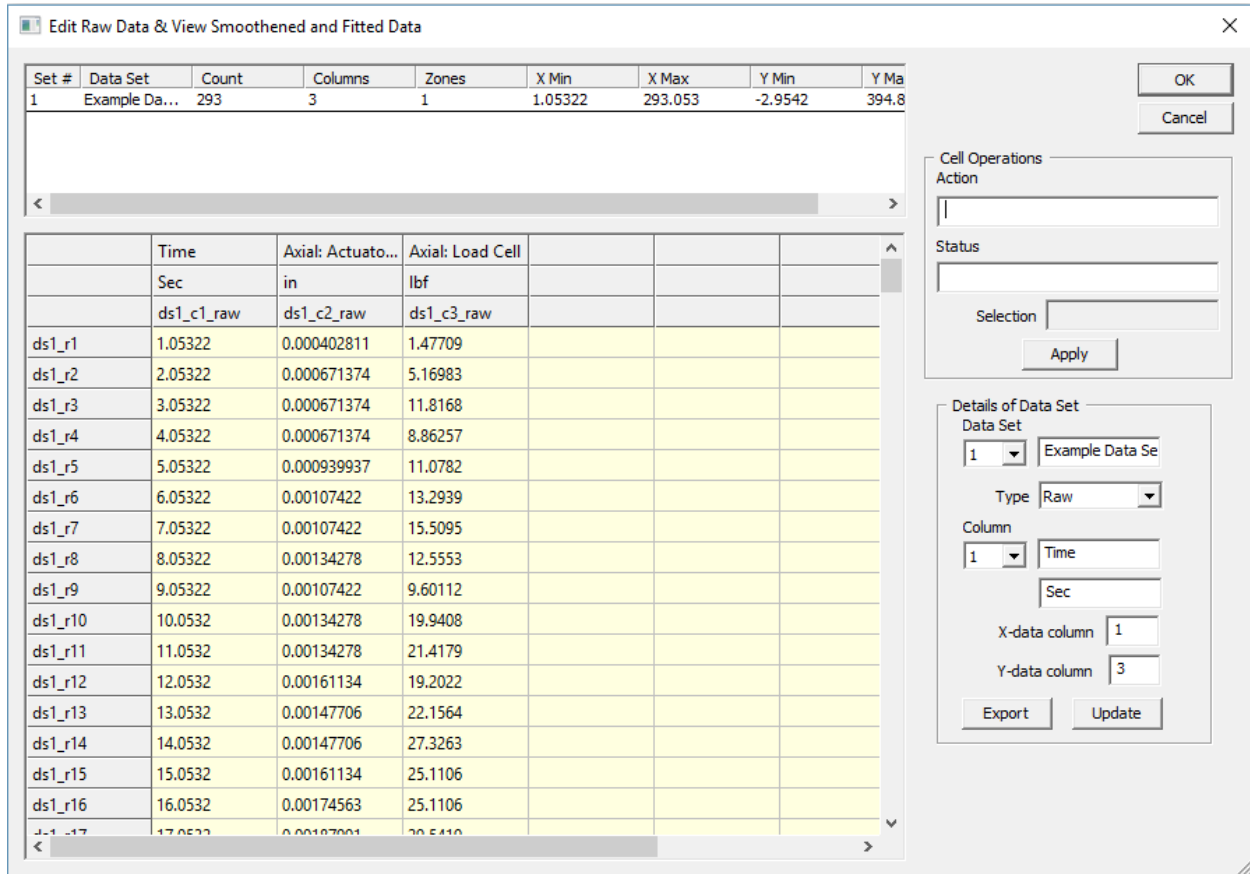


Figure 5. Edit Raw Data & View Smoothened and Fitted Data interface.

Finally, the Cell Operations section allows for editing the data. To edit a column, type the command into the Action sample box. The commands currently implemented are summarized in Table 1. Some of these functions allow for multiple uses at one time. For example, to shift a column to start at zero, typing “zero, 1, 1, 1, 3” will apply the command to both the first and third column of the first data set at once.

Table 1. Edit data commands with details and formatting.

Function	Description	Format
Edit Raw Data	Edits an existing column or creates a new column within a data set based on an equation. Uses column ID	ds?_c?_raw = expression involving other columns

	available at the top of the viewing window.	
Delete Replicate	Deletes a data set.	deleterep, replicate #
Reformat	Discretizes smoothed data within a zone of a data set based on an existing column.	reformat, replicate #, zone #, x column #, # of points
Create	Creates a new data set from existing data sets.	create, replicate name, type, x replicate #, x column #, y replicate #, y column #
Zero	Shifts a column to start at zero.	zero, replicate #, column #
Invert	Inverts a column.	inv, replicate #, column #
Zero and Invert	Performs both the Zero and Invert functions	zeroinv, replicate #, column #

To save any changes made within the spreadsheet or the Details of Data Set section, be sure to press **Update** before pressing **OK**.

2.3 Filter Data

Once data has been processed, identifying outliers, filtering, and fitting are accessed through the **Process data** button, available in the tool bar as shown in Figure 6.

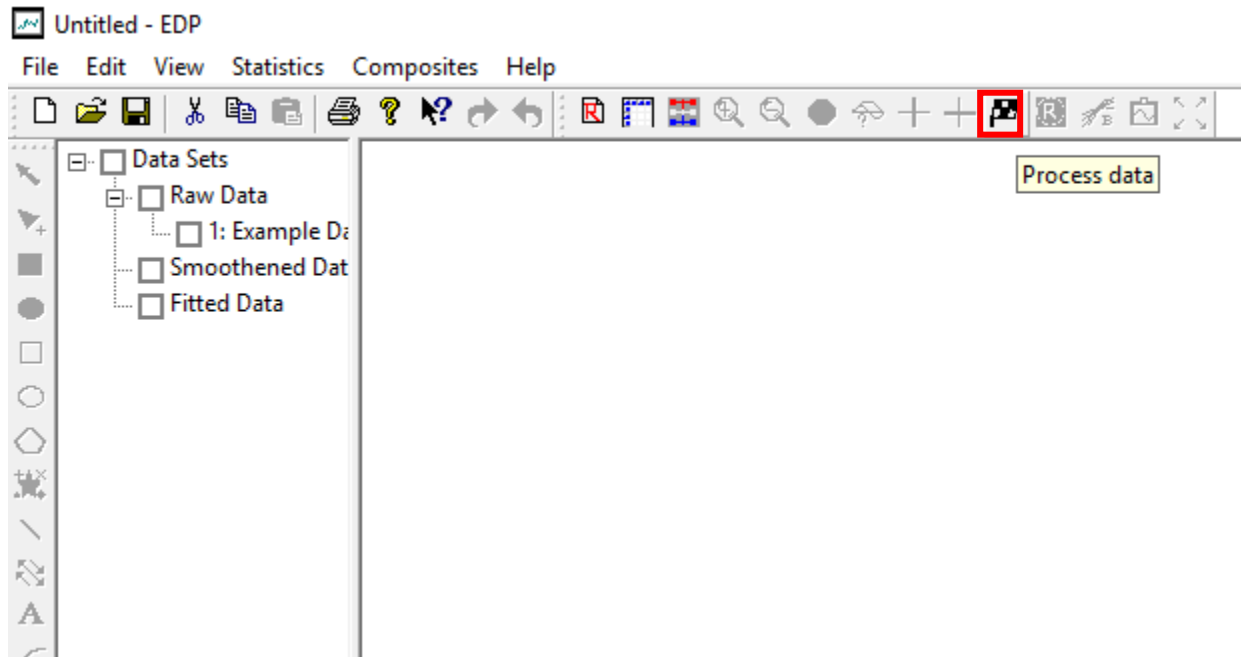


Figure 6. Location of Process data button in tool bar.

The Data Set-Zone Data dialogue box allows for the creation of zones defined by start and end X values. Each zone may have a filter or fit applied between these end values. To define zones for any data set, the User Input section in the upper left corner of the dialogue box allows for the selection of the end values, the fit type, the method to remove outliers, and the smoothing method (with corresponding values for degree of polynomial, the number of points, and the number of repeats as relevant to the selected method). The number of points must be odd

between 3 and 25 for most smoothing methods; PMA and Loess require a minimum of 5 points. Details for each fit type and smoothing method are shown in Table 2 and Table 3.

The Current Data section at the bottom of the dialogue box shows the details of the first zone for each data set.

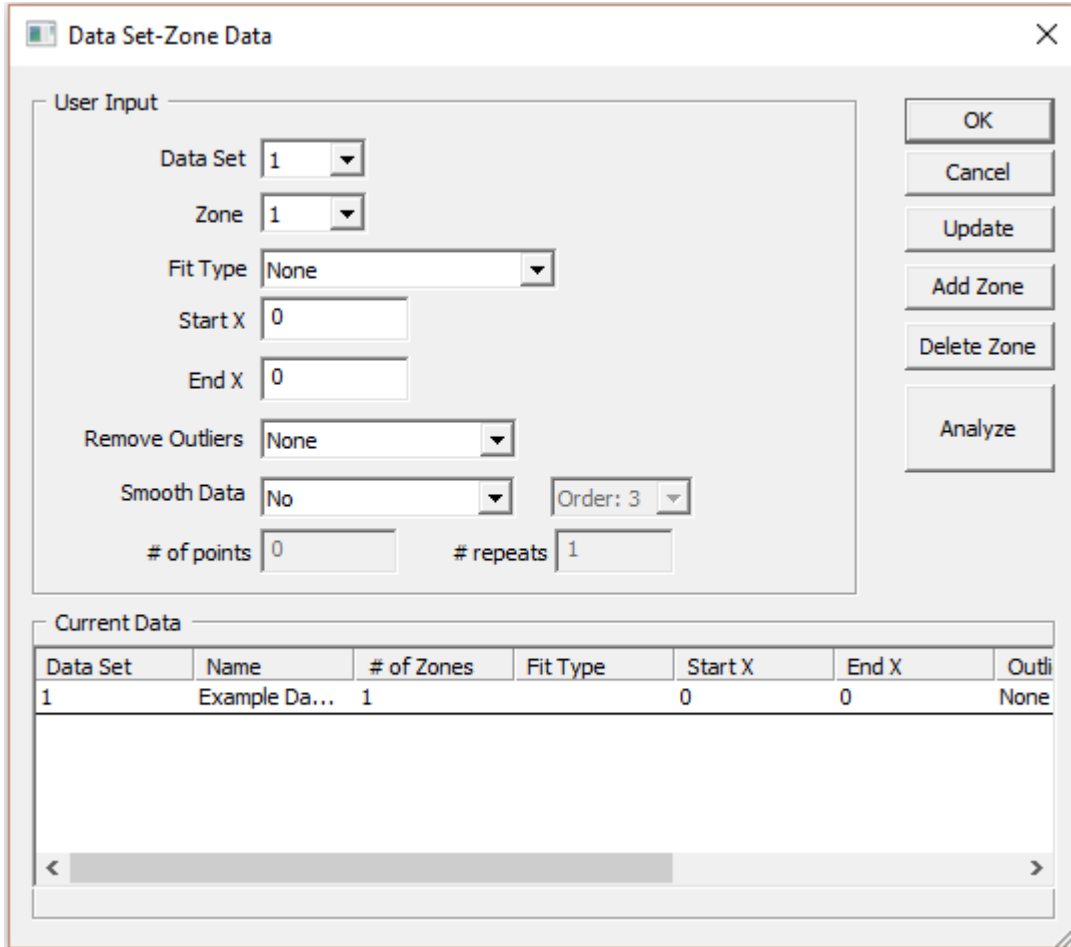


Figure 7. Data Set-Zone Data dialogue box

Table 2. Fitting Types and their descriptions

Fitting Type	Description
Polynomial	Fits the data within the zone to a first, second, third, fourth, or fifth degree polynomial.
Exponential	Fits the zone data to an exponential curve of the form $y = ae^{bx}$
Logarithmic	Fits the zone data to a logarithmic curve of the form $y = a \log(bx)$
Power	Fits the zone data to curve of the form $y = ax^b$

Table 3. Smoothing Methods and brief descriptions.

Smoothing Type	Description
Median	Replaces data points with the median value of a local range.

Simple Moving Average	Replaces data points with the unweighted average value of a local range.
Polynomial Moving Average	Replaces data points with the weighted average value of a local range.
Loess	Replaces data points with a weighted value calculated using local regression (using a second degree polynomial) within a local range giving more weight to proximate values.
Robust Loess	Loess with an additional weight considering outliers.
Lowess	Replaces data points with a weighted value calculated using local regression (using a first degree polynomial) within a local range giving more weight to proximate values.
Robust Lowess	Lowess with an additional weight considering outliers.

To ensure a change to the User Input is saved, the **Update** button must be pressed. Adding and deleting zones are done one at a time. To implement all processing for each zone, press the **Analyze** button. EDP will only analyze zones with fit type, outlier identification, or data smoothing entered. If these are left at default for a zone, the data will simply be copied and no processing will take place.

Smoothed and fitted data are stored in new data types, labeled “smt” and “fit”. The data may then be viewed – but not edited – in the Edit Raw Data & View Smoothened and Fitted Data interface. Smoothened and fitted curves may be plotted individually after processing is complete.

2.4 Best Fit Plot

EDP has the ability to average all curves currently plotted in the interface. The **Best fit plot** button is accessible once more than one curve is currently active (see Plotting and Plotting Options in section 4 for more information on active data sets). Note in Figure 8 that raw data sets 1 and 2 are both checked, thus the **Best fit plot** button is active in the top ribbon.

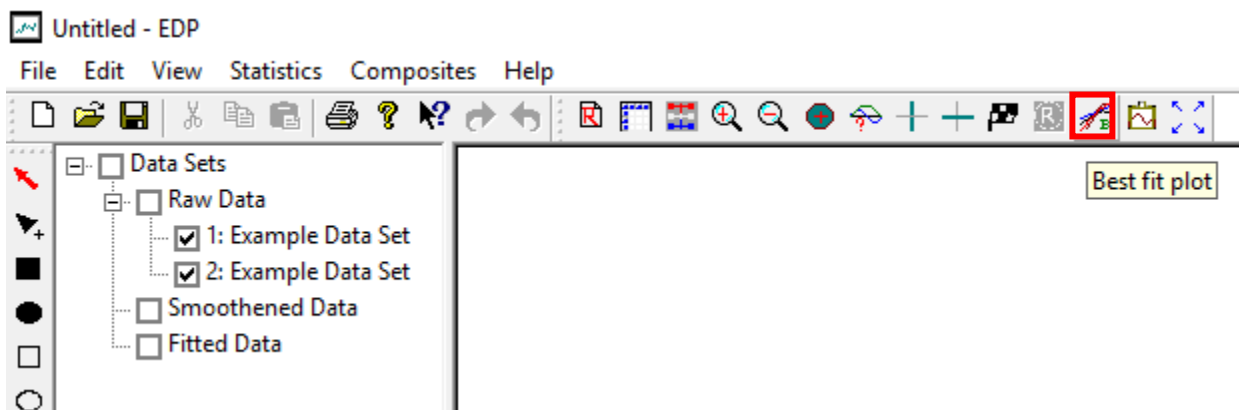


Figure 8. Best fit plot button location in tool bar.

The Best Fit Input interface, shown in Figure 9, has three inputs. The best fit function creates a new data set with the new average curve. The first input is the name of the new data set. The function also only performs the best fit procedure between 0 and an end point decided upon by the user. The three choices of end point type are minimum, average, and maximum. Finally, the

new discrete curve generated by this function may have 5 to 100 data points used in interpolation of the original curves.

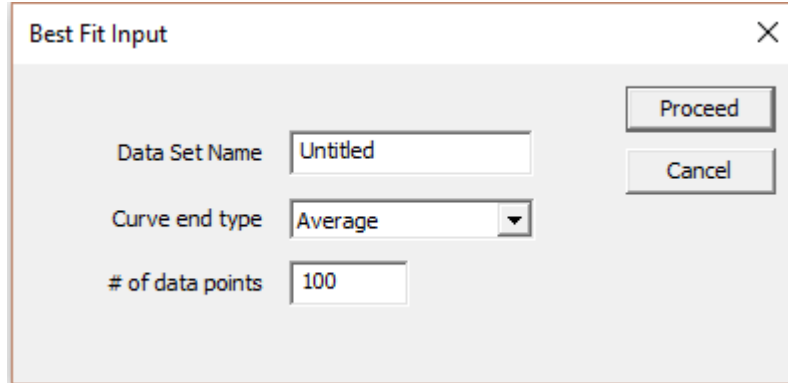


Figure 9. Best Fit Input dialogue box.

Once the three inputs have been selected, press **Proceed** to generate the best fit curve.

The new curve is stored as raw data with the new discrete x-values, the new y-values for each input curve generated via interpolation for each x-value, and the average of those y-values.

2.5 Report

Once data has been successfully processed using the **Analyze** button in the Data Set-Zone Data dialogue, the raw data and processing results may be exported in the form of a report. Before the data is analyzed, the report function is unavailable. To access this feature, click the **Report** button in the top tool bar, as shown in Figure 10. The file must be saved before the Report Selection dialogue appears.



Figure 10. Location of Report button highlighted in tool bar.

Before the report is generated, the Report Selection appears to allow the user to customize what data is exported. Some options allow for data to be exported for only active curves rather than all data sets (see Plotting and Plotting Options in section 4 for more information on active data sets).

If “Use only active data sets” is not selected, all data requested by the user will be reported for all data sets. The Dump options effect what data types are exported. Statistical data may be calculated for either all replicates or just those currently active. Currently, the statistical data is only calculated for the minimum and maximum values of the x and y columns. Press **OK** when the desired options are selected to generate the report in a txt format.

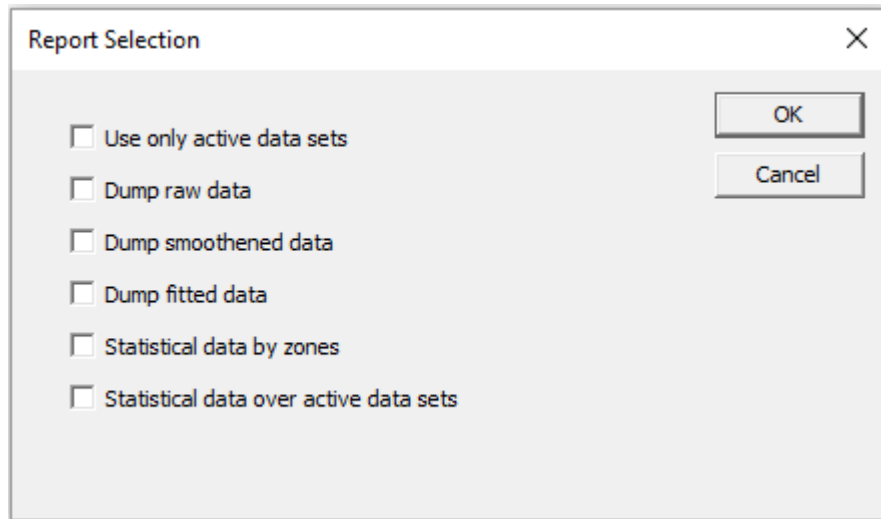


Figure 11. Report Selection dialogue box.

3 An Example

This section illustrates the complete process for processing raw data from multiple tests to generate a representative curve for the response of a unidirectional composite. These processing steps may be applied to any set of raw test data. This example is based on the 2-Direction of the T800S/3900-2B unidirectional composite in tension.

Upon launching the program, note the basic commands available. The tool bar at the top includes several buttons. At the far left is the **New** button, which will clear all current data and present the screen as it is at startup. Next is the **Open** button, with which you may open a previously saved .edp file. The **Save** button is to the right of open and saves all work as currently stored. To get started, select **Read raw data** located in the toolbar as highlighted in red in Figure 12.

3.1 Read Raw Data

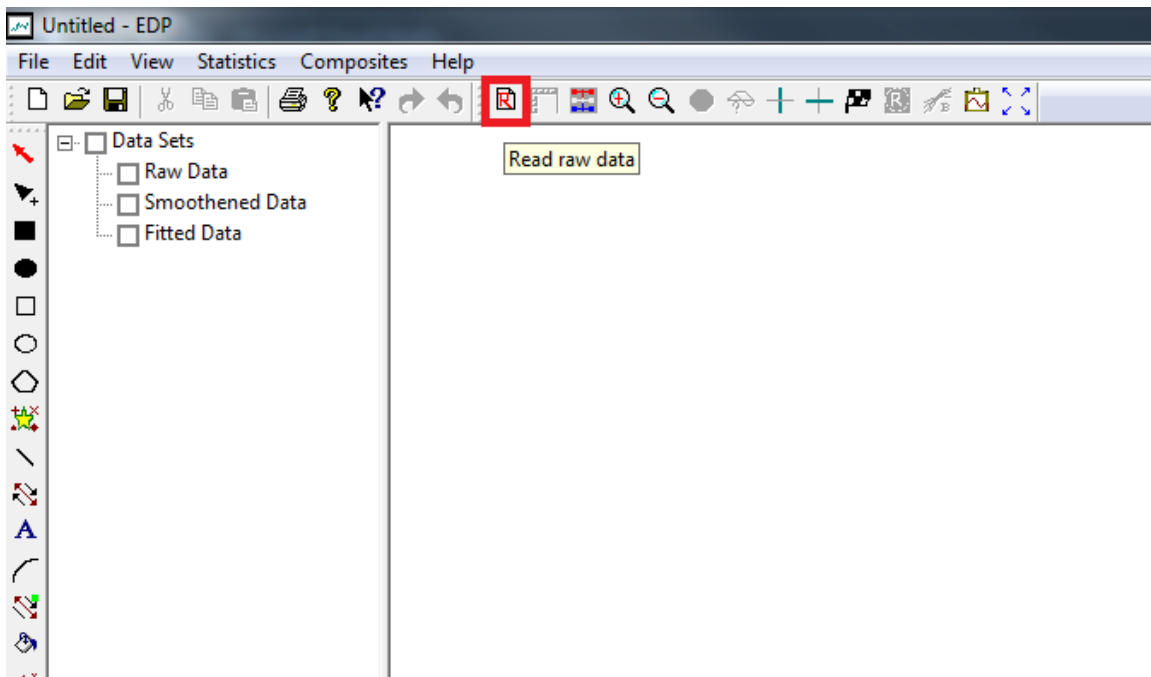


Figure 12. Step 1 of processing involves reading in the raw data. The Read raw data button (highlighted in red) is found at the top of the screen in the tool bar.

Once pressed, you will be presented with the Read Raw Data interface detailed in Figure 13. The first step is to **Browse** folders for one data file to be processed. Be sure to properly name each file prior to loading files.

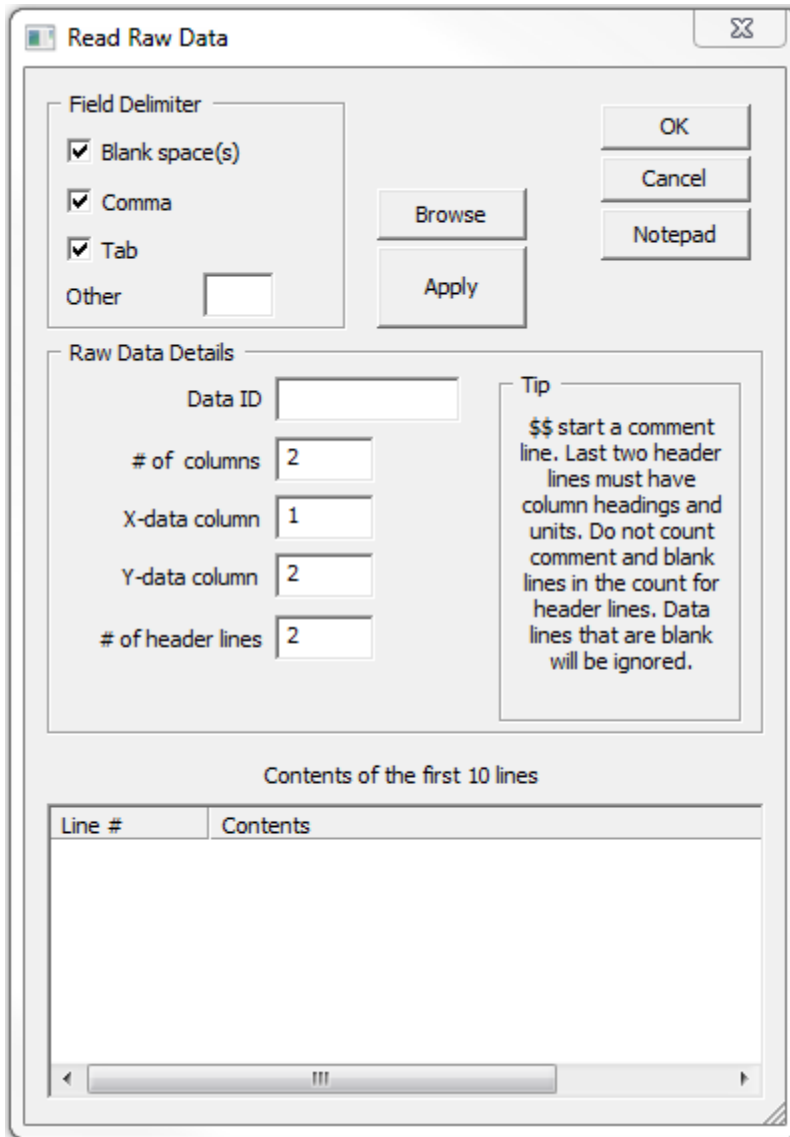


Figure 13. The Read Raw Data interface. In here, multiple sets of data may be read in at once before closing the interface.

After selecting the data file, a preview of the contents is shown at the bottom of the window. Using this, it is a simple matter to fill in the Data ID (the name of the data set or replicate), the number of columns, which columns are to be plotted as x and y-axes (this can be changed later), and the number of header lines. Note the tip on the right that specifies how to interpret the number of header lines.

It is important to differentiate between DIC and MTS data. In Figure 14, the DIC data for replicate 3 has been labelled “TFT2-3_DIC” to indicate the test, the replicate number, and the data being stored. In addition, since the DIC data is stored in a .csv file, only the comma delimiter should be selected in the upper left corner. The number of columns is determined for DIC by counting the number of commas in row one. Since there are 3 commas, there are 4 rows. It may also be necessary to count columns outside of EDP prior to reading raw data. For a

tension test, the longitudinal strain is needed, which labelled as ϵ_{yy} in column 3. Vic 3D 7[®] exports data with 2 header rows with the analysis region in row 1 and the column title in row 2. Press apply to receive confirmation that the replicate successfully read.

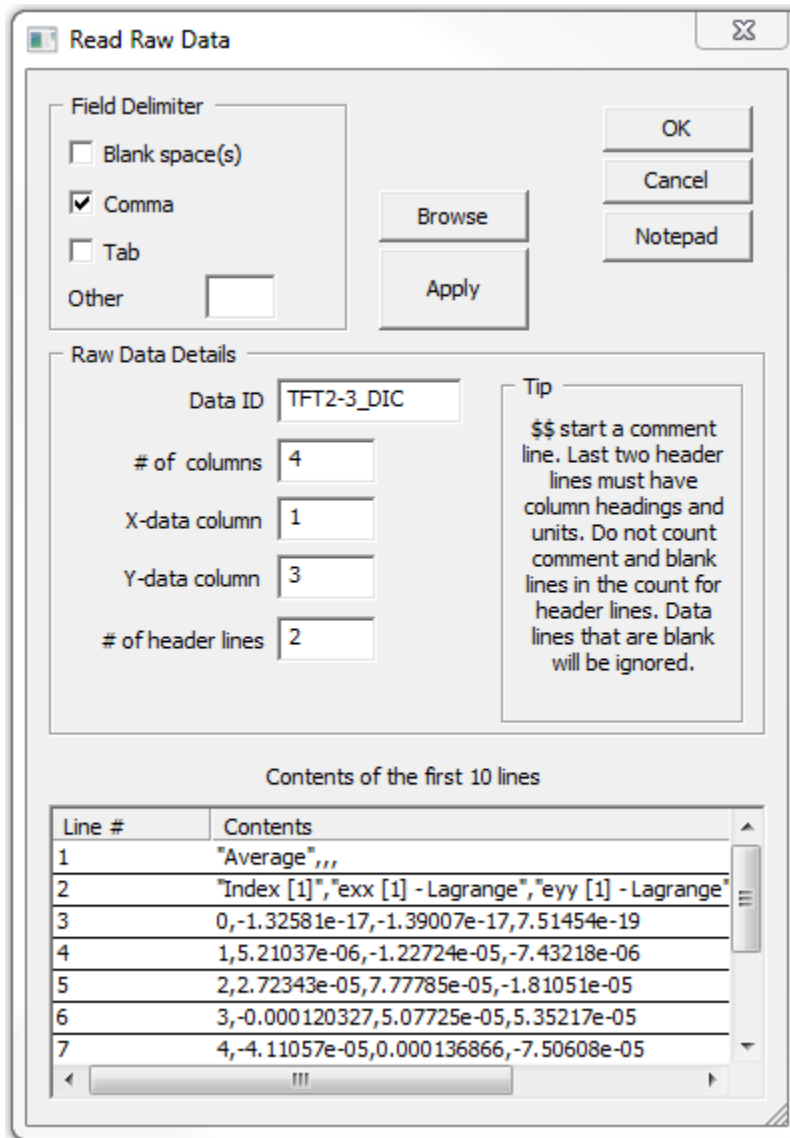


Figure 14. The Read Raw Data interface with DIC information entered.

Next, the MTS data is read. The MTS system exports force data using 5 header lines, but one is blank. As noted in the tip, blank lines are not counted, so 4 is entered as the number of header lines to accommodate. The MTS data is separated by tabs. The MTS data always has three columns: Time, Actuator Displacement, and Force. Time and force are the columns of interest. The Read Raw Data dialogue should appear as it does in Figure 15. Press **Okay** when finished reading all data sets.

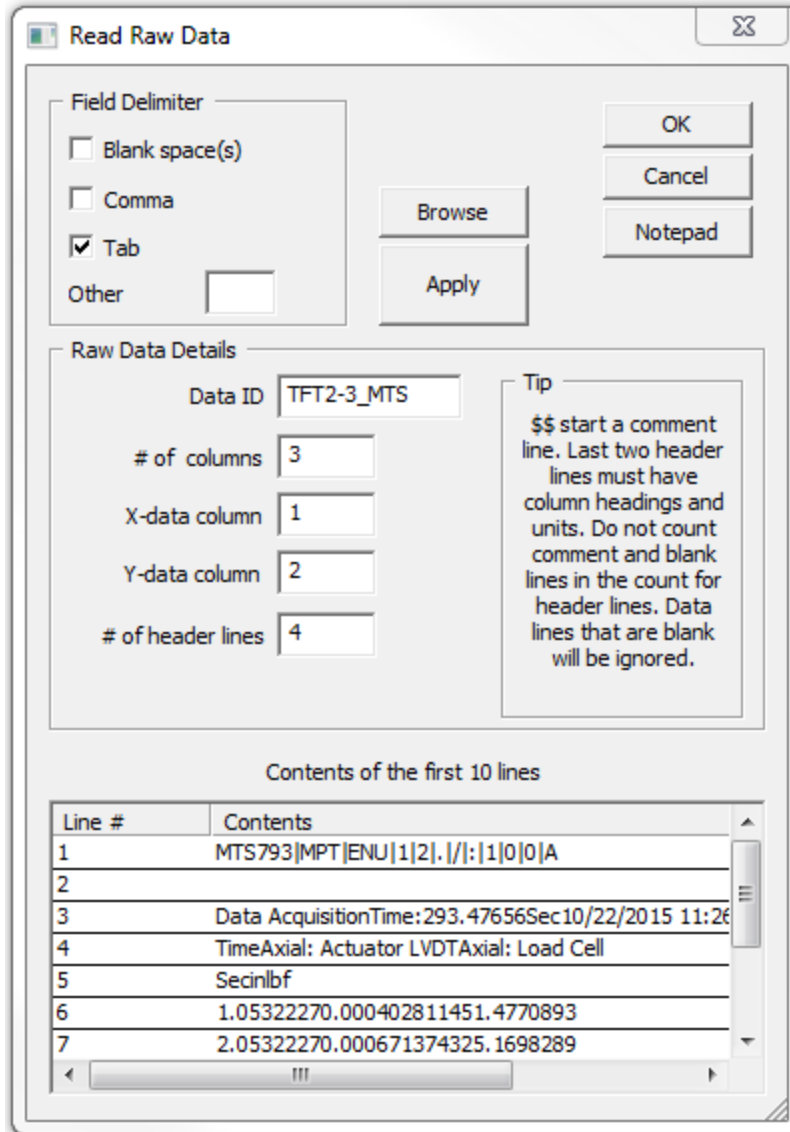


Figure 15. Read Raw Data dialogue with MTS data entered.

If a mistake is made when reading raw data, such as entering an incorrect number of header lines, the command **deleterep** is available for use in the Edit Raw Data dialogue box in the Action input box within the Cell Operations area (see Table 1). Take care when deleting data sets as it is not possible to rearrange data sets at this time.

The raw data is immediately plotted upon pressing okay. DIC and MTS data are on different scales, however, making visualization difficult at this point. Using the check boxes on the top left of the viewing area, it is possible to toggle each curve on and off (see Figure 16). When data is smoothed or fitted, toggling each smoothed or fitted set of data will also be possible. The raw DIC and MTS data can now be visualized as illustrated in Figure 17. Visualizing each data set helps to identify which smoothing methods would work best. In the 2-Direction Tension test, data is consistent with some noise. The drops at the end of each data set should be excluded from processing.

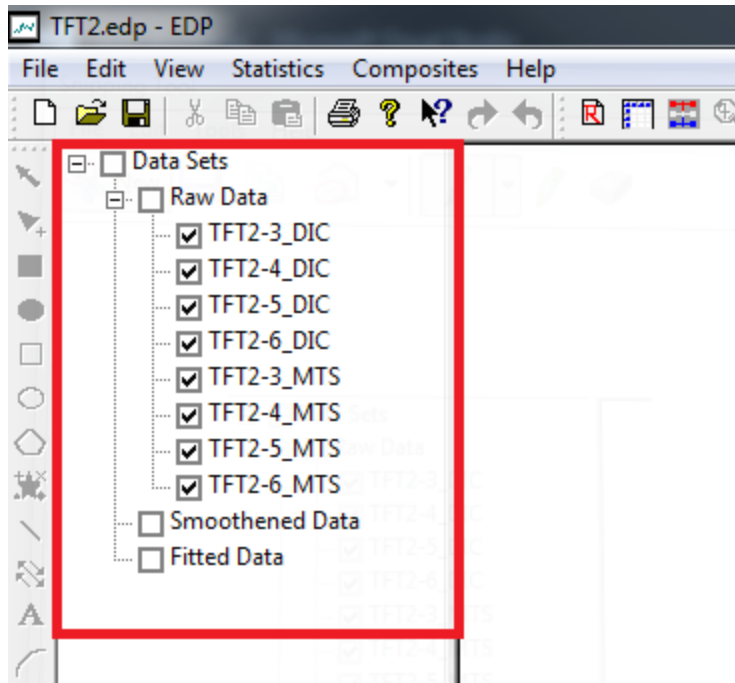


Figure 16. Plot toggle area in top left of view screen.

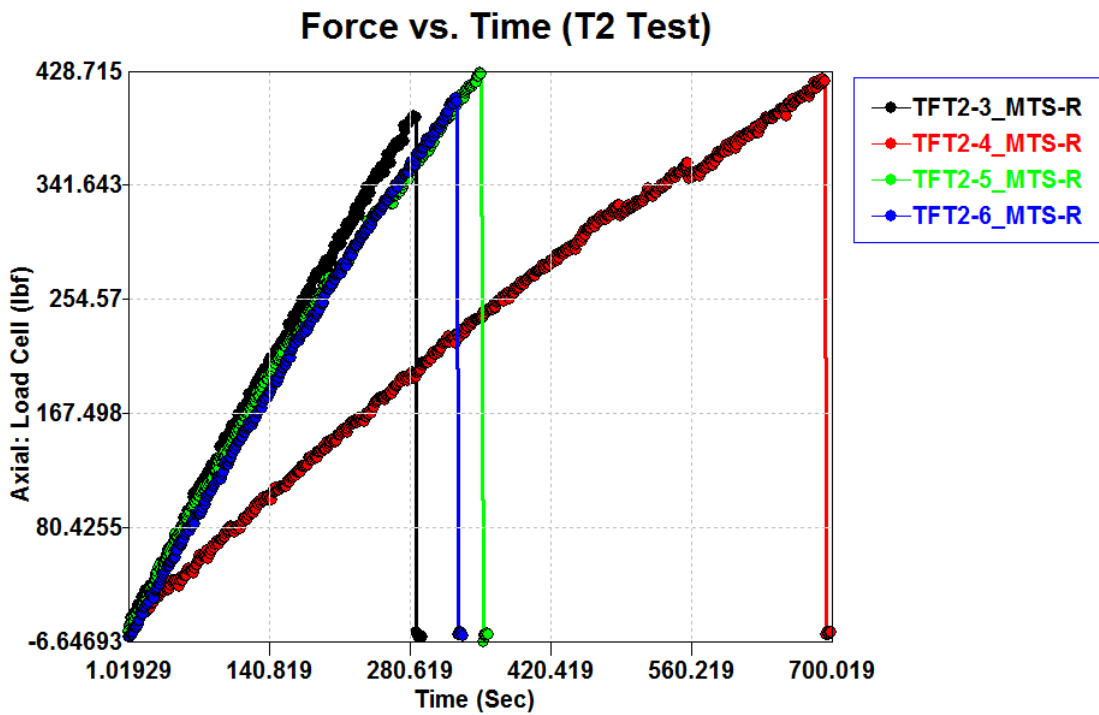
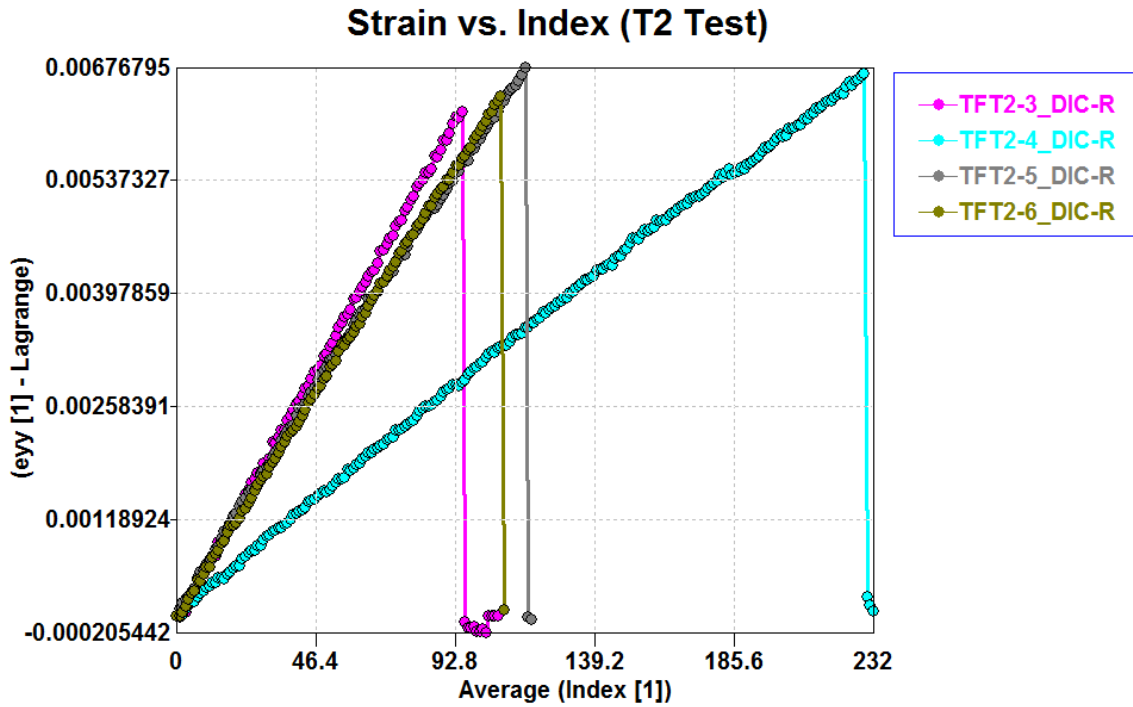


Figure 17. Raw data plotted in EDP.

3.2 Post-Processing

To ensure all data set pairs match and are normalized, the raw data needs to be edited. Select **EDIT or view data** at the top of the screen next to the Read Raw Data button to view the data (see Figure 18).

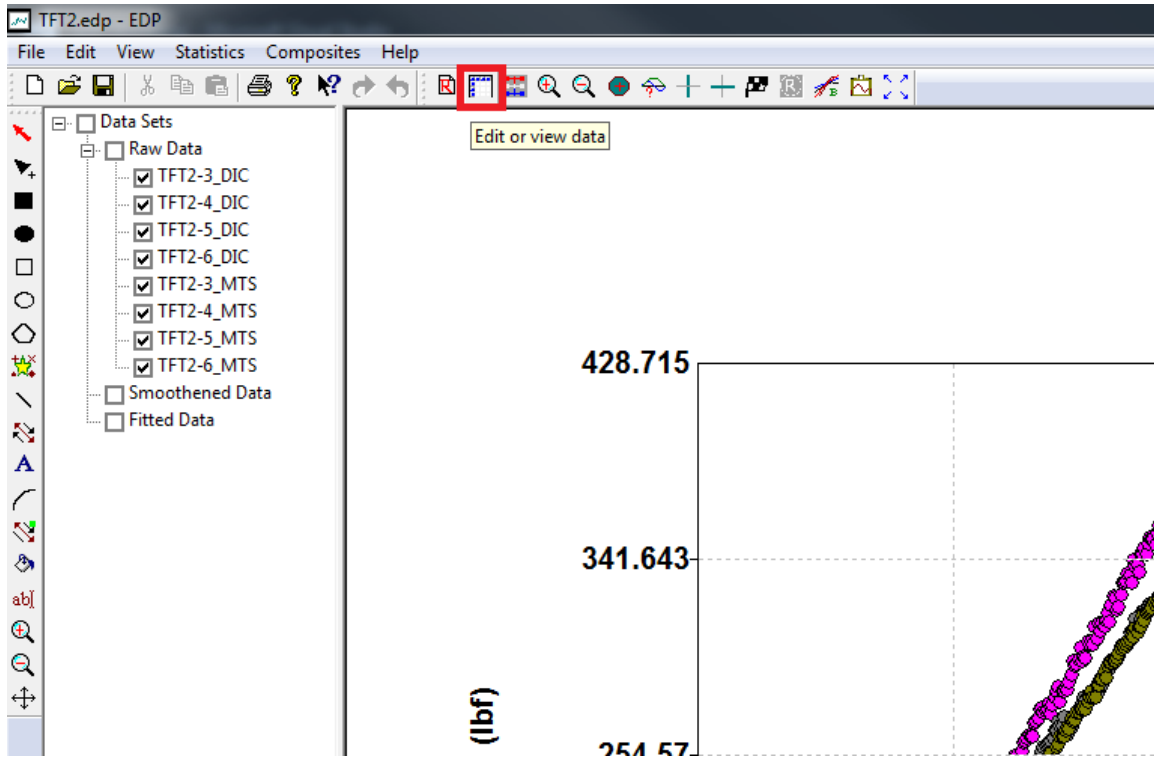


Figure 18. Location of Edit or view data button

Upon opening the Edit Raw Data & View Smoothened and Fitted Data, data from data set one is presented by default. Note the four major areas within this interface shown in Figure 19. At the top is list data showing relevant data for all replicates, including the set number, set name, the number of points, the number of columns, etc. The main feature is the data visualization in the center of the interface. Row ID's are shown on the left while column headers and units are shown above the column ID's. The currently selected data is viewable and editable in this area. Here, it is possible to insert rows/columns, delete rows/columns, and cut, copy, paste, and clear data using right click. To delete or insert, the header must be selected. On the bottom right of the window are the details of the data set currently on screen. Here, set name, column headers, column units, and the x and y-columns can be changed. This is also where the current data set and data type are selected for the viewing area. For a data change made in the details or viewing areas to be stored, the **Update** button must be pressed. Export will create a new text file with the x and y data separated by commas. Finally, in the upper right is the Cell Operations area. Here, Actions can be entered to modify raw and smoothened data. Current commands are shown in Table 1.

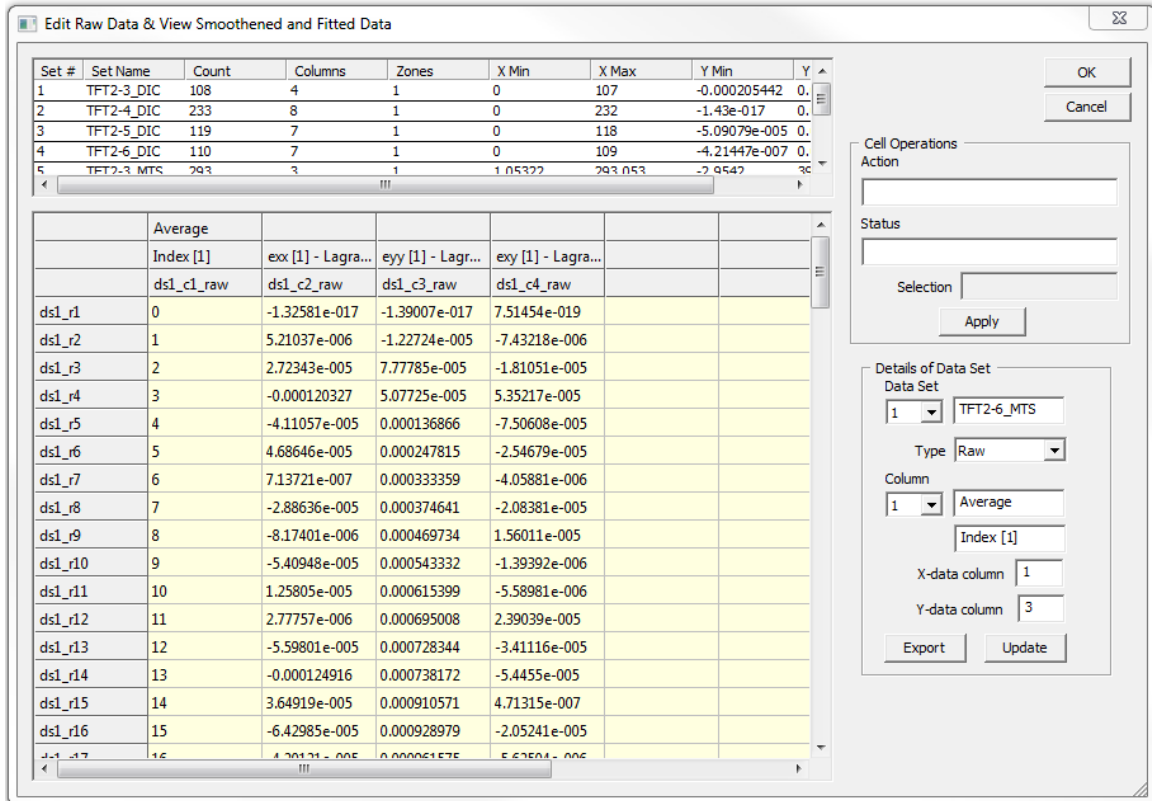


Figure 19. Edit Raw Data & View Smoothened and Fitted Data interface upon launch.

The first step of editing data is normalizing values. The zero and invert commands are used here to ensure all sets of data start at zero time, zero strain, and zero stress as long as the initial values are small compared to the maximum values. For example, MTS time starts at 1.05322 seconds, despite representing the start of the test. Another example is the force column. For TFT2-3, the max force is 394.802 while the initial force is 1.47709, or about 0.4% of the maximum value. The zero command allows for multiple replicate and column pairs to be entered at once (e.g. zero, 1, 1, 1, 3, 5, 1, 5, 3 indicates the first and third columns of data sets 1 and 5 are to be zeroed). Since this is a tension test, there is no need to invert the data. Compression and shear tests may require inverting the data.

Once data is zeroed, the raw data must now be normalized. The DIC data is presented by index instead of time. The capture rate should be recorded during testing. For TFT2 tests, the capture rate was 3. By using the command “ds1_c1_raw=ds1_c1_raw*3”, the indices are converted to units of time. MTS data also shows force instead of the normalized stress. Using the edit raw data function, the force can be converted to stress. To reflect these conversions, use the Details of Data Set area to update the column titles and units.

The changes made should be immediately apparent upon pressing Okay in the Edit Raw Data dialogue box.

3.3 Remove Outliers and Filter Data

Next, the data must be smoothed. Now that data is loaded, the **Process Data** button is available. Select the **Process Data** button in the top tool bar as shown in Figure 20.

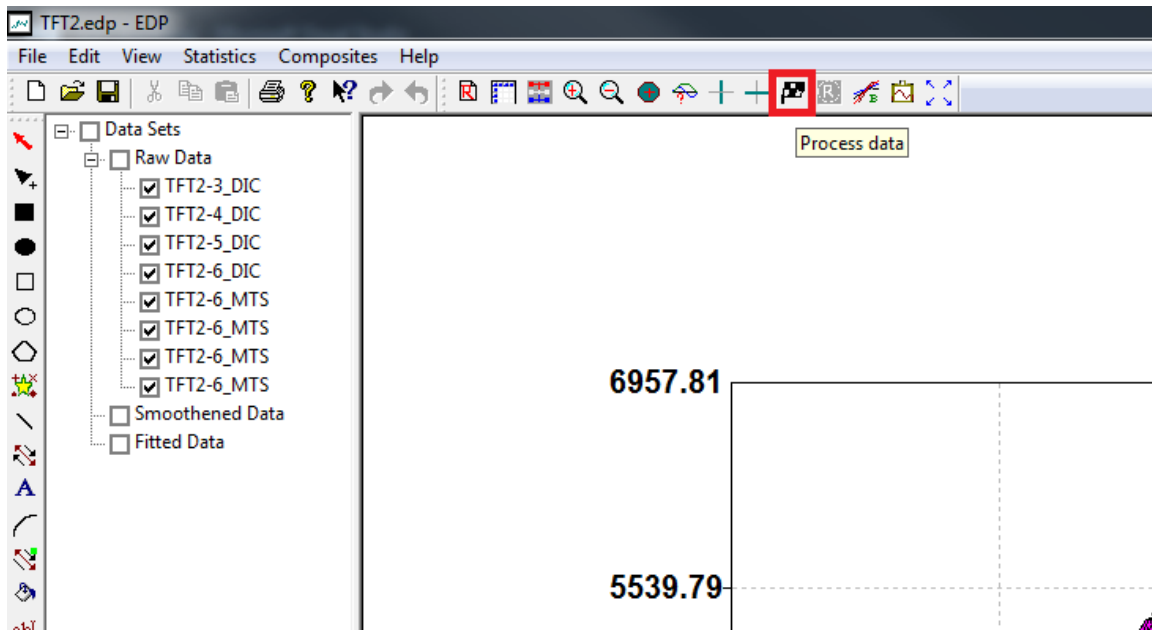


Figure 20. Interface with Process data button highlighted

The Data Set-Zone Data dialogue box is where smoothing and fitting options are selected, shown in Figure 21. Here, all changes to the current Data Set will only be stored upon pressing Update.

Smoothing and fitting is done by zone. If a data set has multiple regions of data (ex. linear and nonlinear regions), additional zones may be added with the Add Zone button on the right. Zones are defined by the start and x values. These values should correspond to those from the x-column defined upon reading or editing data. For the 2-Direction tension tests, the start x should be 0 and the end x depends on the ultimate stress and strain values for each replicate. All end values should be multiples of 3 to ensure stress and strain points match. The current fit types and smoothing methods are outlined in Table 2 and Table 3. The number of points must be odd between 3 and 25 for most smoothing methods; PMA and Loess require a minimum of 5 points.

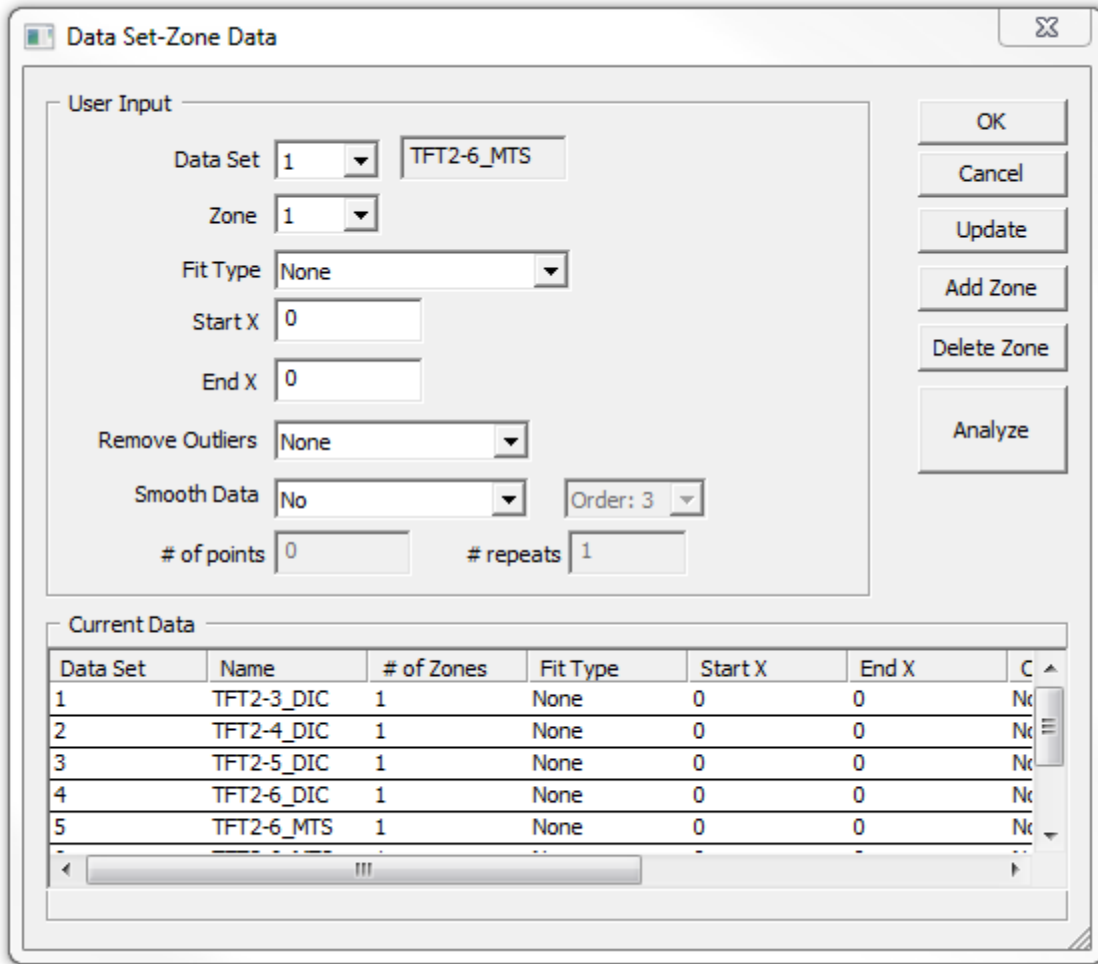


Figure 21. Data Set-Zone Data dialogue box

Since the data appears straight with some noise, SMA smoothing method would be appropriate. Additional information on smoothing methods is available in Table 3. The results of using SMA and Lowess methods are shown in this guide. Select analyze once all zones are defined and press **OK**.

Once analyzed, the Smoothened Data is now able to be toggled on the left. Figure 22 shows the TFT2 smoothened data generated using Lowess with 15 points and 2 repeats. Figure 23 shows the TFT2 smoothened data generated using SMA with 15 points and 2 repeats.

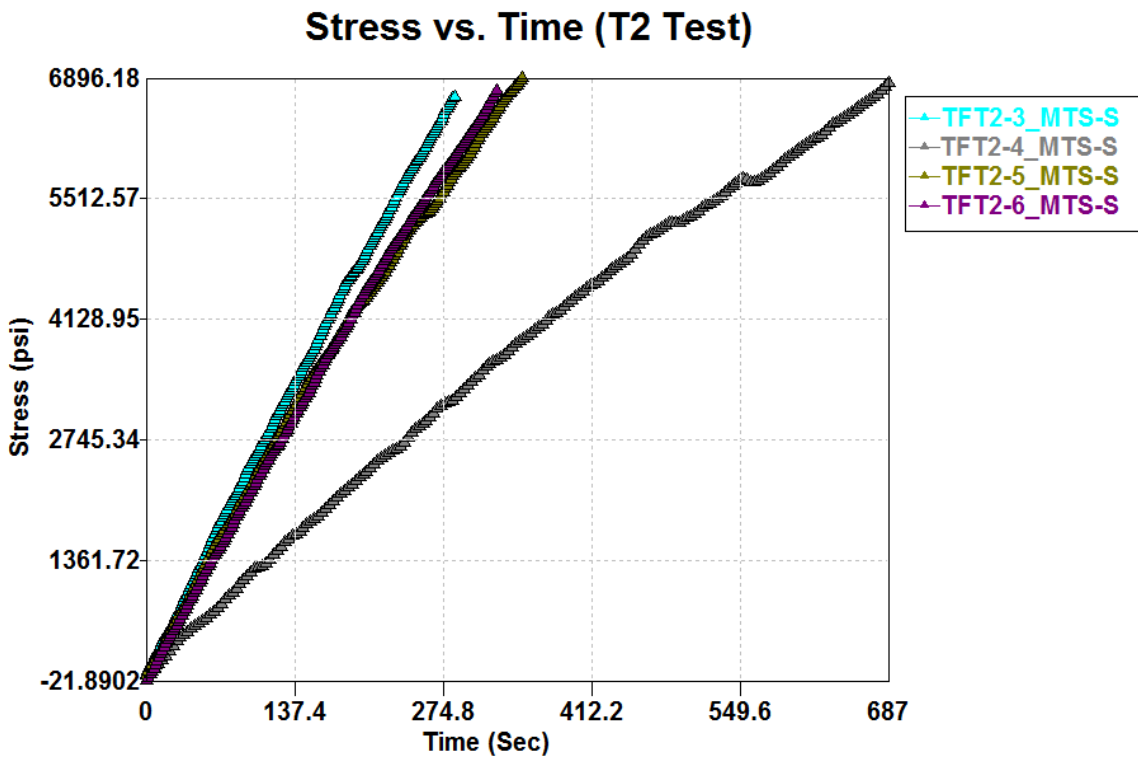
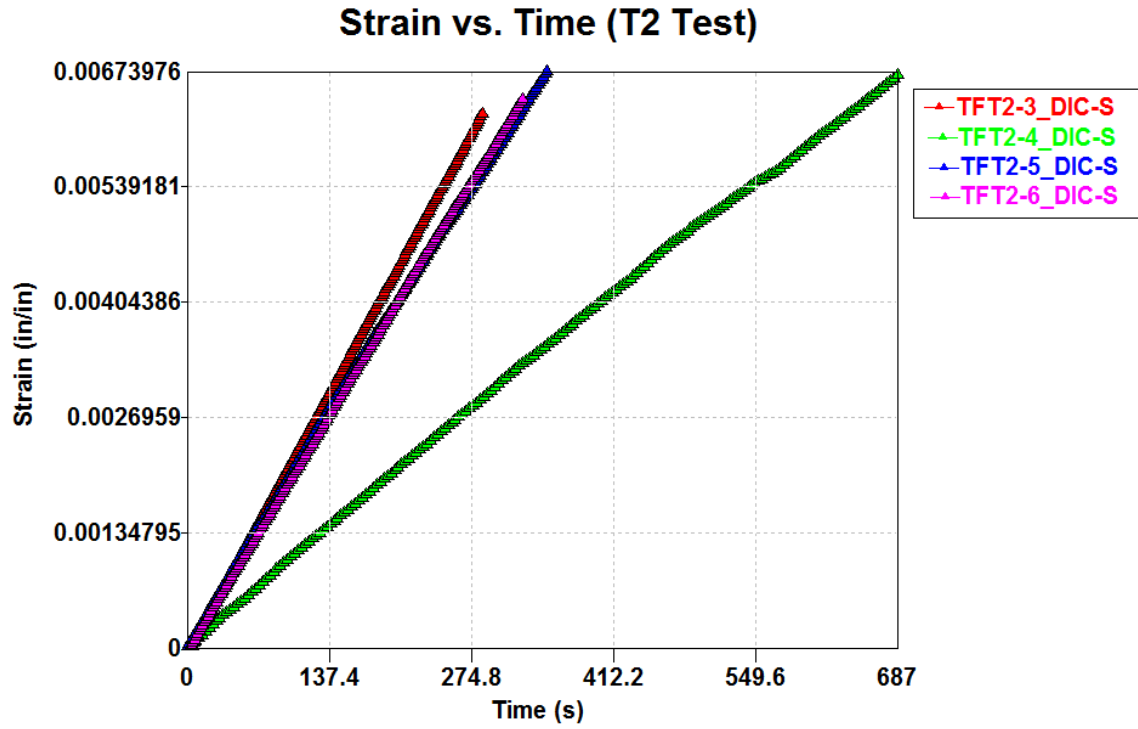


Figure 22. Smoothened data generated with Lowess smoothing plotted in EDP

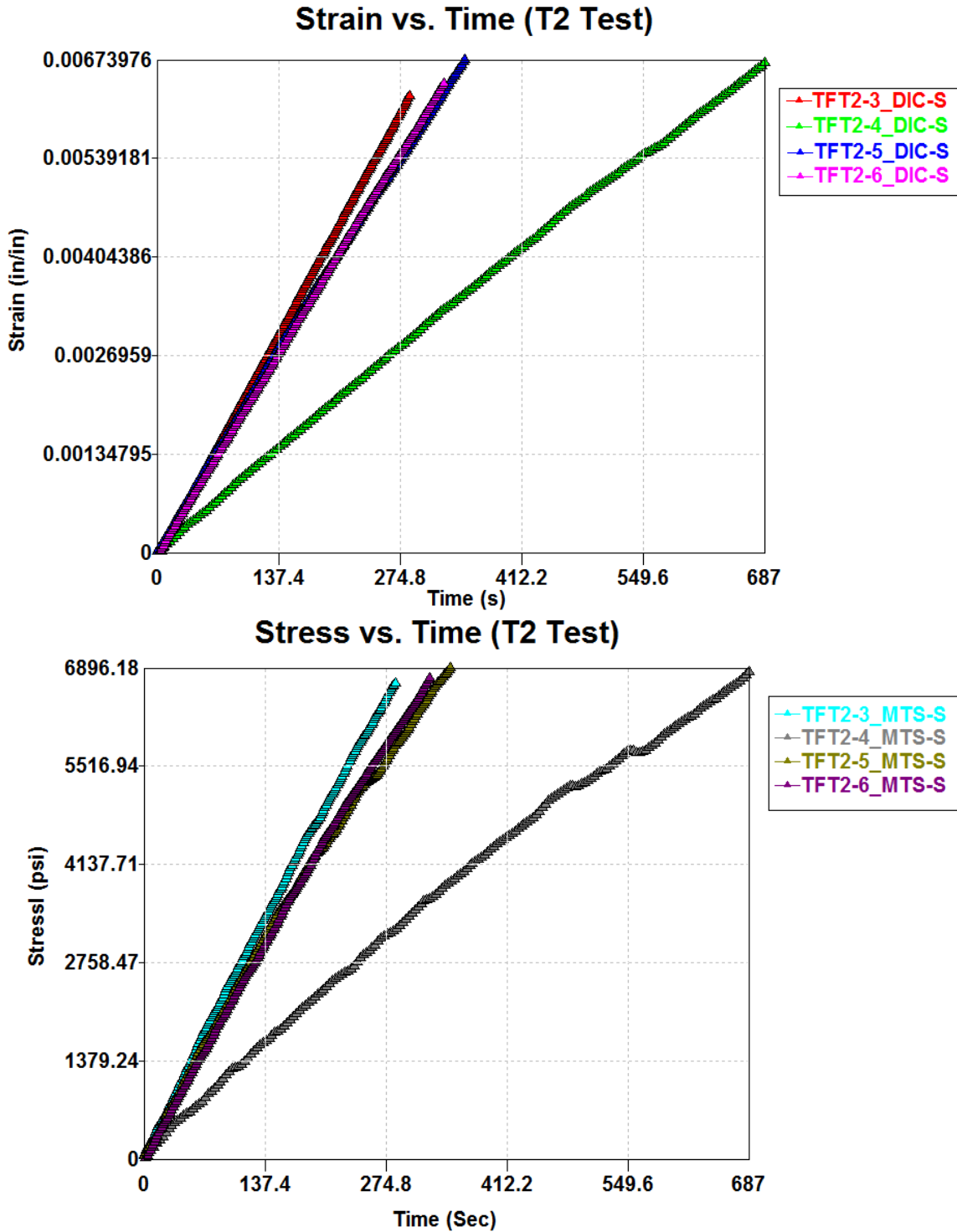


Figure 23. Smoothened data generated with SMA method plotted in EDP

3.4 Plot Stress-Strain Curves

The smoothened data must now be reformatted with the “Reformat” command (detailed in Table 1; ex. “reformat, 1, 1, 1, 200” rediscrretizes data set 1, zone 1, based on column 1 into 200 points)

using the Action prompt within the Edit Raw Data & View Smoothened and Fitted Data dialogue box.

Once all replicates are reformatted, the “create” command can be used (ex. “create, TFT2-3, smt, 1, 3, 5, 3” will create a new replicate titled TFT2-3 based on the smoothed data stored in column 3 of data set 1 and column 3 of data set 2). EDP alerts the user when the new data set is successfully created. The column titles and units are transferred from the source columns automatically. The results for creating the 4 stress-strain curves for the 2-Direction tension test are shown in Figure 24.

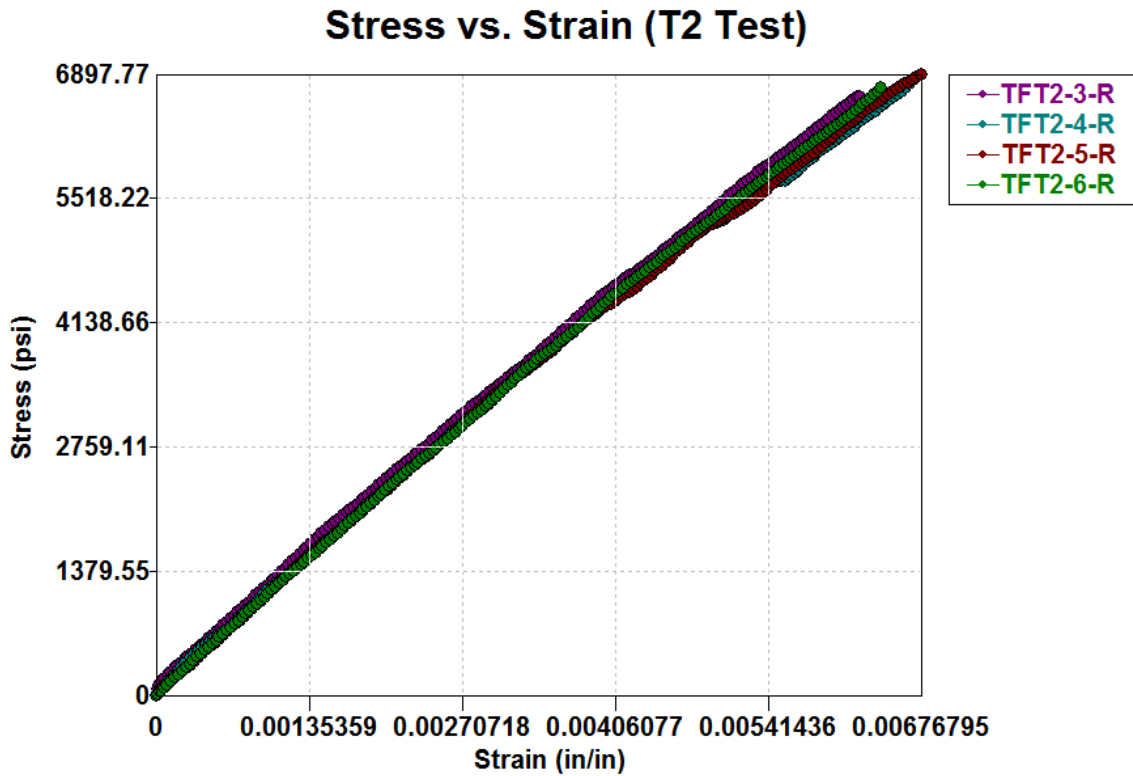


Figure 24. Stress-strain curves for the four replicates plotted in EDP

3.5 Generate the Model Curve

With all stress-strain curves generated, the final step is to generate the best fit or model curve. The **Best fit plot** button is in the top toolbar as shown in Figure 25.

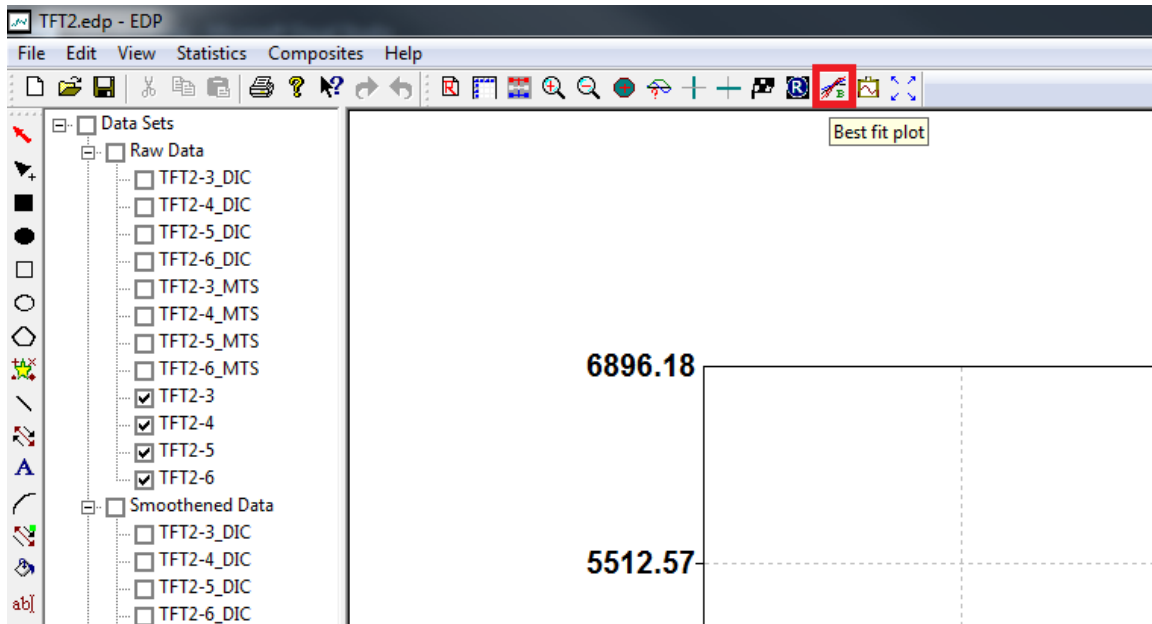


Figure 25. Interface with Best fit plot button highlighted.

The Best Fit plot will be generated based on all curves currently being plotted. When using Lowess or Loess smoothing, be sure all replicates start at 0 prior to creating the best fit (other methods will maintain the same start and end points). Upon pressing **Best fit plot**, the Best Fit Input dialogue box is presented, shown in Figure 26. There are three inputs for creating the best fit: the new data set name, the curve end type, and the number of data points. There are three curve end types: extend, average, and cut. Extend selects the largest end x value as the end point for the best fit and extrapolates shorter curves. Average takes the average of the end points and cuts/extends curves as needed. Cut selects the smallest end x value as the end point for the best fit curve and cuts longer curves. The number of points must be between 5 and 100. For this example, the name will be set to “TFT2”, the end type set to “Average”, and the number of points set to 100.

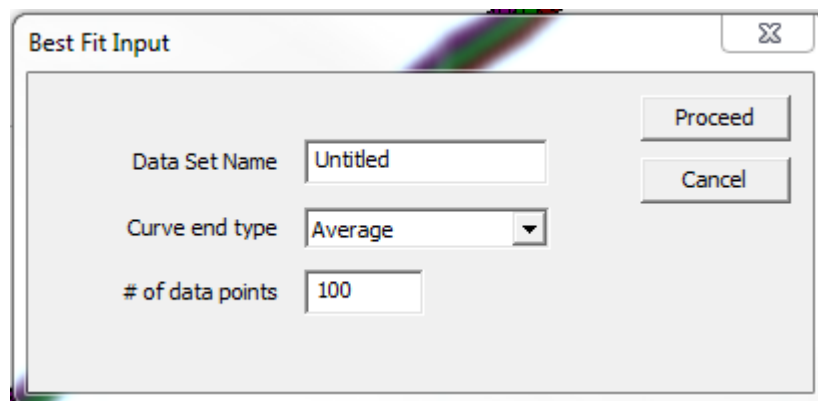


Figure 26. Best Fit Input dialogue box

3.6 Plotting Data

The final curve can then be plotted alone. For better visualization, change the plot limits by pressing the **Edit graph settings** button in the top bar, as shown in Figure 27.

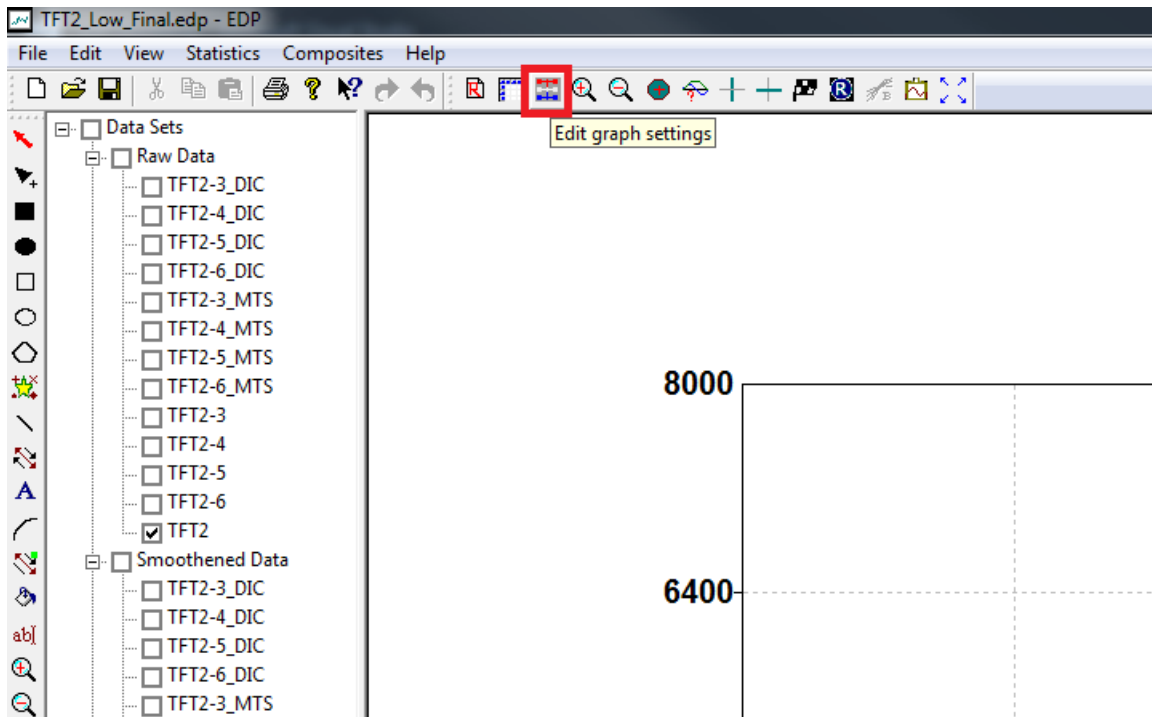


Figure 27. Interface with Edit graph settings button highlighted

The XY Graph Data dialogue box has two tabs. The first tab, Graph Attributes, allows for the axis labels and graph title to be edited. The curve colors, markers, and line types are also customized in this section. The Graph Layout tab allows for the plot limits to be modified. In this tab are miscellaneous options to further customize the plot appearance. Both tabs are shown in Figure 28.

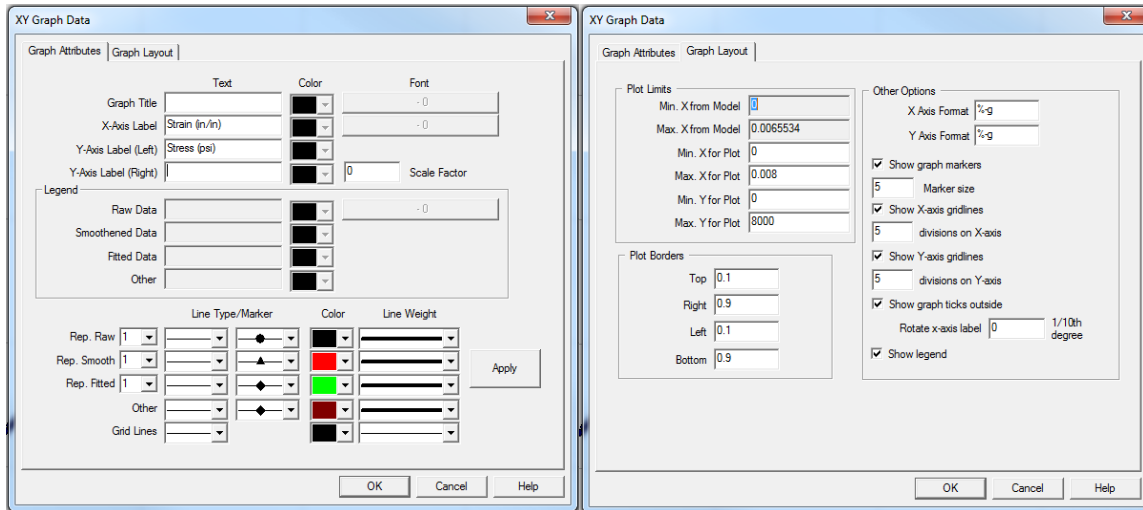


Figure 28. XY Graph Data interface with the Graph Attributes tab (left) and Graph Layout tab (right) shown

The final curve generated with Lowess and SMA smoothing methods with modified plot limits and alternate y-axis are shown in Figure 29. Both curves are very close together with the Lowess curve having a higher ultimate strain and the SMA curve having a higher ultimate stress. Both curves appropriately represent the response of the T800-F3900 composite in the 2-direction. When generating other curves, however, the best smoothing method depends on the quality of the raw data.

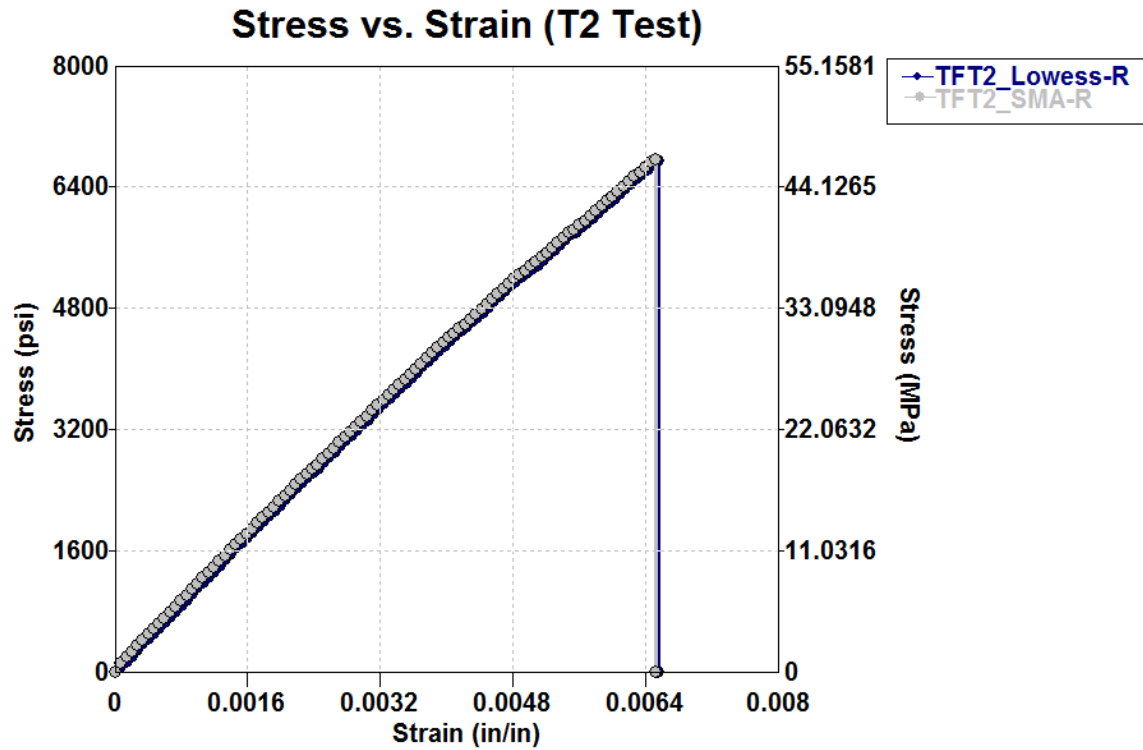


Figure 29. Final model curve for TFT2 generated with Lowess (blue) and SMA (grey) smoothing methods plotted in EDP

4 Advanced Features

4.1 Plotting and Plotting Options

EDP features the ability to plot curves and edit the appearance of the plotting region. Active curves are defined on the left side of the plotting area by using check boxes by the individual raw, smoothed, and fitted data labels.

The **Edit graph settings** button is available in the tool bar once data has been read into EDP, the location of which is shown in Figure 30.

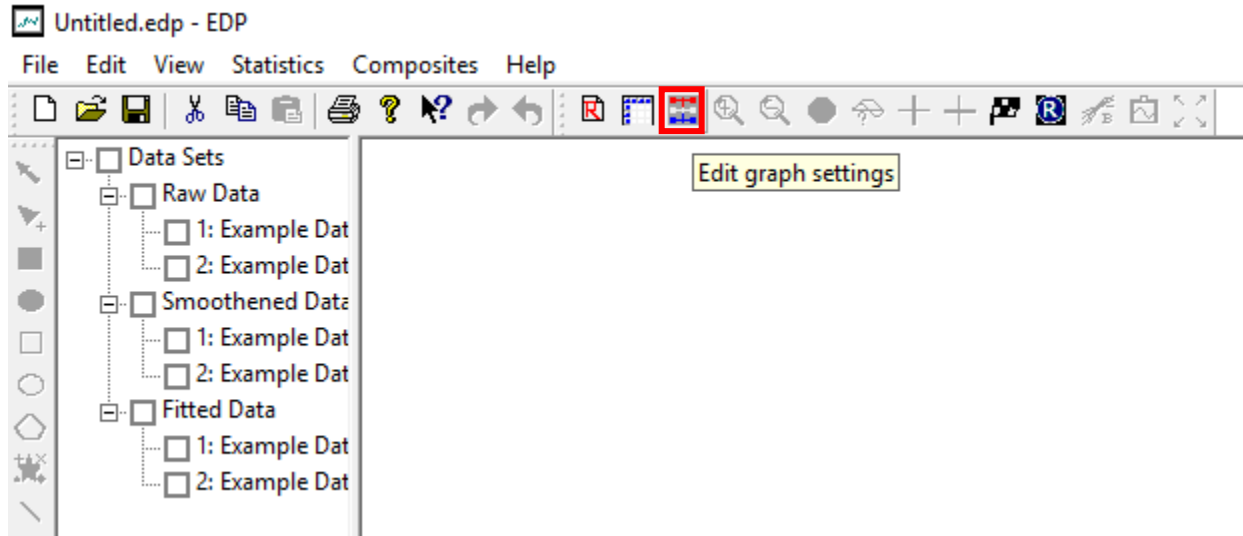


Figure 30. Edit graph settings button highlighted in tool bar and the active data set interface shown on the left.

The XY Graph Data interface is split into two tabs: Graph Attributes and Graph Layout. The Graph Attributes tab (see Figure 31) allows for the graph title and labels to be customized. The x and y-axis labels are automatically filled from the column headers and units for the last replicate currently being plotted, though they may be overwritten. A second y-axis label with an alternate scale may be added on the right side as well. Color and font customization for these labels and legend customization are currently disabled. Customizing these features will be discussed later in this section.

The appearance of individual curves identified by data set number can be customized in this interface as well. The line type, marker type, color, and line weight are customized for each data type in each data set. Grid lines may also be customized by line type, color, and weight. Press **Apply** to save all changes.

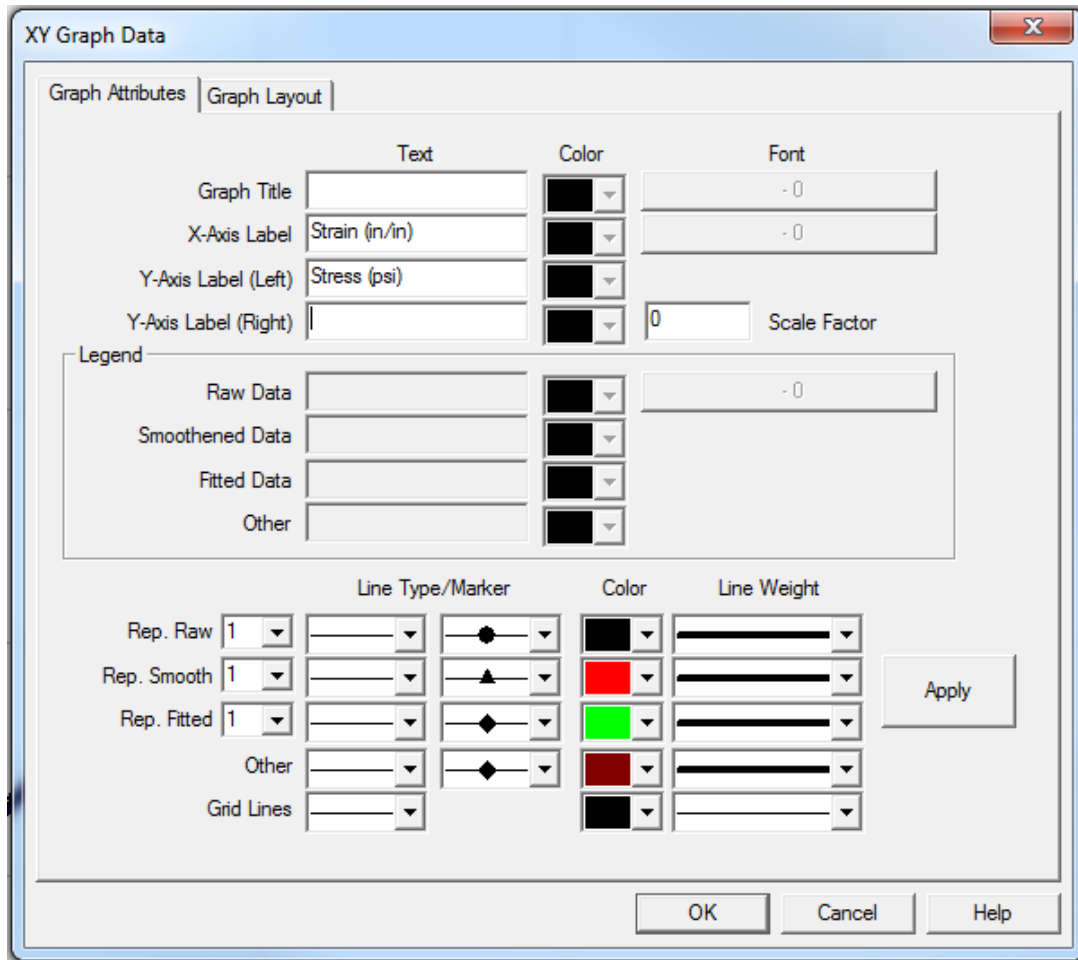


Figure 31. Graph Attributes tab within the XY Graph Data interface.

The Graph Layout tab (see Figure 32) features customization options for Plot Limits, Plot Borders, and miscellaneous plotting options. The minimum and maximum X values from the current plotted curves are shown first for reference. The minimum and maximum X and Y values for the plot are editable. To see the current maximum Y values for reference, the right side of the plotting area shows the extreme values from each active plot.

The plot size is dictated by the Plot Borders options. The Top and Left border values must be between 0 and 0.2, which indicate the relative distance between the plot borders and the interface edges.

The Other Options section includes graph markers toggle, customization for the graph markers, customization for the X and Y-axis gridlines and divisions, and the legend toggle.

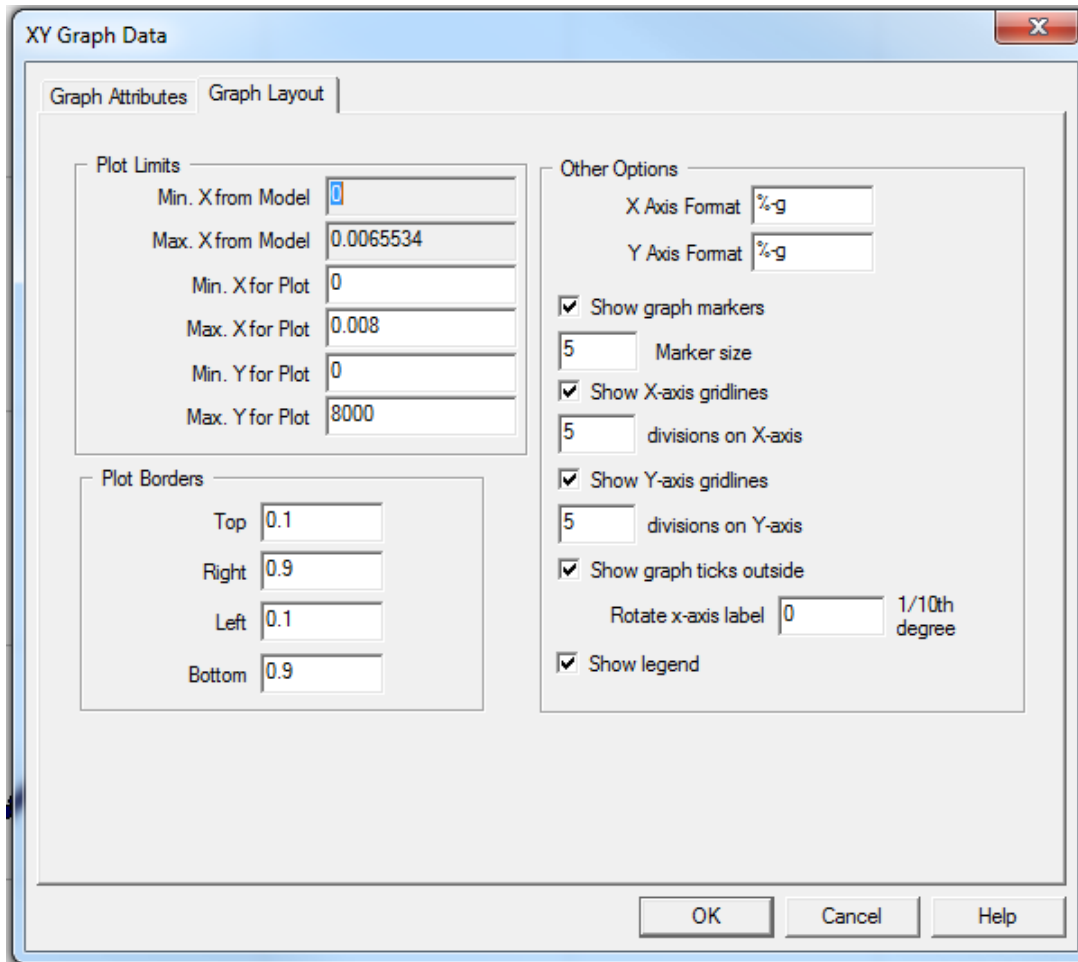


Figure 32. Graph Layout tab within the XY Graph Data interface.

To customize the label font, color, and orientation, the left tool bar must be used. To activate the left tool bar, select the plotting area. To select an object for editing, use the select tool, the top most option represented by a red arrow pointing up and to the left. Once a label is selected, select the **Edit text** button, highlighted in red in Figure 33.

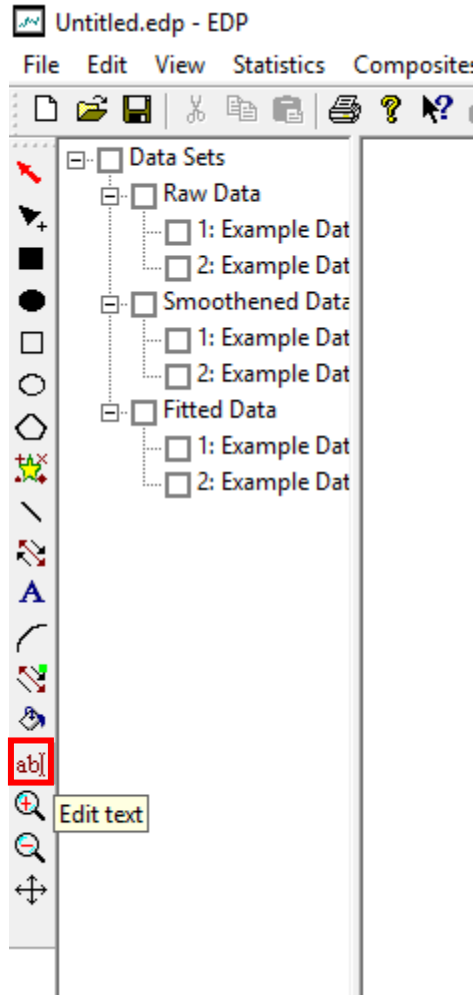


Figure 33. Edit text button highlighted in the left tool bar.

The Edit Text interface, shown in Figure 34, allows for editing of the text of a label, the vertical and horizontal alignment within the text box, the orientation of the text box, and the font style (Note: Orientation is designated in units of $1/10^{\text{th}}$ degrees with a positive value indicating a counter-clockwise rotation). Placement of the label must be done using the select tool.

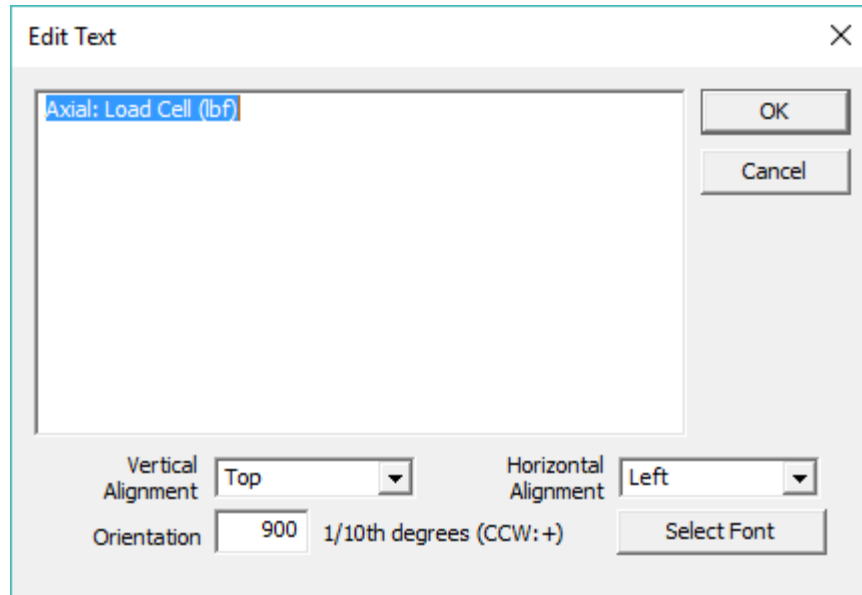


Figure 34. Edit Text interface.

4.2 Generation of Tsai-Wu Failure Surface

The Tsai-Wu failure surface can be generated using EDP. The failure surface can be generated in in-plane space (11-22 space) and out-of-plane space (13-23 space) using the composite strength in 1,2,3 direction in tension and compression and shear strength in the principal plane (Goldberg, et al., 2017).

Click on **Composites** available on the toolbar and click on **Generate Failure Surface** as shown in Figure 35. A dialog box will appear (Figure 36).

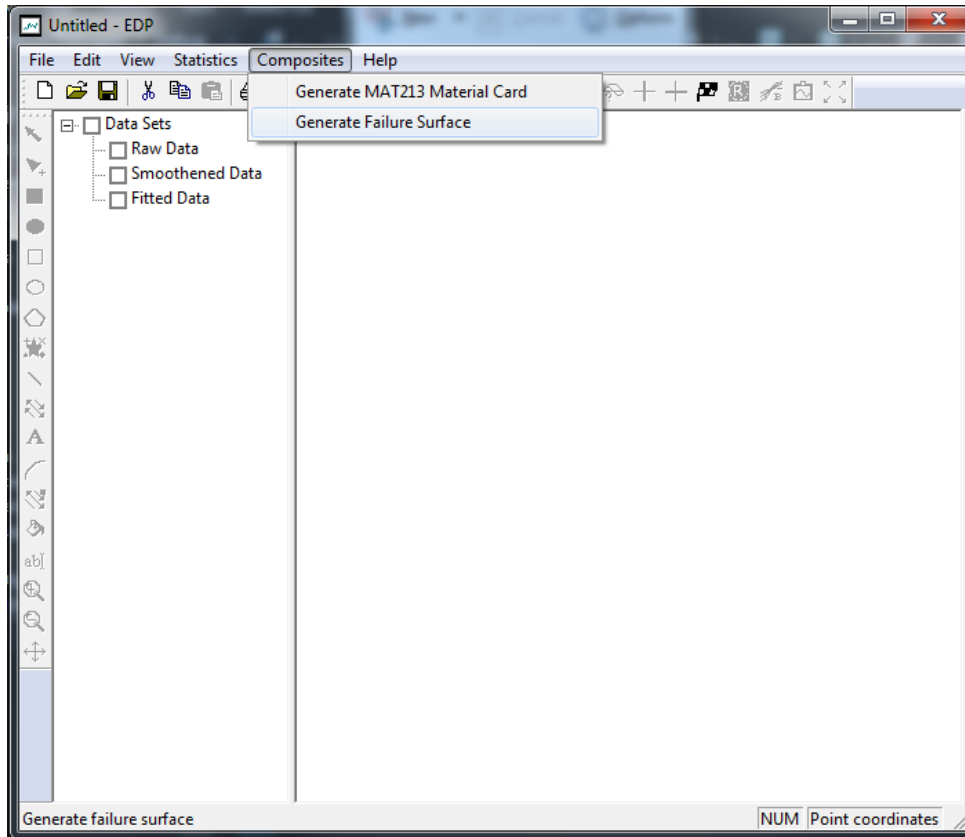


Figure 35. Generate failure surface.

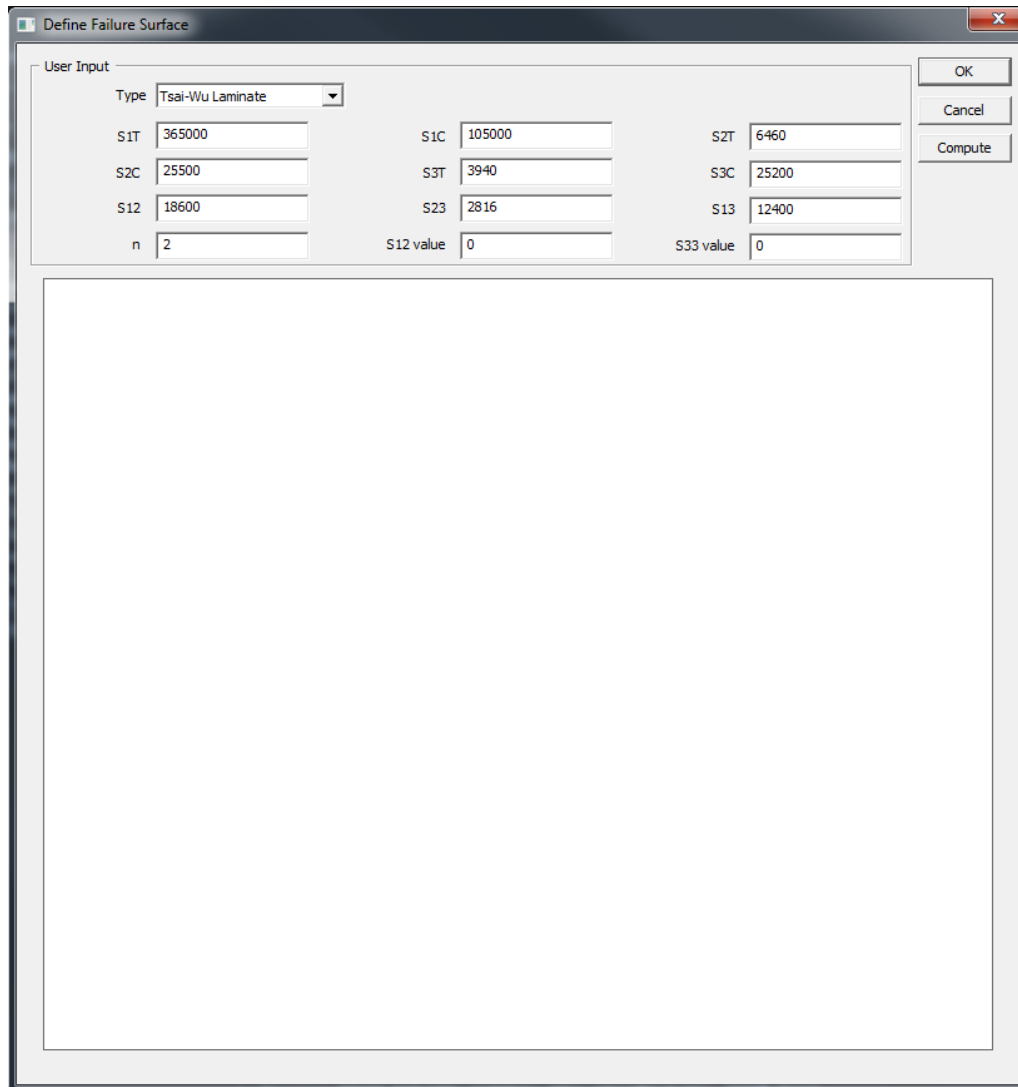


Figure 36. Failure surface dialog box.

On the **Type** of the failure surface, only Tsai-Wu Laminate is available now. Other types of failure surfaces will be added later. *S* denotes the strength of the composite in the respective direction/plane. The values shown in dialog box (Figure 36) are available as default. These values can be changed as required. Click on **Compute**, the in-plane failure surface will be generated by default as shown in

Figure 37. To generate the out-of-plane failure surface and additional plots to define the failure criteria, place the cursor on the graph and right click on it, and menu appears as shown in Figure 38. Additional plots can be generated as required by clicking on the menu.

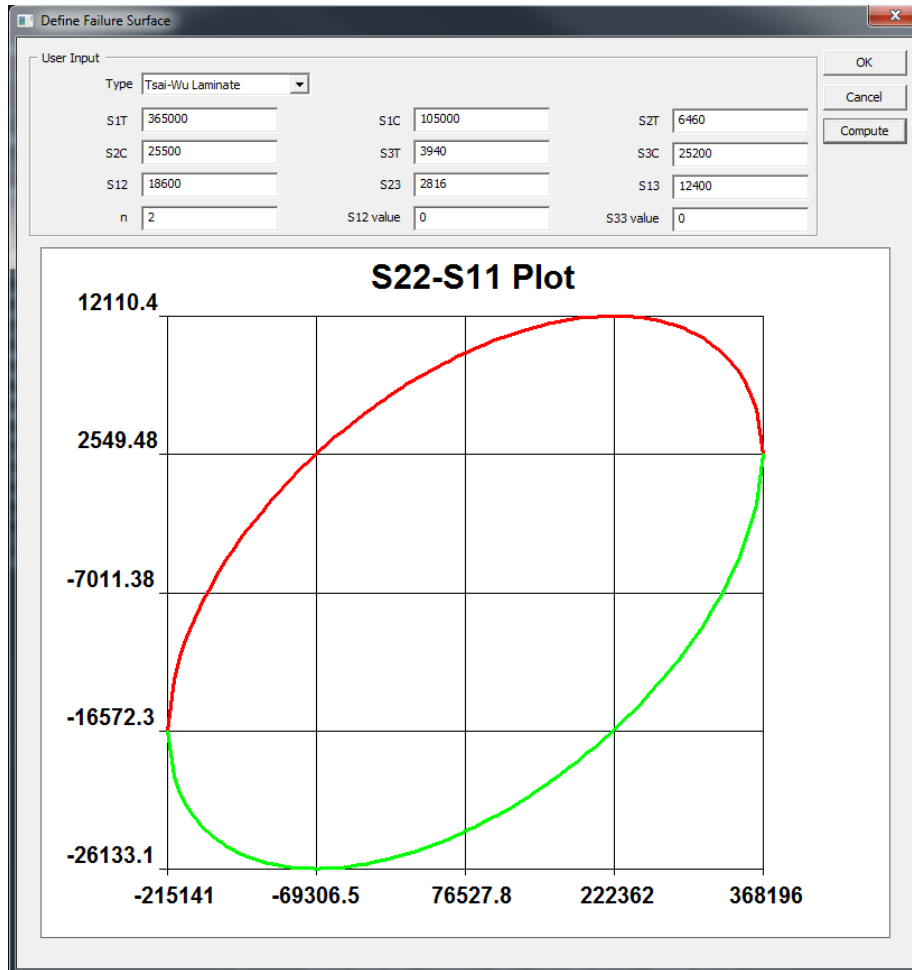


Figure 37. Generation of failure surface.

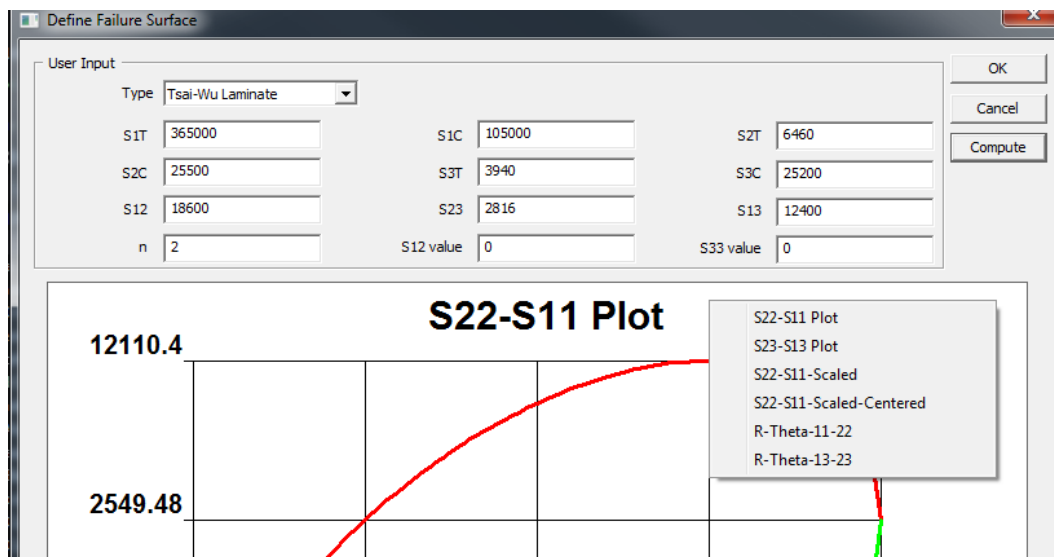


Figure 38. Generation of additional plots.

5 References

- Goldberg, R. K., Carney, K. S., DuBois, P., Hoffarth, C., Khaled, B., Shyamsunder, L., . . . Blankenhorn, G. (2017). *Incorporation of Failure into an Orthotropic Three-Dimensional Model with Tabulated Input Suitable for Use in Composite Impact Problems*. NASA TM-2017-219492.
- The MathWorks, Inc. (2016). *Filtering and Smoothing Data*. Retrieved July 17, 2016, from www.mathworks.com/help/curvefit/smoothing-data.html