

APPENDIX GA36a

LEVEL 4 ASSESSMENT SPECIFICATION

Student name:	LUKAS KODALEWSKI	Student ID number:	
Programme:	HNC Mechanical Engineering		
Module:	Materials		
Module code:	SGDM4003	Contribution to Overall Module Assessment (%):	50%
Lecturer:	Chris Davies	Internal Verifier:	Robert Rees
Assignment Title:	Assignment 1 Tensile Test to Destruction.	Word count (or equivalent):	2000
Submission deadline:	21/11/19	Return date of provisional marks & written feedback:	
Submission method:	All written assessments, where practical and possible, must be submitted via Turnitin unless otherwise instructed by the Lecturer. (Please DO NOT put this assessment specification into Turnitin or it will match many similarities with other students' submissions.) Alternative submission method (if applicable): Late submission of the assessment will result in a late penalty mark. Penalties for late submission: Up to one week late, maximum mark of 40%. Over one week late, 0%. Only the Extenuating Circumstances Panel may approve a change to submission dates.		
Academic honesty / referencing:	Academic honesty is required. In the main body of your submission you must give credit to authors on whose research and ideas your work is based. Append to your submission a reference list that indicates the books, articles, etc. that you have used, cited or quoted in order to complete this assessment.		

**Module Learning Outcomes
(from module syllabus)**

1. Demonstrate a detailed knowledge and understanding of the structure, properties, processing and subsequently the use of engineering materials;
2. Use standard materials testing apparatus and derive the mechanical properties of materials and analyse and understand the cause of materials failures.

STUDENT FEEDBACK FORM

This section details the extent to which the assessment criteria are demonstrated by you, which in turn determines your mark. The marks available for each category of skill are shown. Lecturers will use the space provided to comment on the achievement of the task(s), including those areas in which you have performed well and areas that would benefit from development/improvement.

Generic Assessment Criteria	Marks available	Marks awarded
1. Engagement with Literature Skills	20	
Some engagement with suitable literature is evident but only limited in scope. Further areas (such as the effect of carbon in steel) not fully explored.		12
2. Knowledge and Understanding Skills	30	
Good knowledge and understanding demonstrated but your evaluation was limited in scope and depth.		18
3. Cognitive and Intellectual Skills	20	
Good use of data and correct calculations made. Sound observations made. A comparison against theoretical results could have been taken further.		13
4. Practical Application Skills	15	
Some generalised points about the nature of the tensile test and its use was included. I would have liked more detail here.		9
5. Transferable Skills for Life and Professional Practice	15	
Generally well structured and presented. Some missing references were a concern.		10

Assessment Mark (Assessment marks are subject to ratification at the Exam Board. These comments and marks are to give feedback on module work and are for guidance only until they are confirmed.)

Late Submission Penalties (tick if appropriate)

Up to 1 week late (40% Max)

Over 1 week late (0%)

62 %



HNC Mechanical Engineering

Assignment 1:

Tensile Test To Destruction

Unit: Materials (SGDM4003)

Lukasz Kowalewski

Summary

This report is an overview of the mechanical properties of different materials. These properties were gathered by putting material samples into a destructive Tensile Tests which were carried out at Coleg Sir Gar. The report starts with the background theory related to the test method, material properties and heat treatments which some of the materials undertook. These followed with the detailed list and images of the equipment as well as the steps method used during the tensile tests. Test data was plotted on the Force vs Extension graph (figure 1) which proved the theory that heat treatment makes material more workable (by increasing its ductility, reducing hardness and tensile strength) and extra carbon content in the alloys increasing tensile strength and hardness. Mathematic calculations were done for Yield Stress, Ultimate Tensile Strength and Percentage Elongation at Fracture which were compared against standard references obtained from the well-known MatWeb website. The results were fairly close which confirmed that the Tensile Tests was done correctly. Conclusion at the end of the report explains the simplicity and important of the Tensile Test method in Engineering environment as well as applications at Leggett & Platt.

✓ A good summary.
Some actual data would
have helped.

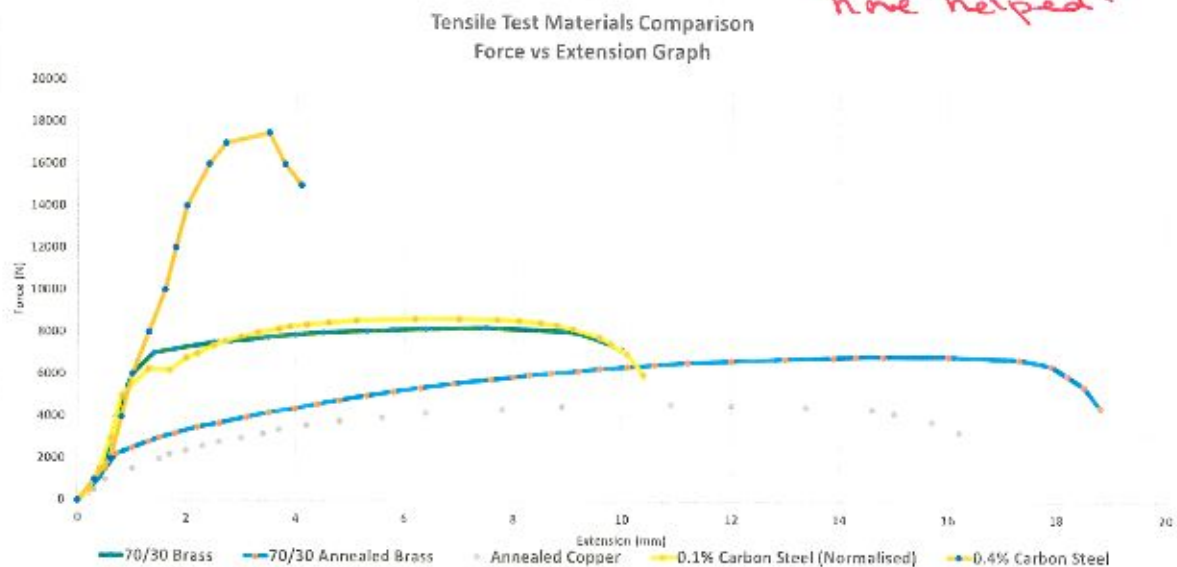


Figure 1 Tensile Test Materials Comparison

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Good structure

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1. Introduction

The practical selection of the **Engineering Materials** such as metals in Manufacturing depends on materials' properties under wide range of different conditions. These "**Properties**" are shown below:

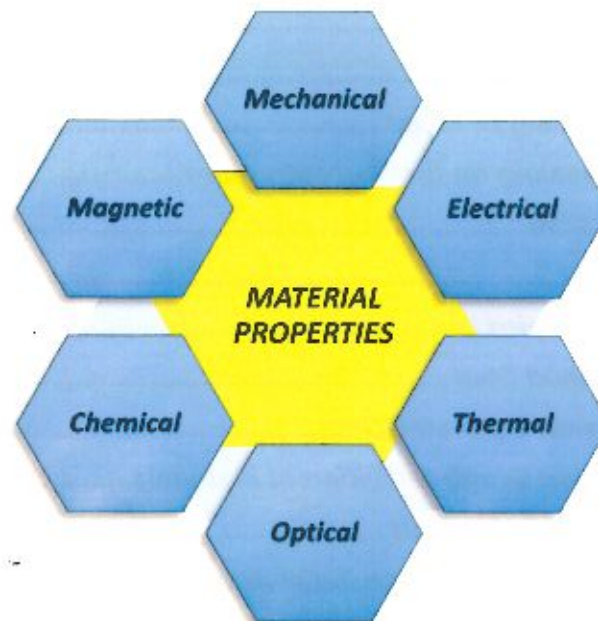


Figure 2 Material Properties

It is important to know that the above stated properties can significantly change by the temperature at which are being used or by any treatment they undertake. For example, annealing (heat treatment) makes steel being soft and ductile or when cold rolling steel becomes harder and less ductile.

In order to investigate some of the main mechanical properties of the materials such as strength, elasticity, plasticity, ductility, toughness or brittleness there are two different testing methods:

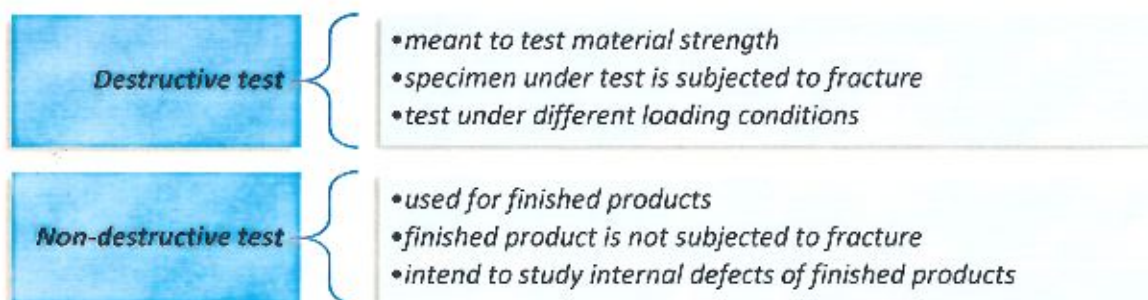


Figure 3 Destructive and Non-destructive test

2. Objective

The **objective** of this report was to investigate the mechanical properties of different materials when subjected to a destructive tensile loading condition. The data obtained from the tensile test for each of the 5 materials enabled further mathematic calculations, comparisons and discussions on the material properties.

3. Background

Tensile test - is one of the techniques for testing mechanical properties of the materials. This test method is used to find yield strength, ultimate tensile strength (UTS), ductility, strain hardening characteristics, modulus of elasticity and Poisson's ratio.

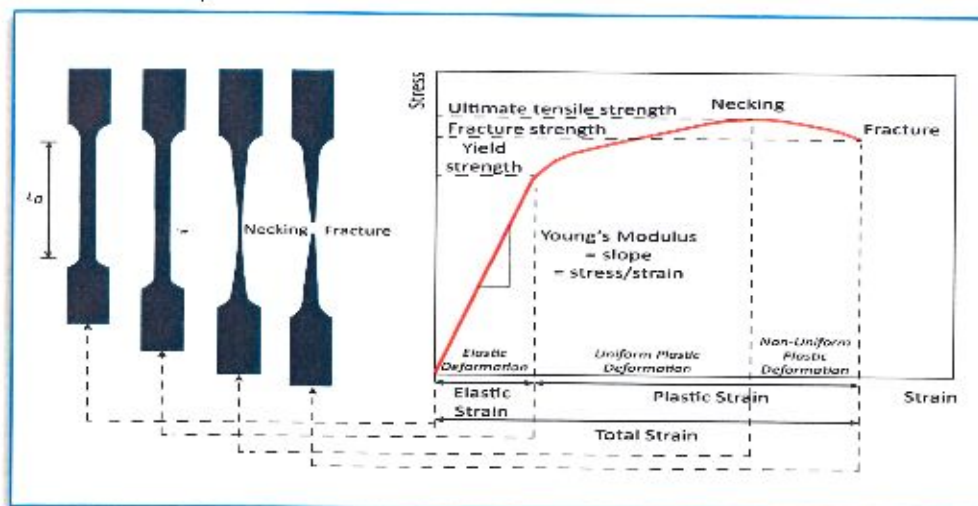


Figure 4 Tensile Test Results

Cold Work – are processes perform at temperature below the metal's recrystallization temperature such as rolling, bending or drawing. Instead of heat use, these processes use high mechanical stresses to make a shape change. For example, when steel sheet is cold rolled, permanent defects change their crystalline structure, large grains become finer, elongated and distorted in the direction of rolling. Materials hardness and tensile strength increases while the ductility decreases as crystals don't have space to move within the metal structure.

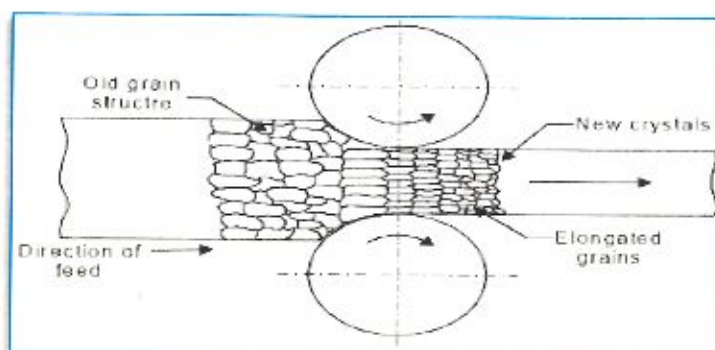


Figure 5 Cold Rolling Process

Annealing – is one of the heat treatments that changes the physical properties of the materials. It is making materials more workable by increasing its ductility and reducing its hardness. It involves heating material to above its recrystallization temperature, maintain temperature and cooling slow enough for the new, larger grains to grow. Figure 6 represents three stages and changes in the material properties during the annealing process.

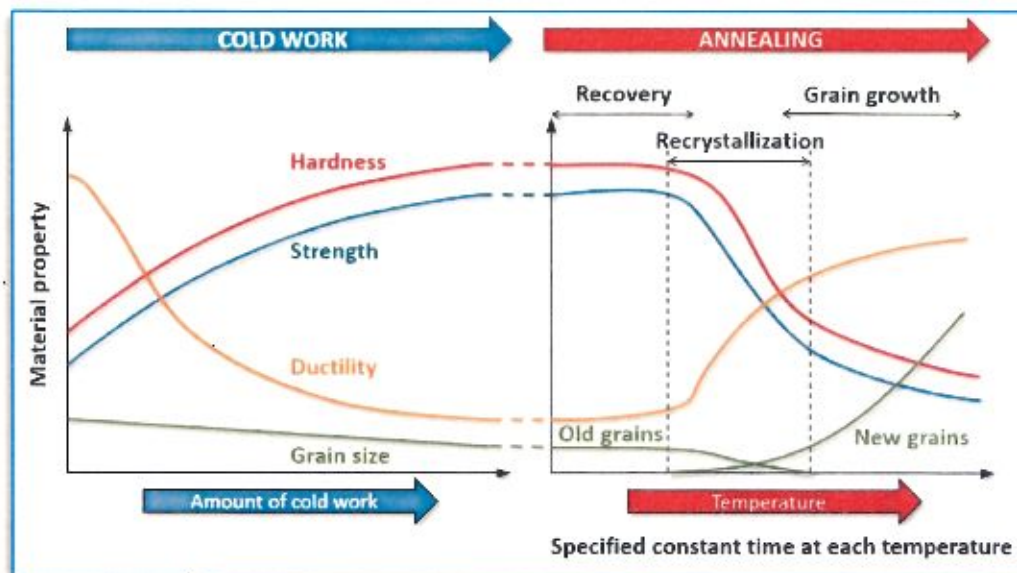


Figure 6 Subsequent Annealing of Metal

Above shown stages can be describe as follow:

1. **Recovery** - at this stage material is heated up to $\approx 0.3T_m$ (melting point). This enables atoms to return to their initial lattice position which results in the reduction or even elimination of residual stresses.
2. **Recrystallisation** - temperature increases up to $\approx 0.5T_m$ (melting point) and new grains start to form and replace previous distorted structure. This reduces the strength of the material and increases ductility.
3. **Grain Growth** – during this stage the new grains fully develop. The temperature and rate of time is controlled. Excessive grain growth normally should be avoided as this reduces the strength of the material.

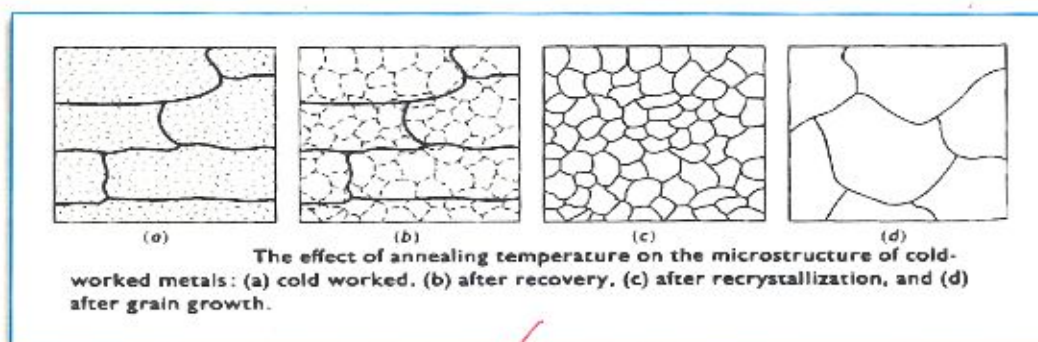


Figure 7 The Effect of Annealing on the Microstructure

Normalising – is a heat treatment process similar to annealing. It makes metals more ductile and tough after being subjected to thermal or mechanical hardening processes. It involves heating material to elevated temperature and allowing to cool down to room temperature in the air temperature after heating.

Strength – is ability to resist tensile, compressive or shear forces without permanent deformation or fracture.

Yield Strength – is the stress needed for producing plastic deformation in materials.

Ductility - is a mechanical property used to describe the extent to which materials can be deformed plastically without fracture. Examples of highly ductile metals are silver, gold, copper, and aluminum. The ductility of steel varies depending on the alloying constituents. Increasing levels of carbon decreases ductility, i.e., the steel becomes more brittle. Good practical example of application ductility is in industry that is making (copper) wires. The unit of ductility is measured in is percentage of elongation.

Toughness - is the ability of a material to absorb energy and plastically deform without fracturing. Toughness requires a balance of strength and ductility. High toughness is particularly important for components which may suffer impact (cars, toys, bikes), or for components where a fracture would be catastrophic (pressure vessels, aircraft). Toughness varies with temperature; some materials change from being tough to brittle as temperature decreases. A famous example of this problem in steels was the battleships which fractured in cold seas during the second World War!

Brittleness – a material is brittle when subjected to stress, it breaks without significant deformation. Brittle materials absorb relatively little energy prior to fracture, even those of high strength. Brittle materials include most ceramics and glasses and some polymers, such as PMMA and polystyrene. Many steels become brittle at low temperatures, depending on their composition and processing.

Elasticity – it is a material ability to spring back to its original shape and size after it has been stretched, compressed, bend or twisted. If too much deformation occurs the material exceeds its elastic limit and stays deformed. Some materials need more force than others to produce the same deformation and this is governed by its modulus.

Modulus of elasticity – is defined as the ratio of tensile stress to strain and determined in a tensile test. This can be considered as stiffness of the material. Good practical application of this property is for making beams used in construction of bridges.

Plasticity – it is a material ability to permanently deform under a given stress. Plastic deformation occurs for example in metal forming processes such as rolling, pressing or forging.

References needed.

4. Equipment

The equipment's used for testing 5 different materials were:

- A horizontal benchtop testing machine model **Hounsfield H20K-W**,
(data sheet and calibration records unknown)

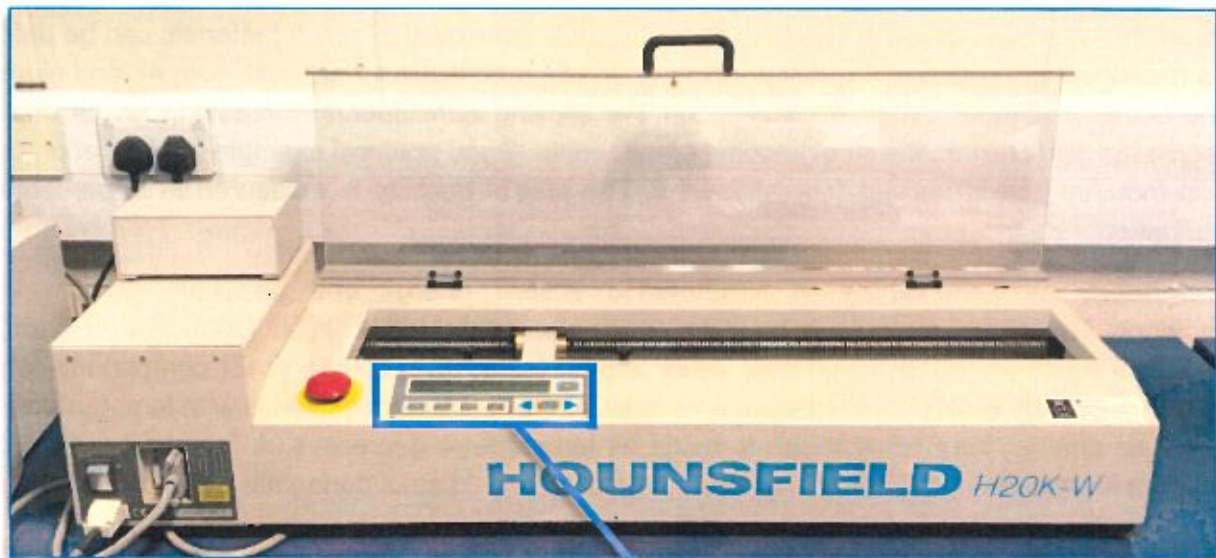


Figure 8 Tensile Test Machine

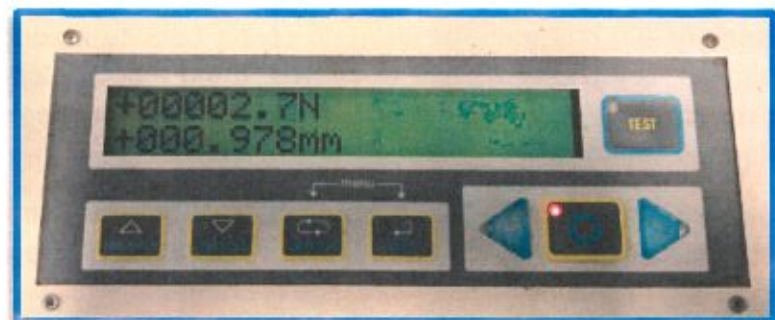


Figure 9 Display Screen

- Material specimens
- Pencil
- Notepad
- Reduction of area gauge
- Computer with Microsoft Excel Software (calculations and graphs)

5. Method

Tensile Test was performed with 5-gauge samples made of different materials. In order to eliminate variations in the test data all gauge samples (figure 10) had the same cylindrical shape and size (20mm² cross section area and 25mm length).



Figure 10 Tested Gauge Samples

Below showed **testing method steps** were followed for testing each of the materials:

Step 1

- A test piece was fixed into machine clamps



Step 2

- When sample was not under tensile force the initial readings were taken (0N force and 0mm extension)

Step 3

- Tensile force was slowly and steadily applied
- All values for force and extension were captured



Step 4

- The maximum force which applied before fracture was capture

Step 5

- The percentage reduction in cross-section area was measured by using reduction of area gauge



Figure 11 Tensile Test Method Step

6. Results

The data obtained from the Tensile Test was tabulated (figure 12). Each of the colours represent different material:

70/30 Brass		70/30 Annealed Brass		Annealed Copper		0.1% Carbon Steel (Normalised)		0.4% Carbon Steel	
Force (N)	Extension (mm)	Force (N)	Extension (mm)	Force (N)	Extension (mm)	Force (N)	Extension (mm)	Force (N)	Extension (mm)
0	0	0	0	0	0	0	0	0	0
1000	0.3	300	0.2	500	0.3	500	0.2	1000	0.3
2000	0.5	1500	0.5	1000	0.5	1500	0.4	2000	0.6
4000	0.7	2200	0.7	1500	1	3000	0.6	4000	0.8
6000	1	2500	1	2000	1.5	5000	0.8	6000	1
7000	1.4	2800	1.3	2200	1.7	6250	1.3	8000	1.3
7200	1.8	3000	1.5	2400	2	6200	1.7	10000	1.6
7400	2.2	3200	1.8	2600	2.3	6800	2	12000	1.8
7500	2.5	3500	2.2	2800	2.6	7000	2.2	14000	2
7600	2.8	3700	2.6	3000	3	7400	2.5	16000	2.4
7700	3.2	4000	3.1	3200	3.4	7600	2.7	17000	2.7
7800	3.5	4200	3.5	3400	3.7	7800	3	17500	3.5
7900	4	4400	4	3600	4.2	8000	3.3	16000	3.8
8000	4.5	4600	4.4	3800	4.8	8200	3.7	15000	4.1
8100	5.3	4800	4.8	4000	5.6	8300	3.9		
8150	5.8	5000	5.3	4200	6.4	8400	4.2		
8200	6.4	5200	5.8	4400	7.8	8500	4.6		
8250	7.5	5400	6.3	4500	8.9	8600	5.1		
8100	8.9	5600	6.9	4600	10.9	8700	6.2		
8000	9.2	5800	7.6	4550	12	8700	7		
7700	9.6	5900	8	4500	13.4	8650	7.7		
7200	10	6000	8.3	4400	14.6	8600	8.1		
		6100	8.7	4200	15	8500	8.5		
		6200	9.2	3800	15.7	8400	8.8		
		6300	9.6	3300	16.2	8200	9.1		
		6400	10.1			7800	9.6		
		6500	10.6			7500	9.8		
		6600	11.2			7000	10.1		
		6700	12			6000	10.4		
		6800	13						
		6850	13.9						
		6900	14.3						
		6900	14.8						
		6900	16						
		6800	17.3						
		6500	17.9						
		6000	18.2						
		5500	18.5						
		4500	18.8						

Figure 12 Force vs Extension Tabulated Data

Force and extension data were used to plot graphical illustration of material properties. For the better comparison of the material characteristics all 5 results were plotted on the same graph by using the same scale (for details see appendix 2,3,4,5,6,7).

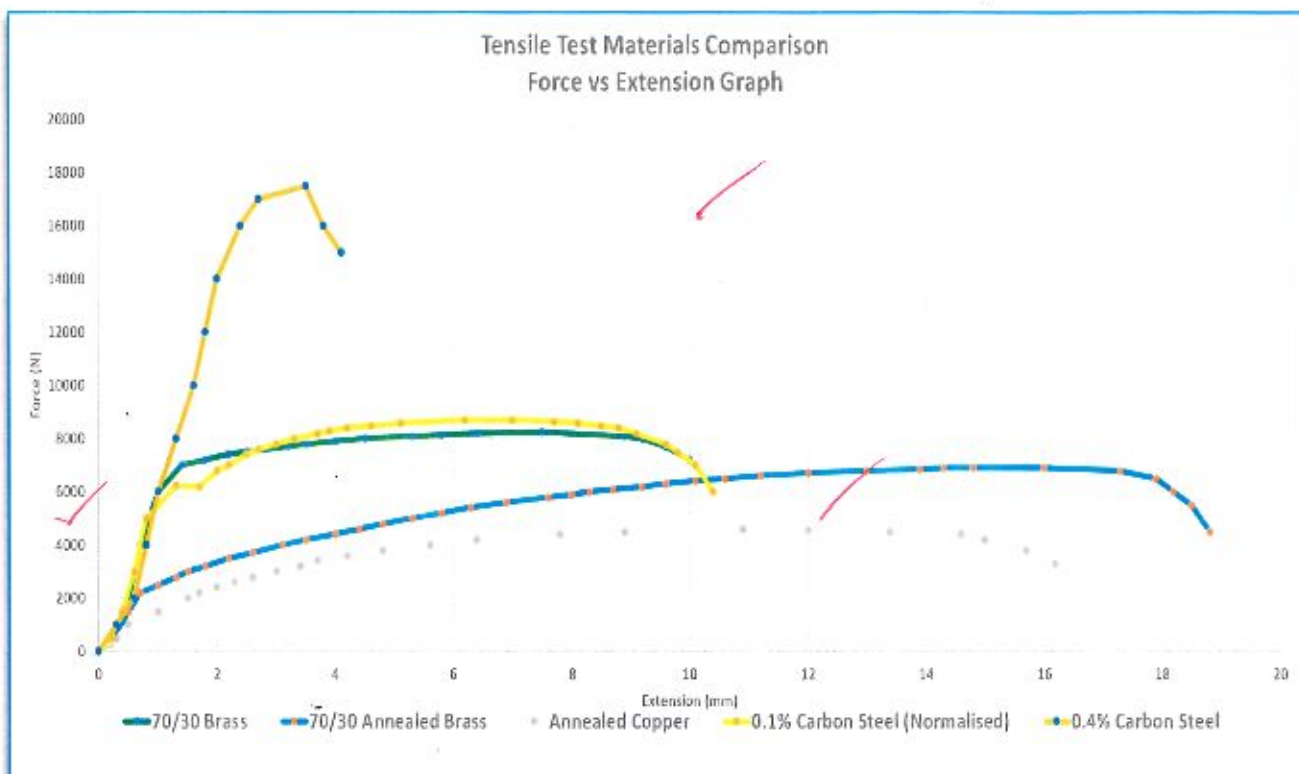


Figure 13 Force vs Extension Graph for Different Materials

Plotted graphs and data gathered from the test allowed to perform **mathematic calculations** of the lower yield strength, ultimate tensile strength, reduction in area percentage at fracture and elongation percentage at fracture. Calculations showed below were done for 70/30 Brass.

$$\text{Ultimate Tensile Strength (UTS)} = \frac{\text{Maximum Force (N)}}{\text{Original Cross Section Area (m}^2\text{)}} = \frac{8250}{0.00002} = 412.5 \text{ MN/m}^2$$

$$\text{Lower Yield Stress} = \frac{\text{Yield Force (N)}}{\text{Original Cross Section Area (m}^2\text{)}} = \frac{6000}{0.00002} = 300 \text{ MN/m}^2$$

$$\% \text{ of Elongation at Fracture} = \frac{\text{Change in Length (m)}}{\text{Original Length (m)}} \times 100 = \frac{0.01047}{0.025} \times 100 = 41.88\%$$

$$\% \text{ of Reduction in Area} = \frac{\text{Change in Cross Section Area (m}^2\text{)}}{\text{Original Cross Section Area (m}^2\text{)}} \times 100 = \frac{0.00002 - 0.000008}{0.00002} \times 100 = 60\%$$

The same formulas were inserted into *Excel* functions and the properties of remaining 4 materials were calculated (figure 11).

<i>Material</i>	<i>70/30 Brass</i>	<i>70/30 Annealed Brass</i>	<i>Annealed Copper</i>	<i>0.1% Carbon Steel (Normalised)</i>	<i>0.4% Carbon Steel</i>
Cross Section Area (CSA) (m ²)	0.00002	0.00002	0.00002	0.00002	0.00002
Gauge Length (m)	0.025	0.025	0.025	0.025	0.025
Total Extension (m)	0.01047	0.019	0.0165	0.0106	0.0043
Total Length (m)	0.03547	0.044	0.0415	0.0356	0.0293
Max Force (kN)	8.25	6.9	4.6	8.7	17.5
Ultimate Tensile Strength (UTS) (MN/m ²)	412.5	345	230	435	875
Yield Force (kN)	6	2.2	1	6.2	14
Yield Stress (MN/m ²)	300	110	50	310	700
Elongation at Fracture (%)	42%	76%	66%	42%	17%
Cross Section Reduction Area (%)	60%	70%	72%	45%	25%

Figure 14 Table Results for All Materials

7. Discussion of Results

Materials' Properties Comparison

The Force vs Extension graph (figure 12) gives a good indication of the materials' properties without doing any mathematic calculation. It is clear that 0.4% Carbon Steel retained the highest 17.5kN tensile force where 70/30 Brass and 0.1% Carbon Steel around 8-9kN and both Annealed materials only between 4.5-7kN force. The 0.4% Carbon content in the steel makes it not only the strongest but also the stiffest and more brittle material than others. This is since Iron (when in liquid form) changes its Face Centred Cubic (F.C.C) atomic structure to Body Centred Cubic (B.C.C) structure when making this alloy. When it comes to grain structure steel is made of Ferrites (Iron) which give steel the property of ductility and Pearlites made in layers of Iron and Iron Carbide which give the steel properties of hardness and strength. This is visible on the graph by comparing 0.1% to 0.4% Carbon Steel. Another property which can be read from the graph is a yield point which gives the same order in terms of the highest yield point. Below 14kN tensile force this material will return to the original length were rest of them will experienced permanent deformation (necking) followed by fracture. By looking at the extension axis on the graph we see how ductile the materials are. The higher extension equals to the higher ductility. That is because of the heat treatment some of the materials undertook.

*Effect of Carbon could
have been included here.
Fez formation etc*

Heat Treatment

There are 3 heat treated materials. Copper and 70/30 Brass are the materials which were annealed and 0.1% Carbon Steel which was normalised. Below shown graph (figure 15) is the comparison between annealed and not annealed (possibly cold worked) 70/30 Brass and normalised 0.1% Carbon Steel.

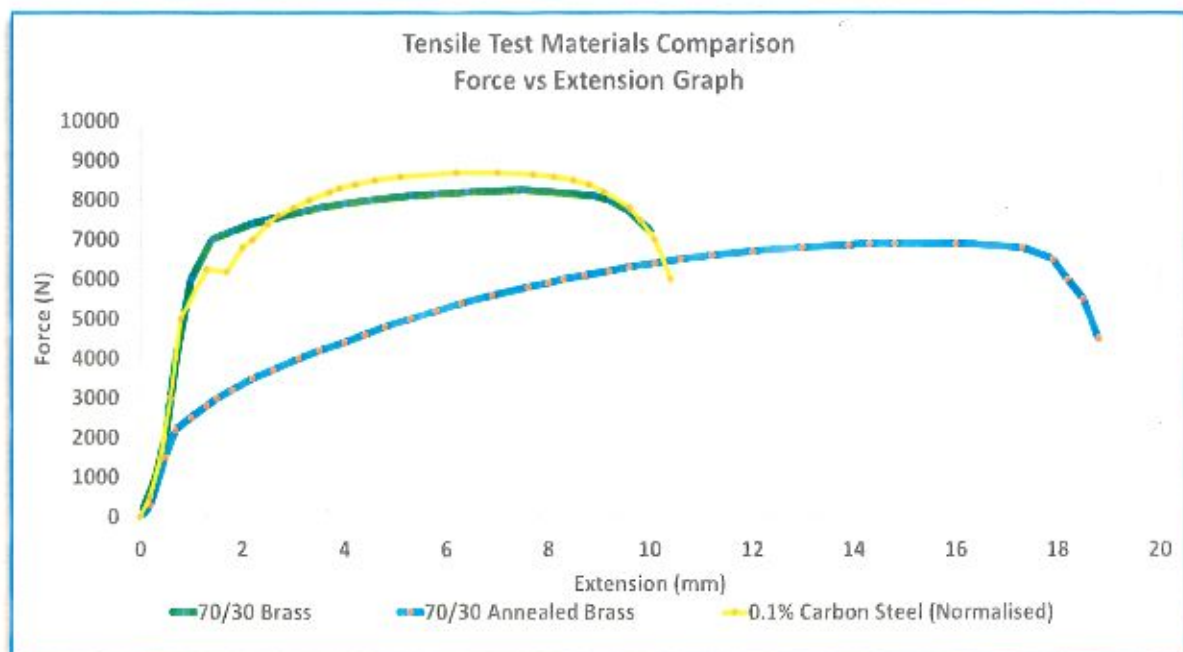


Figure 15 The Effect of Heat Treatment on 70/30 Brass and 0.1% Carbon Steel

As described at the beginning in the background theory the heating process affected materials' properties. 70/30 Brass have fine, elongated and distorted grains which make high tensile strength and hardness. After annealing 70/30 Brass it was noticed that ductility was almost twice as much as before annealing and strength was reduced. These have happened due to the recrystallization process. The residual stresses from previous processes were eliminated and new grains formed. Then in the slow controlled (temperature and time) cooling process these grains grow to the full size creating the new structure. This made increase in the material ductility while reducing hardness. 0.1% Normalised Carbon Steel experienced the same heat treatment as annealing however the cooling process was done by allowing material to cool down to the room temperature in the open air. This made material being less ductile but harder than annealing process.

Properties Comparison Against Standard Reference Values

The values for all of the properties discussed so far were taken directly from the graphs. For properties such as Ultimate Tensile Strength (UTS), Yield Stress and Percentage Elongation at Fracture mathematic calculations were made (see figure 13). These values were compared against standard (average) references gathered from the well-known "MatWeb" website. MatWeb contains over 125k data sheets for various materials.

A discussion on result needed here

Property	70/30 Brass		70/30 Annealed Brass		Annealed Copper		0.1% Carbon Steel (Normalised)		0.4% Carbon Steel	
	Lab value	Standard value	Lab value	Standard value	Lab value	Standard value	Lab value	Standard value	Lab value	Standard value
Yield Stress (MN/m ²)	300	315	110	110	50	33.3	310	325	700	795
Ultimate Tensile Strength (MN/m ²)	412.5	400	345	330	230	210	435	425	875	1150
Percentage Elongation at Fracture (%)	42	35	76	65	66	60	42	37	17	15

Figure 16 Properties Comparison Table Against MatWeb

Comparison showing that in most of the materials/properties tensile test made at Coleg Sir Gar provided results in line with those on MatWeb. Little differences can be explained as:

- Standard value data from MatWeb is average
- Machine calibration data is unknown
- Data from the tensile test was transferred manually from test machine (not digitally)
- Data was typed into Excel sheet (could be typo mistake)
- Test pieces may have had defects (corrosion, surface damage, etc.)

8. Conclusion

The results gathered from the tensile test prove the theory that annealing, and normalising softens a material, making it less hard and strong but more ductile. Another important finding is the grain structure in alloys. Small percentage of Carbon content in steel makes Pearlite grains which significantly increase material strength and hardness.

Tensile Test is one of the most used mechanical testing methods in a various of different industries. By measuring force required to elongate a material sample to breaking point (fracture) this simple test can determine lots of properties. These properties allow Design Engineers to predict how materials will behave in their intended application. Design Engineers are mainly interested in the properties gathered from the elastic zone, especially when safety is important factor. On the other hand, Production Engineer will be focusing more on the plastic zone, these properties can be used for example to see how cold work or heat treatment change the materials' properties which can help to reduce material costs.

At Leggett & Platt we do tensile test to control quality of receiving manufacturing materials, provide consistency in production processes, ensure compliance in customers specification and achieve lean manufacturing goals.

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9. Bibliography

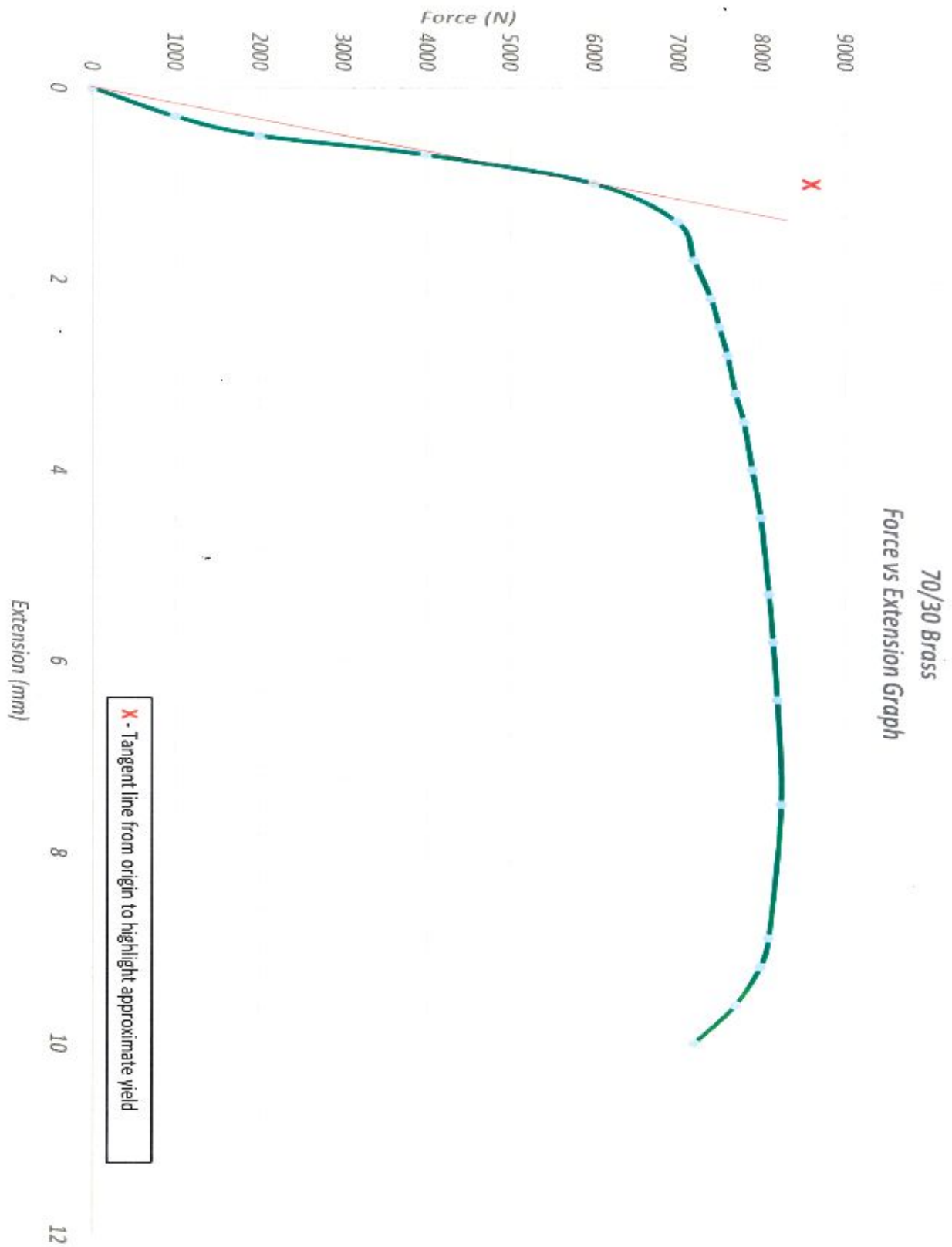
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10. Appendices

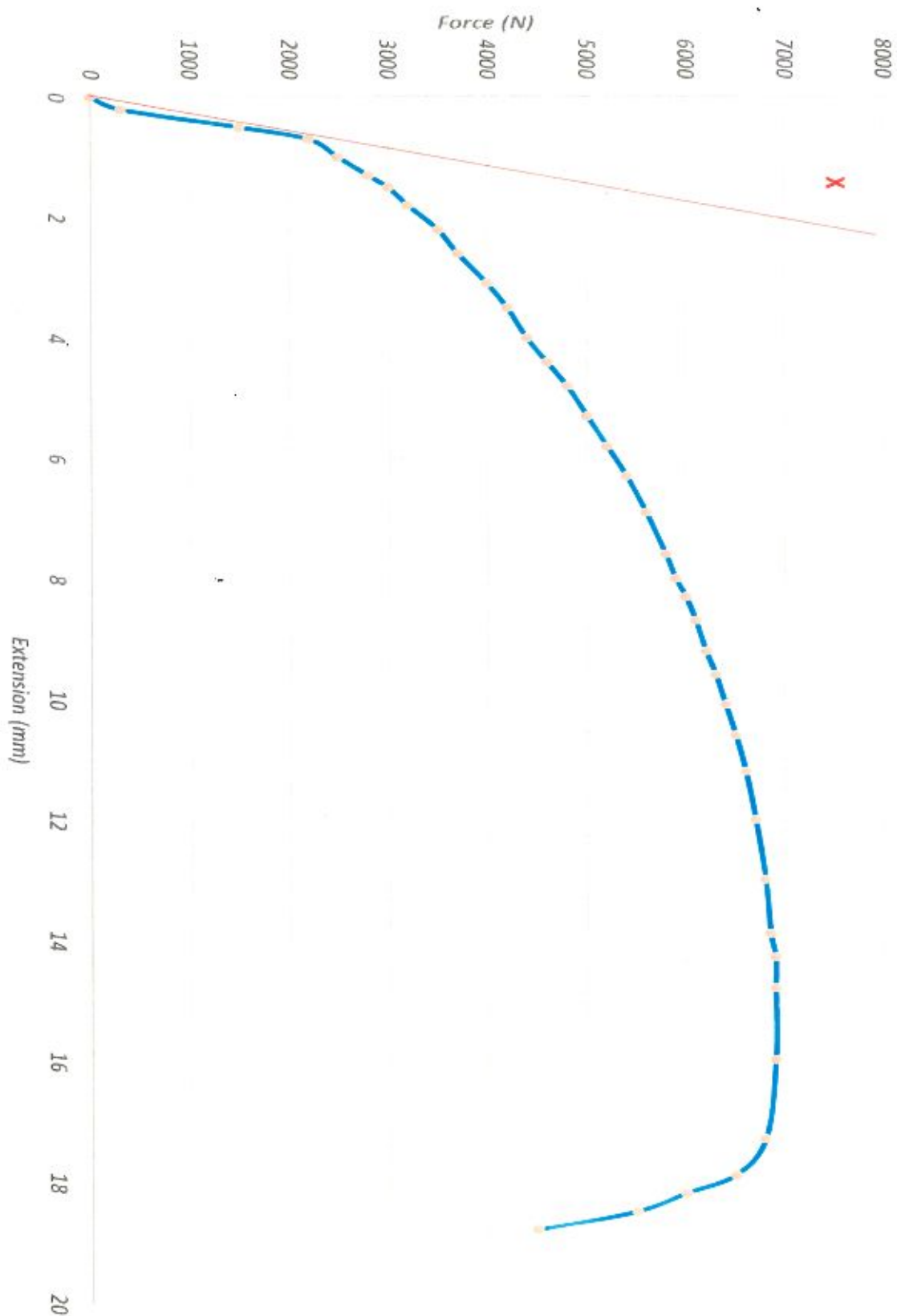
Appendix 1 – Tensile Test Data Table

70/30 Brass		70/30 Annealed Brass		Annealed Copper		0.1% Carbon Steel (Normalised)		0.4% Carbon Steel	
Force (N)	Extension (mm)	Force (N)	Extension (mm)	Force (N)	Extension (mm)	Force (N)	Extension (mm)	Force (N)	Extension (mm)
0	0	0	0	0	0	0	0	0	0
1000	0.3	800	0.2	500	0.3	500	0.2	1000	0.3
2000	0.5	1500	0.5	1000	0.5	1500	0.4	2000	0.6
4000	0.7	2200	0.7	1500	1	3000	0.6	4000	0.8
6000	1	2500	1	2000	1.5	5000	0.8	6000	1
7500	1.4	2800	1.3	2200	1.7	6250	1.3	8000	1.3
7200	1.8	3000	1.5	2400	2	6200	1.7	10000	1.6
7400	2.2	3200	1.8	2600	2.3	6800	2	12000	1.8
7500	2.5	3500	2.2	2800	2.6	7000	2.2	14000	2
7600	2.8	3700	2.6	3000	3	7400	2.5	16000	2.4
7700	3.2	4000	3.1	3200	3.4	7600	2.7	17000	2.7
7800	3.5	4200	3.5	3400	3.7	7800	3	17500	3.5
7900	4	4400	4	3600	4.2	8000	3.3	15000	3.8
8000	4.5	4600	4.4	3800	4.8	8200	3.7	15000	4.1
8100	5.3	4800	4.8	4000	5.6	8300	3.9		
8150	5.8	5000	5.3	4200	6.4	8400	4.2		
8200	6.4	5200	5.8	4400	7.8	8500	4.6		
8250	7.5	5400	6.3	4500	8.9	8600	5.1		
8300	8.9	5600	6.9	4600	10.9	8700	6.2		
8400	9.2	5800	7.6	4550	12	8700	7		
7700	9.6	5900	8	4500	13.4	8650	7.7		
7200	10	6000	8.3	4400	14.6	8600	8.1		
		6100	8.7	4200	15	8500	8.5		
		6200	9.2	3800	15.7	8400	8.8		
		6300	9.6	3300	16.2	8200	9.1		
		6400	10.1			7800	9.6		
		6500	10.6			7500	9.8		
		6600	11.2			7000	10.1		
		6700	12			6000	10.4		
		6800	13						
		6850	13.9						
		6900	14.3						
		6900	14.8						
		6900	16						
		6800	17.3						
		6500	17.9						
		6000	18.2						
		5500	18.5						
		4500	18.8						

Appendix 2 – 70/30 Brass Force vs Extension Graph

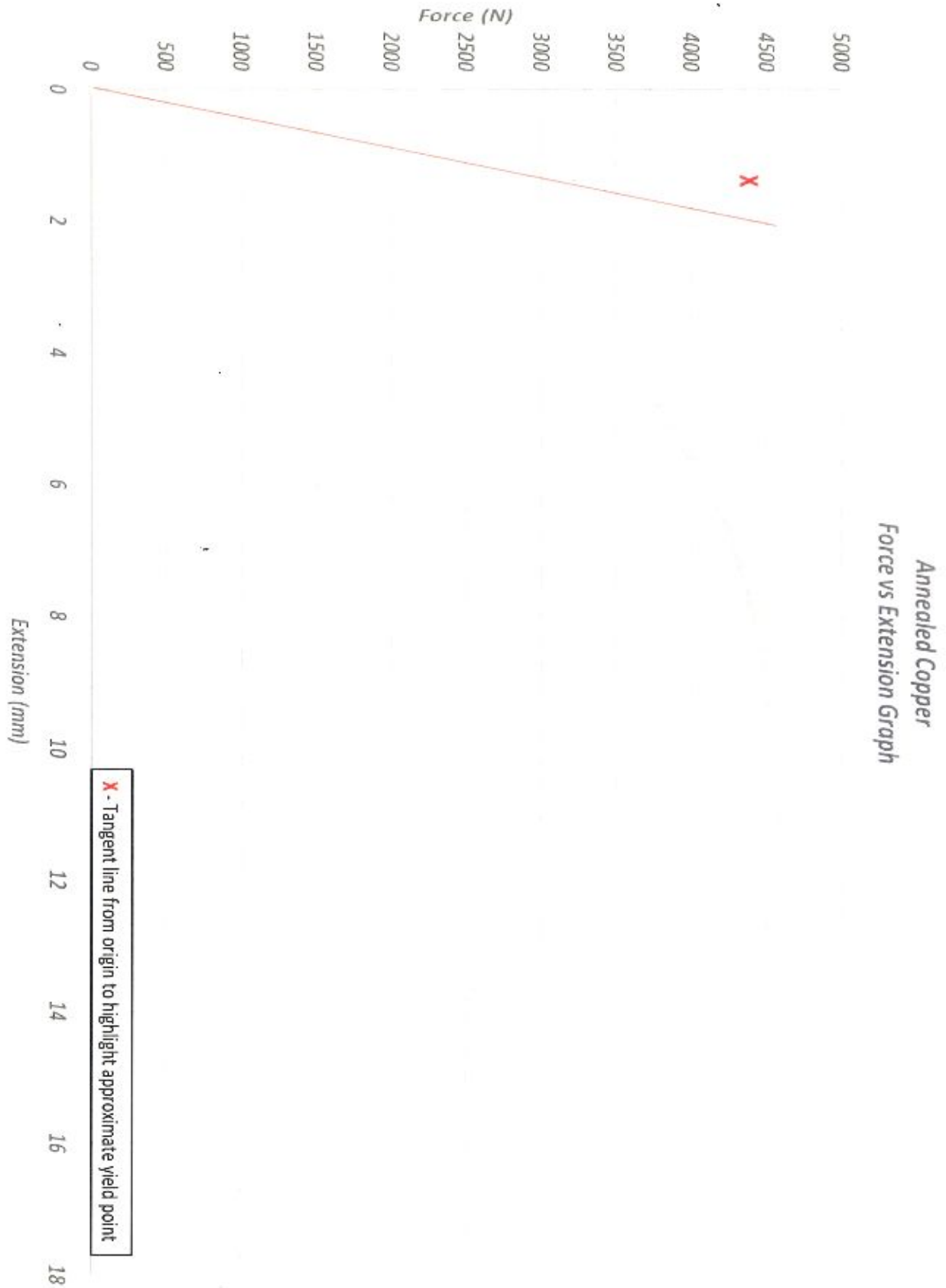


Appendix 3 – 70/30 Annealed Brass Force vs Extension Graph

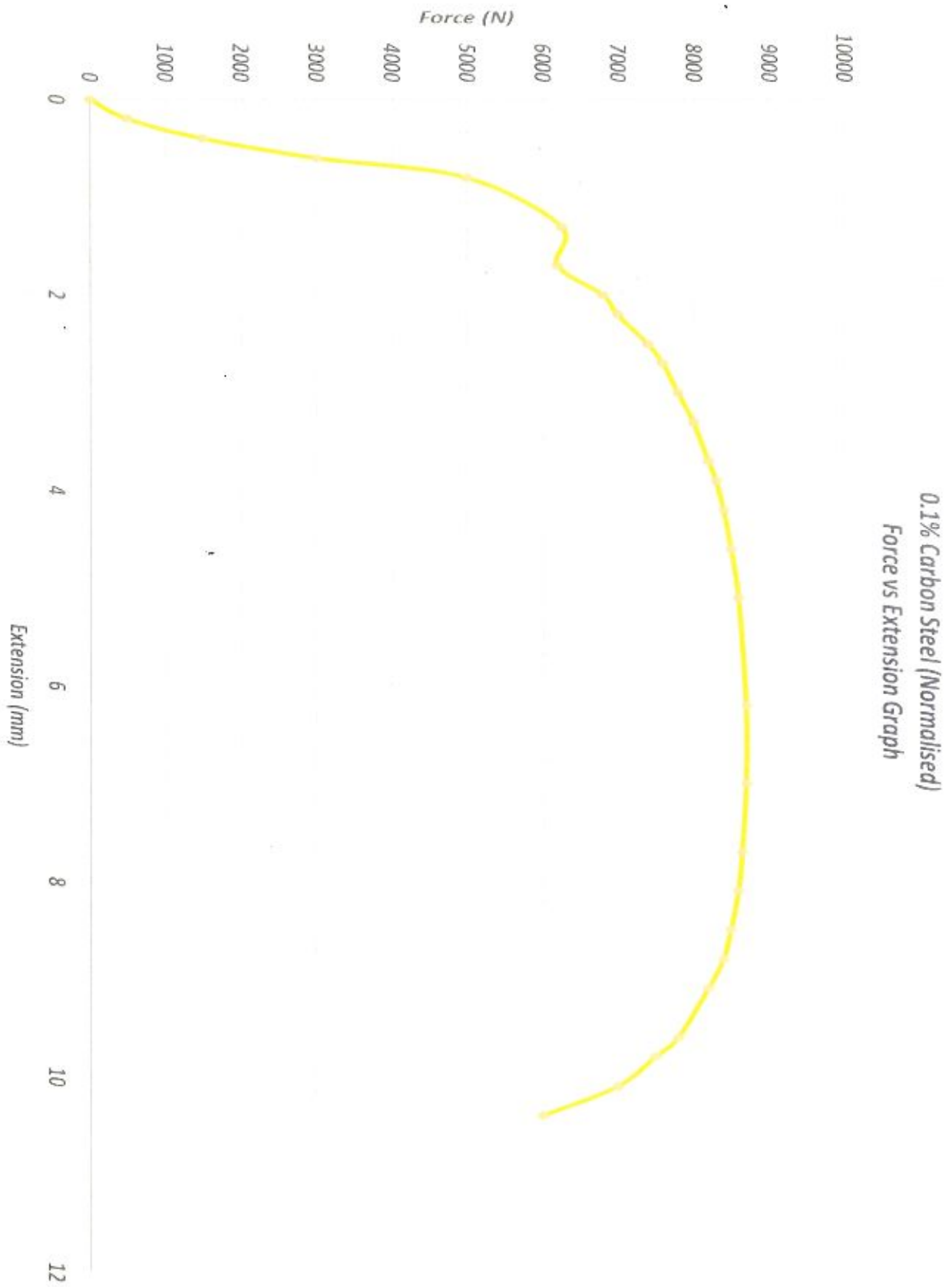


70/30 Annealed Brass
Force vs Extension Graph

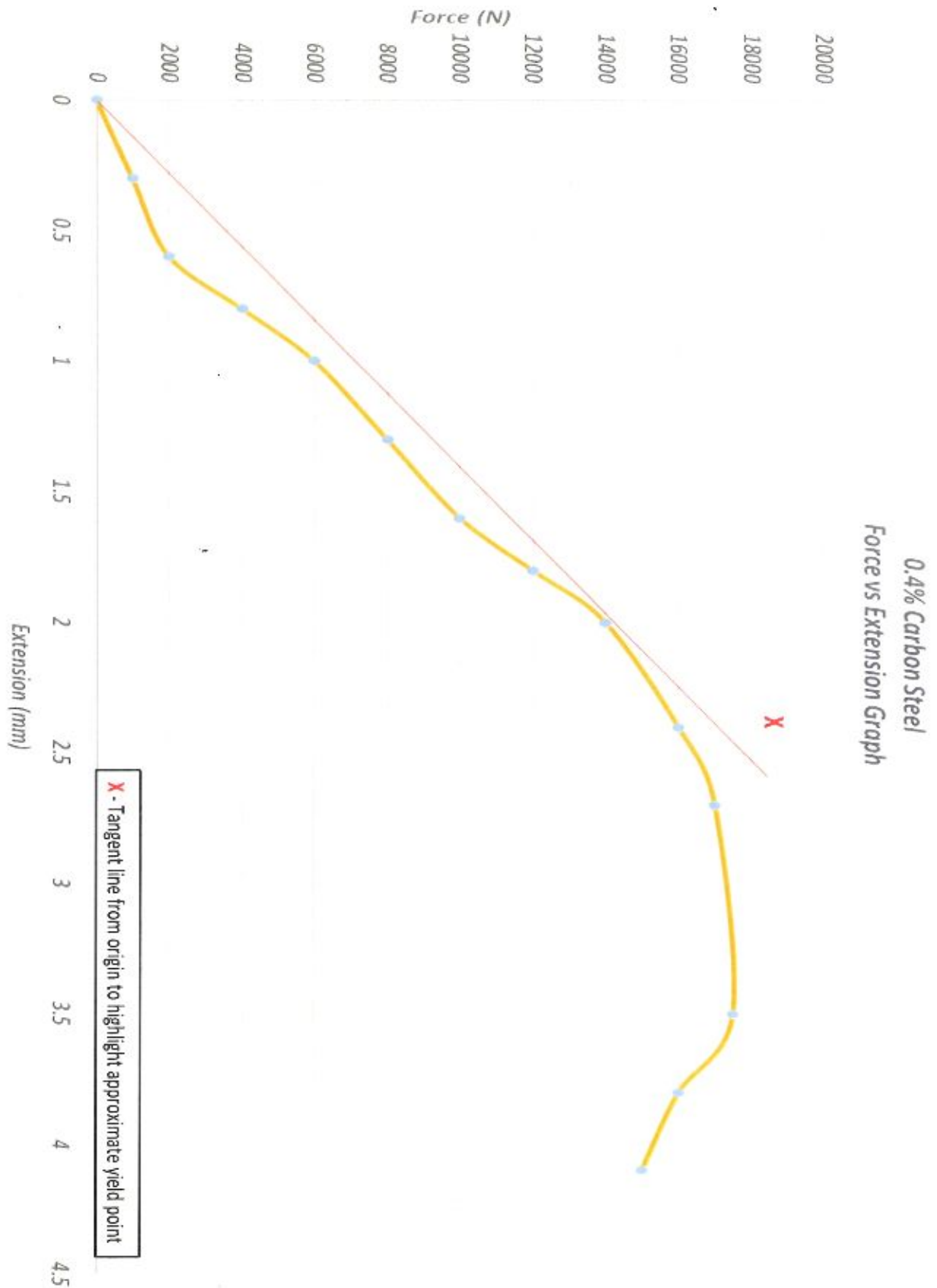
Appendix 4 – Annealed Copper Force vs Extension Graph



Appendix 5 – 0.1% Carbon Steel (Normalised) Force vs Extension Graph



Appendix 6 – 0.4% Carbon Steel Force vs Extension Graph



Appendix 7 – Force vs Extension Graph for Different Materials

Tensile Test Materials Comparison Force vs Extension Graph

