

## Memorandum

### Purpose

The tension lab investigated the tensile properties of polyethylene, nylon 6,6, and fiberglass composite. In addition to experimentally determining the tensile properties, the lab investigated how the materials responded to the loads placed upon them.

A hydraulic separation machine and a screw separation machine were the main tools used in the laboratory. In addition to the hydraulic separation machine, a sensitive caliper provided accurate measurements of the material samples.

### Procedure

The Tension I lab was very straightforward.

The lab consisted of three parts: Taking measurements from the material, using the hydraulic separator to test the material, and compiling the data provided by the hydraulic separator.

Measurements needed to be taken from the material because the tensile properties are dependent on the amount of material being tested. Using the sensitive caliper, accurate measurements of the width and height of the sample material were taken and copied into the lab notebooks.

The machine part of the laboratory was very straightforward. First, the material sample to be tested was inserted and clamped in the hydraulic separator. Second, the machine was programmed to move at a specific rate, and apply up to 6000 lbs of force in order to continue moving. Third, the computer program that recorded the data was zeroed out and programmed to start recording data. Finally, the machine was set to start testing the material.

Compiling the data took the most thought in the lab. It required thinking about the values returned by the machines, the measurements taken by hand, and how they relate to material properties.

The Tension II lab procedures mirrored those of the Tension I lab. The main difference was using a screw style separation machine rather than a hydraulic machine. In addition, because the aluminum and steel samples did not have a very large extension value, the amount of extension was measured using a separate tool rather than using the extension value returned by the machine.

The screw style separation machine was not as automated as the hydraulic separator. After programming in the rate to travel and the maximum force permitted, the extension and tension values were copied onto paper by hand. One person watched the value of the extensometer and indicated to the second person when the extensometer returned predetermined values. The second person recorded the tension value returned by the separation machine.

The extensometer was not very convenient to use. The device was necessary because the metals stretched a very small amount, and the extension value returned by the machine includes the amount the sample stretched plus the amount the material holding the sample in place stretched. By attaching the extensometer to the sample being tested, the extension value returned was just the amount of stretch of the sample. The main

difficult encountered was the extensometer did not attached squarely to the sample. The values returned by the device were negative for some time, and then increased until the numbers became positive.

## Results

### Equations used

Two equations were used to evaluate the raw data provided by the machines.

The first equation was used to calculate the amount of strain on the material sample. It is

Strain =  $\frac{\Delta L}{L}$  Where L is the amount of extension. This equation provided the numbers for the x-axis of the graph.

The second equation was used to calculate the amount of force on the material sample.

It is Stress =  $\frac{F}{A}$ , where F is the force on the sample and A is the area of the sample being tested. This equation provided the numbers for the y-axis on the graph.

Using these two equations, the graphs attached were generated. In addition, the data table following this section and all of the data analysis was performed using these two equations.

### Results Obtained

The fiberglass composite exhibited very uniform results. The composite stretched and stretched the intended amount under a force that increased in a linear fashion. The entire amount of extension was under Young's Modulus, that is, it would have regained its original shape up until the fracture point had we let the pressure off. The fiberglass sample, however, did not start to neck or show very visible signs of strain until the actual fracture. Please see Figure 1 the stress vs. strain graph of fiberglass composite.

The polyethylene reached its ultimate tensile strength much quicker. The stress increased rapidly until it reached the ultimate tensile strength, then the stress rapidly decreased as the sample started to neck, and then the stress increased slowly right before a second neck developed. The polyethylene sample did not break despite the two inches of strain the sample underwent. Please see Figure 2 for the stress vs. strain graph of polyethylene.

Nylon 6,6 behaved in similar fashion to polyethylene. The sample took a much greater force to stretch the material. The nylon sample broke after less than one inch of strain. As in polyethylene, the nylon sample started to neck before breaking. Please see Figure 3 for the stress vs. strain graph of nylon 6,6.

Steel and aluminum behaved in a similar fashion. After the ultimate tensile strength was reached, both of the samples continued to stretch for quite some time before the sample broke. In both of the samples, only the first 5 to 10 percent of the total elongation occurred before the elastic limit was reached. The ultimate tensile strength was only slightly greater than the force placed upon the sample at the elastic limit.

Please see Figure 4 for the stress vs. strain graph of aluminum and Figure 5 for the graph of steel.

Cast iron behaved in a similar fashion to the fiberglass composite. The amount of force placed upon the sample to elongate it continued to rise until the material broke. As in the other two metallic samples, the elastic limit was within 5 to 10 percent of the total elongation. Please see Figure 6 for the stress vs. strain graph of cast iron.

The following is a table of the numerical results

	Known Ultimate Tensile Strength	Measured Ultimate Tensile Strength	Percent Difference	Elastic Limit (in/in)
<b>Polyethylene</b>	2500	4285	71%	0.24
<b>Nylon 6,6</b>	10000	11572	15%	0.027
<b>Fiberglass Composite</b>	Varies	42749		0.00065
<b>Steel</b>	110000	139690	26.9%	0.00009
<b>Aluminum</b>	45000	48127	6.9%	0.004
<b>Cast Iron</b>	42000	38742	8.4%	0.00057

### Interpretation of Results

The results of the laboratory testing for the Tension I lab should have been quite accurate. The hydraulic separator is highly accurate at the loads applied to the materials. The corners of the material were cut square. There were minute scratches on the surface of both the polyethylene and nylon 6/6. Scratches of any sort affect the test results. Since the scratches were minor, they did not affect the experimental values significantly.

The results of the laboratory testing for the Tension II lab may not have been as accurate. Not having automated recording of the data created some error in the results. The primary problem with hand recording of data was the delay between the time the extensometer showed a value and the time the tension was copied into a notebook. This delay was small, yet it did result in some number being between 10 and 30 pounds off. In addition, the extensometer's negative values that it returned in the beginning are areas of possible error. The values should be accurate, but it would have been better had the extensometer returned positive values from the very beginning.

### Conclusion

The polyethylene, nylon, aluminum, and steel were all ductile materials, meaning the materials continued to elongate past the ultimate tensile strength. The ductility of the sample could be visually noticed by the neck that developed after the elastic limit was

reached. It could also be analytically noticed by noting that the sample continued to separate after the ultimate tensile strength was reached.

Cast iron and the fiberglass composite were the two materials that were brittle. The force required to separate each sample continued to increase until it broke into two. The ultimate tensile strength was the last applied force before the sample broke into two pieces. There were no visual or analytical clues to indicate the sample was about ready to break.

Polyethylene and nylon work well in low stress applications, such as soda pop bottles, clothing, and washers. The ductility of the materials and the ease of forming them into unusual shapes cause them to work well as containers, because the containers are inexpensive to manufacture and are very impact resistant.

Fiberglass composite is a very light material that withstands a great deal of force in the direction of the fibers, but does not withstand much force perpendicular to the fibers. As such, it works well for weight bearing loads in weight sensitive applications. At the same time, fiberglass composite gives no indication before it fails, therefore, it should not be the only support for the weight-bearing load.

Steel and aluminum work well as additional support for composite structures, as the primary material for buildings, bridges and countless other projects, and as reinforcement for other building materials. The ductility of steel and aluminum make it easy to inspect for fatigue and stress, hence, bridges and buildings can be closed long before they safety hazard. The low cost of steel and ability to work it in many different shapes makes it a good choice for cost sensitive applications.

Cast iron, being a brittle material, does not work well in high stress applications. The material will fail easily if it is worked enough or given a high load. At the same time, cast iron is easily welded and is very strong. Stoves, fireplaces, and other household goods are often made out of cast iron because it is easily cast into different shapes.

## **Bibliography**

Norton, Robert L. Machine Design: An integrated approach. Prentice Hall: Upper Saddle River, 1996.