

TENSILE DATA ANALYSIS

The Tensile Example document presents a method to generate a stress-strain curve from test data. This visual representation helps to guide the determination of material properties for design. A completed worksheet, “Steel6150Tens” is in the Help folder.

Using Names

Names can be used during analysis. For example, Define “Stl6150a_Stress” to refer to E12:E404. A list of names with their references may be listed in the sheet with Insert>Name>Paste.

Comments

Right click on a cell to add comments to document your procedures.

UTS	668.36063	Mpa	
Modulus	166.4	GPa	
Time(sec)	Stress (Mpa)	Offset Stress(M	
4	0	2.70E+00	-3.24E+02
4	1	8.00E+00	-3.24E+02

MTIL: S=Load/area.
*1000 for kN.

Analysis of Tensile Data

The basic material properties that may be derived from the stress-strain curve are, in the order of occurrence:

- Elastic Modulus.
- Yield Strength.
- Ultimate Tensile Strength.
- Fracture strain.

Fracture Strain

The property that is determined most readily is the fracture strain, the strain at the last data point. This strain is also the maximum strain.

UTS

The ultimate tensile strength (UTS) is the largest value of stress. The MAX function may be used. Select a cell to display this information, and then “=max”(range of cells). In the example for 6150 steel, the entry is “=max(e12:e404)”. If it is a valid equation, it will display in all caps.

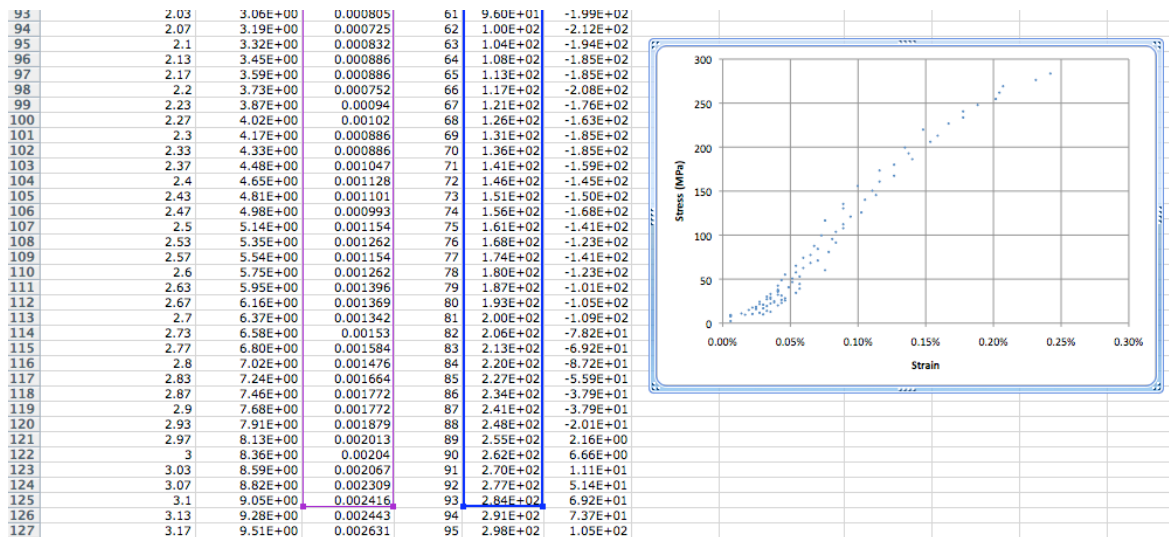
If the name “Stl6150a_Stress” is defined as E12:E404, then the formula can be written “=max(Stl6150a_Stress)”.

Modulus

The Elastic Modulus is the slope of the plot in the initial linear portion. First make a copy of your stress-strain chart in the worksheet. You will adjust the data ranges in the copied chart to zoom in on the region of interest. *Keep the original.*

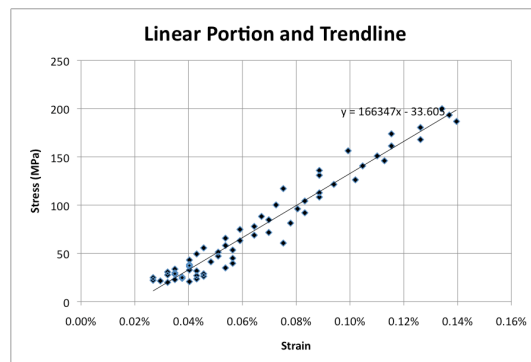
Estimate the maximum stress in the linear portion. Find the row corresponding to that stress. On the copied chart adjust the ranges of X and Y values. Open the “Select Data Source” dialogue box and manually change the cell addresses for maximum stress and the corresponding strain. If row 125 contains the data, make the X value range \$C\$32:\$C\$125 and similar for Y values.

If axes scales have been manually set, reset them to automatic so the chart will auto-scale. For clarity, make the Percent on the Strain axis show more decimal places.



To make finer adjustments, click on a data point on the chart and note that the ranges are outlined on the worksheet. Drag the chart so that the data and the chart are both visible. Or open a New Window so that you can see both. Drag a corner of the data range until the chart shows a linear distribution. Some of the initial points close to zero may also be non-linear and may be eliminated to determine the modulus. Small fluctuations of the sensor outputs are relatively large for these small strains, so there appears to be a significant scatter; however the trend is clear.

Right-click on a data point in the chart and select “Add Trendline”. The default fit is linear. Select Options > Display Equation on Chart. The X-coefficient is the slope of the line. The units are MPa / <dimensionless>. Convert to GPa by dividing by 1000. Label the cell “Stl6150a_modulus.”



Yield Point

Low-carbon mild steels in the annealed or normalized condition have stress-strain curves with a peak stress, and then a lower yield region in which the stress is nearly constant over a short range. The yield stress may be taken as the lowest stress in that region.

The stress-strain curves for most materials do not present such an obvious yield point. Yield may be defined as the proportional limit, where linearity ends; however, this point is subject to interpretation and may not define a transition to plastic behavior anyway.

The common method is to construct a line parallel to the modulus line. The line is offset to pass through the strain axis at 0.2% (0.002). The intersection of this line with the stress-strain curve is defined as the yield point. This designation is arbitrary; however, a designer knows the limitations of this criterion and plans accordingly.

The equation of the offset line has the slope of the modulus (E) with the intercept with the horizontal axis at a strain of 0.002. If the units of modulus are GPa, there must be a factor of 1000 to convert to MPa. The result is

$$\text{Stress(MPa)} = \text{modulus(GPa)} * (\text{strain} - 0.002) * 1000$$

To the right of Stress (MPa), make a column heading for Offset Stress (MPa). In the first cell, type the equation “=Stl6150a_modulus * (“, <click on C32>, “- 0.002) * 1000”. Copy down the column. The values are negative until the strain (column C) exceeds 0.002.

Make another copy of the original stress-strain chart. Highlight *all* of the data in the Offset Stress column. Edit>Copy. Click on the chart and Paste. The offset line should appear, but it is jammed near the vertical axis. Rescale the strain axis to a maximum of 1%. Readjust if needed. Click on a data point of the offset line and Format Data Series to include a line. Adjust axes and appearance as needed.

The stress can be determined reasonably by visual inspection. Straight-line segments can be formulated from the data for a more precise point.

Reporting

Depending on the version of Office, different methods are used to insert the chart into your report. Some versions allow the chart to be copied directly and pasted into the report. Other versions require saving the chart as a picture to insert into Word.

How Excel Plots Data

Excel charts data one-to-one from the respective ranges. The value in the first cell of the Y-range correlates with the value in the first cell of the X-range. In the example, the Series for the offset line might have ranges of Y: \$F\$32:\$F\$200 and X: \$C\$32:\$C\$200. In the pursuit quest of efficiency, you decide to include only the offset values (Column F) that are positive and less than 700. The Y-range is changed to \$F\$121:\$F\$138. But the data points plot in the wrong place! The first value in the Y-range in cell *F121* is plotted with the first value in the X-range in cell *C32*, not *C121*! The solution is to set the X-range as \$C121:\$C138.