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	Мра					
	Modulus	166.4	GPa					
			-	MTIL: S=Load/area. *1000 for kN.				
	Time(sec)	Stress (Mpa)	Offset Stess(N					
4	0	2.70E+00	-3.24E+02	700	T			
4	1	8.00E+00	-3.24E+02					

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 autoscale. For clarity, make the Percent on the Strain axis show more decimal places.

$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	93	2.03	3.06E+00	0.000805	61	9.60E+01	-1.99E+02								
95 2.1 3.32±00 0.000832 63 1.04±02 1.44±02 96 2.13 3.45±00 0.000886 66 1.08±02 1.85±02 97 2.17 3.59±00 0.000752 66 1.17±02 2.08±02 99 2.23 3.87±00 0.000752 66 1.17±02 2.08±02 100 2.27 4.02±00 0.00086 69 1.31±02 1.85±02 101 2.3 4.37±00 0.000886 69 1.35±02 1.45±02 103 2.37 4.48±00 0.001047 71 1.41±02 1.45±02 1.45±02 105 2.43 4.81±00 0.001128 72 1.68±02 1.41±02 1.59±02 106 2.47 4.98±00 0.001362 76 1.68±02 1.23±02 1.50±02 107 2.5 5.14±00 0.001362 76 1.80±02 1.23±02 1.05±02 111 2.63 5.95±00 0.001362 78 1.80±02 1.09±02 1.00±02 1.00±02 1.09±02 0.00% 0	94	2.07	3.19E+00	0.000725	62	1.00E+02	-2.12E+02								
96 2.13 3.45E+00 0.000886 64 1.08E+02 1.8SE+02 97 2.17 3.59E+00 0.000752 66 1.13E+02 1.8SE+02 99 2.23 3.73E+00 0.00094 67 1.2EE+02 1.6SE+02 100 2.27 4.02E+00 0.00094 67 1.2EE+02 1.6SE+02 101 2.3 4.37E+00 0.000886 69 1.3EE+02 1.6SE+02 103 2.37 4.48E+00 0.00128 72 1.46E+02 1.4SE+02 106 2.47 4.96E+00 0.001128 72 1.46E+02 1.4SE+02 1.66E+02 106 2.47 4.96E+00 0.001262 76 1.66E+02 1.23E+02 1.06E+02 107 2.5 5.4E+00 0.001262 76 1.68E+02 1.23E+02 1.06E+02 1.23E+02 108 2.57 5.54E+00 0.001262 78 1.80E+02 1.05E+02 1.00E+02 1.02E+02 0.00W 0.0W 0.0W 0.0W 0.0W 0.0W 0.0W 0.0W 0.0W <t< td=""><td>95</td><td>2.1</td><td>3.32E+00</td><td>0.000832</td><td>63</td><td>1.04E+02</td><td>-1.94E+02</td><td></td><td></td><td></td><td>****</td><td></td><td></td><td></td><td></td></t<>	95	2.1	3.32E+00	0.000832	63	1.04E+02	-1.94E+02				****				
97 2.17 3.59E+00 0.000886 655 1.13E+02 -1.88E+02 98 2.2 3.78E+00 0.000752 66 1.7E+02 -2.08E+02 99 2.23 3.87E+00 0.000752 66 1.7E+02 -1.68E+02 100 2.27 4.02E+00 0.000886 69 1.31E+02 -1.85E+02 103 2.33 4.48E+00 0.0001647 71 1.41E+02 -1.59E+02 105 2.44 4.85E+00 0.001128 72 1.46E+02 -1.59E+02 106 2.44 4.98E+00 0.001126 75 1.61E+02 -1.41E+02 107 2.5 5.14E+00 0.001252 76 1.68E+02 -1.41E+02 109 2.57 5.54E+00 0.001262 78 1.80E+02 -1.01E+02 111 2.66 5.75E+00 0.001364 83 2.13E+02 -1.01E+02 112 2.67 6.16E+00 0.001364 83 2.13E+02 -0.05E+02 113 2.76 6.38E+00 0.001272 86 2.22E+02 <td>96</td> <td>2.13</td> <td>3.45E+00</td> <td>0.000886</td> <td>64</td> <td>1.08E+02</td> <td>-1.85E+02</td> <td>300</td> <td>1</td> <td>1</td> <td>1</td> <td></td> <td></td> <td></td> <td></td>	96	2.13	3.45E+00	0.000886	64	1.08E+02	-1.85E+02	300	1	1	1				
98 2.2 3.73E+00 0.000752 66 1.17E+02 -2.08E+02 100 2.27 4.02E+00 0.00094 67 1.21E+02 -1.63E+02 101 2.3 4.17E+00 0.000886 69 1.31E+02 -1.63E+02 102 2.33 4.33E+00 0.000886 70 1.36E+02 -1.85E+02 103 2.37 4.48E+00 0.001128 72 1.46E+02 -1.45E+02 105 2.43 4.81E+00 0.001124 75 1.61E+02 -1.63E+02 106 2.47 4.98E+00 0.001254 77 1.74E+02 -1.41E+02 107 2.57 5.54E+00 0.001262 78 1.60E+02 -1.23E+02 109 2.57 5.54E+00 0.001364 77 1.74E+02 -1.01E+02 -1.00E+02 111 2.66 5.75E+00 0.001362 78 1.80E+02 -1.23E+02 -0.00% 0.05% 0.0% 0.25% 0.30% 113 2.77 6.54E+00 0.001364 82 2.20E+02 -5.59E+01 -1.05	97	2.17	3.59E+00	0.000886	65	1.13E+02	-1.85E+02								
99 2.23 3.87E+00 0.00094 67 1.21E+02 1.76E+02 100 2.27 4.02E+00 0.00102 68 1.25E+02 1.63E+02 1.63E+02 101 2.3 4.17E+00 0.000886 69 1.31E+02 1.85E+02 103 2.37 4.48E+00 0.001147 71 1.41E+02 1.59E+02 105 2.43 4.65E+00 0.001128 72 1.44E+02 1.59E+02 106 2.47 4.98E+00 0.001134 75 1.61E+02 1.45E+02 1.63E+02 106 2.47 4.98E+00 0.001154 75 1.61E+02 1.41E+02 1.45E+02 108 2.53 5.35E+00 0.001252 76 1.68E+02 1.23E+02 1.41E+02 1.23E+02 110 2.66 5.75E+00 0.001342 81 2.06E+02 1.02E+02 1.02E+02 1.02E+02 1.02E+02 1.03E+02 1.03E+02 1.02E+02 1.02E+02 </td <td>98</td> <td>2.2</td> <td>3.73E+00</td> <td>0.000752</td> <td>66</td> <td>1.17E+02</td> <td>-2.08E+02</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>12</td> <td></td> <td></td>	98	2.2	3.73E+00	0.000752	66	1.17E+02	-2.08E+02						12		
100 2.27 4.02E+00 0.00102 68 1.25E+02 1.63E+02 1.63E+02 1.85E+02 101 2.33 4.33E+00 0.000866 70 1.35E+02 1.85E+02 1.55E+02 103 2.37 4.48E+00 0.001047 71 1.41E+02 -1.55E+02 1.55E+02 1.55E+02 106 2.43 4.81E+00 0.001128 72 1.46E+02 -1.45E+02 1.55E+02 1.65E+02 106 2.47 4.98E+00 0.001124 75 1.61E+02 -1.35E+02 1.65E+02 1.65E+02 1.65E+02 1.65E+02 1.65E+02 1.65E+02 1.65E+02 1.65E+02 1.65E+02 1.05E+02 0.000K 0.00K 0.00K 0.00K 0.00K 0.20K	99	2.23	3.87E+00	0.00094	67	1.21E+02	-1.76E+02	250	-					+	
101 2.3 4.17E+00 0.000886 69 1.31E+02 1.85E+02 102 2.33 4.38E+00 0.000886 70 1.35E+02 1.85E+02 103 2.37 4.48E+00 0.001128 72 1.46E+02 1.59E+02 105 2.43 4.81E+00 0.001128 72 1.46E+02 1.59E+02 106 2.44 4.98E+00 0.001134 73 1.51E+02 -1.56E+02 106 2.44 4.98E+00 0.001154 75 1.61E+02 -1.41E+02 107 2.5 5.34E+00 0.001154 77 1.74E+02 -1.41E+02 108 2.53 5.55E+00 0.001262 78 1.80E+02 -1.01E+02 111 2.63 5.55E+00 0.001369 80 1.93E+02 -1.01E+02 113 2.77 6.86E+00 0.001384 82 2.06E+02 -8.72E+01	100	2.27	4.02E+00	0.00102	68	1.26E+02	-1.63E+02					1.1			
102 2.33 4.33E+00 0.000866 70 1.36E+02 1.58E+02 103 2.37 4.48E+00 0.001047 71 1.41E+02 1.58E+02 104 2.4 4.65E+00 0.001128 72 1.46E+02 -1.59E+02 105 2.43 4.81E+00 0.001198 72 1.46E+02 -1.59E+02 106 2.47 4.98E+00 0.001194 75 1.61E+02 -1.41E+02 108 2.53 5.53E+00 0.001262 76 1.68E+02 -1.23E+02 109 2.57 5.54E+00 0.001262 78 1.80E+02 -1.23E+02 111 2.63 5.95E+00 0.001396 79 1.87E+02 -1.05E+02 113 2.7 6.37E+00 0.001384 81 2.06E+02 -1.05E+02 114 2.73 6.58E+00 0.001384 82 2.06E+02 -3.05E+01 115 2.77 6.80E+00 0.001384 82 2.0E+02 -5.95E+01 116 2.88 7.02E+00 0.001772 86 2.34E+02 <td>101</td> <td>2.3</td> <td>4.17E+00</td> <td>0.000886</td> <td>69</td> <td>1.31E+02</td> <td>-1.85E+02</td> <td></td> <td></td> <td></td> <td></td> <td>1.5</td> <td></td> <td></td> <td></td>	101	2.3	4.17E+00	0.000886	69	1.31E+02	-1.85E+02					1.5			
103 2.37 4.48E+00 0.001047 71 1.41E+02 1.59E+02 0 105 2.43 4.81E+00 0.001128 72 1.45E+02 1.59E+02 0 106 2.47 4.98E+00 0.000993 74 1.55E+02 -1.50E+02 0 107 2.5 5.14E+00 0.001154 75 1.61E+02 -1.41E+02 0 0 108 2.53 5.35E+00 0.001262 76 1.66E+02 -1.21E+02 0 0 0 109 2.57 5.54E+00 0.001262 78 1.80E+02 -1.01E+02 1.00E+02 0.00% 0.05% 0.10% 0.25% 0.30% 113 2.77 6.80E+00 0.00138 82 2.0E+02 -1.0E+02 -1.0E+02 <td>102</td> <td>2.33</td> <td>4.33E+00</td> <td>0.000886</td> <td>70</td> <td>1.36E+02</td> <td>-1.85E+02</td> <td>200</td> <td></td> <td></td> <td></td> <td>-</td> <td></td> <td></td> <td></td>	102	2.33	4.33E+00	0.000886	70	1.36E+02	-1.85E+02	200				-			
104 2.4 4.65E+00 0.001128 72 1.45E+02 5 105 2.43 4.81E+00 0.001101 73 1.51E+02 1.50E+02 5 106 2.47 4.98E+00 0.00093 74 1.56E+02 -1.68E+02 -1.68E+02 -1.68E+02 107 2.5 5.35E+00 0.001262 76 1.66E+02 -1.23E+02 5 108 2.57 5.55E+00 0.001262 78 1.60E+02 -1.23E+02 -1.41E+02 -1.41E+02 110 2.63 5.55E+00 0.001369 80 1.93E+02 -1.05E+02 -1.05E+02 -1.01E+02 113 2.7 6.57E+00 0.001342 81 2.00E+02 -1.05E+02 -1.05E+02 -1.05E+02 -1.05E+02 113 2.77 6.58E+00 0.001533 82 2.00E+02 -3.79E+01 -1.05E+02 -1.0	103	2.37	4.48E+00	0.001047	71	1.41E+02	-1.59E+02	(P)			1.1.1				
105 2.43 4.81E+00 0.001101 73 1.51E+02 1.50E+02 1.60E+02 1.60E+00 1.60E+02	104	2.4	4.65E+00	0.001128	72	1.46E+02	-1.45E+02	ž			1.1				
106 2.47 4.98E+00 0.00093 74 1.56E+02 5 107 2.5 5.14E+00 0.001154 75 1.61E+02 -1.41E+02 108 2.53 5.35E+00 0.001262 76 1.66E+02 -1.23E+02 109 2.57 5.54E+00 0.001262 78 1.80E+02 -1.23E+02 110 2.63 5.55E+00 0.001262 78 1.80E+02 -1.23E+02 111 2.63 5.55E+00 0.001369 79 1.87E+02 -1.03E+02 112 2.67 6.56E+00 0.001386 81 2.06E+02 -1.05E+02 113 2.77 6.58E+00 0.00153 82 2.06E+02 -7.52E+01 115 2.77 6.680E+00 0.00154 83 2.13E+02 -6.92E+01 116 2.8 7.02E+00 0.001674 84 2.20E+02 -3.79E+01 117 2.83 7.46E+00 0.001772 86 2.34E+02 -3.79E+01	105	2.43	4.81E+00	0.001101	73	1.51E+02	-1.50E+02	g 150						+	
107 2.5 5.14E+00 0.001154 75 1.61E+02 1.41E+02 1 108 2.53 5.35E+00 0.001262 76 1.66E+02 1.23E+02 1 109 2.57 5.54E+00 0.001262 78 1.86E+02 1.23E+02 1.01E+02 110 2.6 5.75E+00 0.001396 79 1.87E+02 -1.01E+02 1.00E+02 1.03E+02 111 2.63 5.95E+00 0.001349 80 1.93E+02 -1.05E+02 1.00E+02 1.00E+02 1.00E+02 0.00% 0.00% 0.10% 0.25% 0.30% 113 2.77 6.58E+00 0.001348 82 1.20E+02 -1.09E+02 0.00% 0.00% 0.10% 0.25% 0.30% 115 2.77 6.50E+00 0.001772 86 2.20E+02 -5.59E+01 5train 5train 0.20% 0.25% 0.30% 116 2.89 7.46E+00 0.001772 86 2.37E+01 5train 5train 5train 1.20 120 2.93 7.91E+00 0.00267	106	2.47	4.98E+00	0.000993	74	1.56E+02	-1.68E+02	: B		· · ·		1			3
108 2.53 5.35E+00 0.001262 76 1.68E+02 -1.23E+02 109 2.57 5.54E+00 0.001154 77 1.74E+02 -1.23E+02 110 2.6 5.75E+00 0.001362 78 1.80E+02 -1.03E+02 111 2.63 5.95E+00 0.001369 80 1.93E+02 -1.03E+02 112 2.67 6.16E+00 0.001369 80 1.93E+02 -1.03E+02 113 2.77 6.37E+00 0.001378 82 2.06E+02 -7.82E+01 116 2.8 7.02E+00 0.001476 84 2.20E+02 -8.92E+01 118 2.87 7.64E+00 0.001772 86 2.42E+02 -3.79E+01 119 2.9 7.68E+00 0.001772 87 2.44E+02 -3.79E+01 120 2.93 7.91E+00 0.00267 91 2.77E+02 -1.01E+01 121 2.97 8.13E+00 0.002309 92 2.77E+02 1.1E+01 - - - 122 3.03 8.59E+00 0.00	107	2.5	5.14E+00	0.001154	75	1.61E+02	-1.41E+02	5 0		1.11					1
109 2.57 5.54E+00 0.001154 77 1.74E+02 1.41E+02 110 2.66 5.75E+00 0.001262 78 1.80E+02 1.23E+02 111 2.63 5.95E+00 0.001396 79 1.87E+02 -1.05E+02 112 2.66 6.16E+00 0.001396 80 1.93E+02 -1.05E+02 113 2.7 6.58E+00 0.00134 81 2.00E+02 -1.05E+02 115 2.77 6.58E+00 0.00153 82 2.06E+02 -5.92E+01 116 2.8 7.02E+00 0.001646 85 2.27E+02 -5.95E+01 117 2.83 7.24E+00 0.001772 86 2.34E+02 -3.79E+01 118 2.87 7.46E+00 0.001772 87 2.41E+02 -3.79E+01 120 2.93 7.91E+00 0.001772 87 2.41E+02 -3.79E+01 121 2.97 8.13E+00 0.00247 98 2.48E+02 -2.01E+01	108	2.53	5.35E+00	0.001262	76	1.68E+02	-1.23E+02	100		1.1					
110 2.6 5.75E+00 0.001252 78 1.80E+02 -1.02E+02 111 2.63 5.95E+00 0.001396 79 1.87E+02 -1.02E+02 112 2.67 6.16E+00 0.001396 80 1.93E+02 -1.02E+02 113 2.7 6.37E+00 0.001342 81 2.00E+02 -1.03E+02 114 2.73 6.58E+00 0.00153 82 2.06E+02 -7.82E+01 115 2.77 6.60E+00 0.001476 84 2.13E+02 -8.92E+01 116 2.8 7.02E+00 0.001772 86 2.32E+01 - - 118 2.87 7.64E+00 0.001772 86 2.379E+01 - - - 119 2.9 7.86E+00 0.001772 87 2.41E+02 -3.79E+01 - - - 120 2.97 8.13E+00 0.002476 92 2.20E+00 - - - - - 121 2.97 8.13E+00 0.002476 92 2.20E+00 - <	109	2.57	5.54E+00	0.001154	77	1.74E+02	-1.41E+02			1.611					
111 2.63 5.95E+00 0.001396 79 1.67E+02 1.01E+02 112 2.67 6.16E+00 0.001396 80 1.93E+02 1.05E+02 1.05E+02 113 2.7 6.37E+00 0.001398 80 1.93E+02 1.05E+02 1.05E+02 114 2.73 6.58E+00 0.001534 82 2.06E+02 -1.09E+02 0.00% 0.05% 0.10% 0.5% 0.20% 0.20% 0.30% 115 2.77 6.80E+00 0.001648 83 2.13E+02 -6.92E+01 0.00% 0.05% 0.10% 0.5% 0.20% 0.30% 116 2.88 7.02E+00 0.001647 84 2.20E+02 -5.59E+01 5 5 5 5 5 0.00% 0.05% 0.10% 0.5% 0.20% 0.30% 117 2.83 7.46E+00 0.001772 86 2.44E+02 -2.01E+01 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5	110	2.6	5.75E+00	0.001262	78	1.80E+02	-1.23E+02								
112 2.67 6.564+00 0.001349 80 1.93E+02 -1.05E+02 113 2.77 6.58E+00 0.00133 82 2.06E+02 -1.09E+02 0 114 2.73 6.58E+00 0.001342 81 2.06E+02 -1.09E+02 0 0.005% 0.10% 0.15% 0.20% 0.25% 0.30% 115 2.77 6.80E+00 0.001584 83 2.13E+02 -6.92E+01 0.00% 0.05% 0.10% 0.15% 0.20% 0.25% 0.30% 116 2.8 7.02E+00 0.001772 86 2.37E+01 5.59E+01 5train	111	2.63	5.95E+00	0.001396	79	1.87E+02	-1.01E+02	50		£					
113 2.7 6.37E+00 0.001342 81 2.00E+02 -1.09E+02 0 0 1.09E+02 0 0 1.09E+02 0	112	2.67	6.16E+00	0.001369	80	1.93E+02	-1.05E+02		1.11						
114 2.73 6.58E+00 0.00153 82 2.06E+02 82E+01 0.00% 0.15% 0.20% 0.25% 0.30% 115 2.77 6.60E+00 0.001584 83 2.15E+02 -6.92E+01 0.00% 0.05% 0.10% 0.15% 0.20% 0.30% 116 2.88 7.02E+00 0.001664 85 2.27E+02 -5.59E+01 5train 5train 117 2.83 7.24E+00 0.001772 86 2.37E+02 -3.79E+01 5train 120 2.93 7.91E+00 0.001879 88 2.48E+02 -2.01E+01 5train 121 2.97 8.13E+00 0.00243 89 2.55E+02 2.56E+00 5train 122 3 8.35E+00 0.00249 91 2.70E+02 5.14E+01 5train 123 3.03 8.59E+00 0.00249 92 2.77E+02 5.14E+01 5train 124 3.07 8.82E+00 0.002416 93 2.84E+02 6.92E+01 5train 125 3.1 9.05E+00 0.002416 93 2.84E+02 6.92E+01 5train 126 3.13 9.28E+00 0.002439 94 2.91E+02<	113	2.7	6.37E+00	0.001342	81	2.00E+02	-1.09E+02		- stronger						
115 2.77 6.80E+00 0.001584 83 2.13E+02 6.92E+01 0.00% 0.05% 0.10% 0.15% 0.20% 0.20% 0.30% 116 2.8 7.02E+00 0.001476 84 2.20E+02 -8.72E+01 5.559E+01 5train 5train 117 2.83 7.24E+00 0.001772 86 2.34E+02 -3.79E+01 5train 5tr	114	2.73	6.58E+00	0.00153	82	2.06E+02	-7.82E+01								
116 2.8 7.02E+00 0.001476 84 2.20E+02 8.72E+01 Strain 117 2.83 7.24E+00 0.001664 85 2.27E+02 5.59E+01 - 118 2.87 7.46E+00 0.001772 86 2.34E+02 -3.79E+01 - 119 2.9 7.68E+00 0.001772 87 2.41E+02 -3.79E+01 - 120 2.93 7.91E+00 0.001879 88 2.44E+02 -2.01E+01 - 121 2.97 8.13E+00 0.00213 89 2.55E+02 2.16E+00 - 122 3 8.36E+00 0.002047 91 2.70E+02 5.16E+00 - 123 3.03 8.59E+00 0.002047 91 2.70E+02 5.14E+01 - 124 3.07 8.82E+00 0.002416 93 2.84E+02 6.92E+01 - 125 3.1 9.05E+00 0.002416 93 2.84E+02 6.92E+01 - 126 3.13 9.28E+00 0.002431 94 2.91E+02 1.05E+02 - 127 3.17 9.51E+00 0.002431 94 2.91E+02 1.05E+02 -	115	2.77	6.80E+00	0.001584	83	2.13E+02	-6.92E+01		0.00% 0.0	05% 0.	10% 0.	.15% 0.3	20% 0.	25%	0.30%
117 2.83 7,24E+00 0.00164 85 2.27E+02 -5.59E+01	116	2.8	7.02E+00	0.001476	84	2.20E+02	-8.72E+01				St	train			
118 2.87 7.46E+00 0.001772 86 2.34E+02 3.79E+01 0.00172 8.0 2.00	117	2.83	7.24E+00	0.001664	85	2.27E+02	-5.59E+01								
119 2.9 7,68E+00 0.001772 87 2.41E+02 -3.79E+01 120 2.93 7,91E+00 0.001879 88 2.48E+02 -2.01E+01 121 2.97 8.13E+00 0.002013 89 2.55E+02 2.16E+00 122 3 8.36E+00 0.002067 91 2.70E+02 1.11E+01 124 3.07 8.62E+00 0.002309 92 2.77E+02 5.14E+01 125 3.1 9.05E+00 0.002445 93 2.86E+02 6.92E+01 126 3.13 9.28E+00 0.002431 94 2.91E+02 7.37E+01 127 3.17 9.51E+00 0.002431 95 2.98E+02 1.05E+02	118	2.87	7.46E+00	0.001772	86	2.34E+02	-3.79E+01	(ii)							- C
120 2.93 7.91E+00 0.001879 88 2.48E+02 -2.01E+01 121 2.97 8.13E+00 0.002013 89 2.55E+02 2.16E+00 122 3 8.36E+00 0.002047 90 2.62E+02 6.66E+00 123 3.03 8.59E+00 0.002067 91 2.70E+02 1.11E+01 124 3.07 8.82E+00 0.002367 92 2.77E+02 5.14E+01 125 3.1 9.05E+00 0.002445 94 2.91E+02 7.37E+01 126 3.13 9.28E+00 0.002433 94 2.91E+02 1.05E+02 127 3.17 9.51E+00 0.002631 95 2.98E+02 1.05E+02	119	2.9	7.68E+00	0.001772	87	2.41E+02	-3.79E+01								
121 2.97 8.13E+00 0.002013 89 2.55E+02 2.16E+00 122 3 8.36E+00 0.00204 90 2.62E+02 6.66E+00 123 3.03 8.59E+00 0.002067 91 2.70E+02 1.11E+01 124 3.07 8.82E+00 0.002309 92 2.77E+02 5.14E+01 125 3.1 9.05E+00 0.002416 93 2.84E+02 6.92E+01 126 3.13 9.28E+00 0.002434 94 2.91E+02 1.05E+02 127 3.17 9.51E+00 0.002631 95 2.98E+02 1.05E+02	120	2.93	7.91E+00	0.001879	88	2.48E+02	-2.01E+01								
122 3 8.36E+00 0.00204 90 2.62E+02 6.66E+00 123 3.03 8.59E+00 0.002067 91 2.70E+02 1.11E+01 124 3.07 8.62E+00 0.002309 92 2.77E+02 5.14E+01 125 3.1 9.05E+00 0.002416 93 2.84E+02 6.92E+01 126 3.13 9.28E+00 0.002431 94 2.91E+02 7.37E+01 127 3.17 9.51E+00 0.002631 95 2.98E+02 1.05E+02	121	2.97	8.13E+00	0.002013	89	2.55E+02	2.16E+00								
123 3.03 8.59E+00 0.00267 91 2.70E+02 1.11E+01 124 3.07 8.82E+00 0.002309 92 2.77E+02 5.14E+01 125 3.1 9.05E+00 0.002416 93 2.84E+02 6.92E+01 126 3.13 9.28E+00 0.002443 94 2.91E+02 6.92E+01 127 3.17 9.51E+00 0.002631 95 2.98E+02 1.05E+02	122	3	8.36E+00	0.00204	90	2.62E+02	6.66E+00								
124 3.07 8.82E+00 0.002309 92 2.77E+02 5.14E+01 125 3.1 9.05E+00 0.002416 93 2.84E+02 6.92E+01 126 3.13 9.28E+00 0.002433 94 2.91E+02 7.37E+01 127 3.17 9.51E+00 0.002631 95 2.98E+02 1.05E+02	123	3.03	8.59E+00	0.002067	91	2.70E+02	1.11E+01								
125 3.1 9.05E+00 0.002416 93 2.84E+02 6.92E+01 126 3.13 9.28E+00 0.002443 94 2.91E+02 7.37E+01 127 3.17 9.51E+00 0.002631 95 2.98E+02 1.05E+02	124	3.07	8.82E+00	0.002309	92	2.77E+02	5.14E+01								
126 3.13 9.28E+00 0.002443 94 2.91E+02 7.37E+01 127 3.17 9.51E+00 0.002631 95 2.98E+02 1.05E+02	125	3.1	9.05E+00	0.002416	93	2.84E+02	6.92E+01								
127 3.17 9.51E+00 0.002631 95 2.98E+02 1.05E+02	126	3.13	9.28E+00	0.002443	94	2.91E+02	7.37E+01								
	127	3.17	9.51E+00	0.002631	95	2.98E+02	1.05E+02								

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 nonlinear 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

Stress(MPa) = modulus(GPa) * (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: F32:F200 and X: C32:C200. 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 F121:F138. But the data points plot in the wrong place! The first value in the Y-range in cell *F*121 is plotted with the first value in the X-range in cell *C*32, not *C*121! The solution is to set the X-range as C121:C138.