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| https://lh3.googleusercontent.com/y283eTVNvJaLmT-Jcj6YWZEn_AurXgKGA5HBiNYqA0iAwX6YhfgeZKhuiPowDuRnKmeFV0UsS9J0lGHGWKLBh6xLDI1UJoZtM4flPhK5T3Ip4VWGYwrDCdAOQilpwC5BBgSd6Ucr348  Operational Manual  Thermal Protection System Tensile Tester | Abstract  Concise manual detailing the operations and considerations of the tensile tester designed as part of the capstone project for LSU’s engineering department per commission of Nation Aeronautics and Space Administration.  Garrett Barton  Team #14 LSU EE4820 Spring 2019 |

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# System Overview

The device that was created was designed to replace the current electric tensile tester used to test the tensile strength of thermal insulation (specifically that of a foam consistency). The current tensile tester was designed and build by Honeywell in the 1970s, and the replacement parts have become difficult to source. The design details of the new tensile test can be found in the reports posted elsewhere and only the operation and basic maintenance will be discussed here. The device is operated with to buttons with a 7-segment LED display and microSD card storage. The device is currently powered by an Arduino Mega 2561, which is programed in a C variant called the Arduino Wiring Language. The battery system is array of nine sells in a 3 cells in series (a string) and 3 strings in parallel resulting in 12.6 Vdc nominal and 6 A maximum constant current. The device was found via testing, using 45 lb weights, that the battery life to be about an hour.

The code has a section global variable declaration at the top and outlines many of the preset values so that they may be easily changed without having to go digging into the rest of the lines.

* The motor in particular operates on a ratio for setting the output of the motor driver. The range is from -400 to 400 with the negative only describing the polarity or direction of the motor. Thus, the range is, for practical purposes only 0 to 400. The maximum voltage of the battery array is 12.6 Vdc, and to output about 3 would require that the voltage be about 4 Vdc; therefore, a ratio coefficient of 155 is used. At the end of the code (version 2.0) there is a breakdown of voltages and there corresponding ratio coefficients.
* There are other settings such as time that the display will display something that the user can change to suit experiences.
* The only other section that has code that the user may need to change/access is the interlock section (called IsDone() found just after the main loop). Here interlock conditions are defined. This section is flexible in that it is set up such that when an interlock condition is met then a variable is set to 1, and this variable is returned from the function call. The value returned from IsDone() is used to break loops and thus the number of interlock conditions can be changed.

# Warnings

The device while designed to be as safe as possible does have dangers associated with it.

* The batteries are Lithium Ion and the specific cells chosen are LCO (Lithium Cobalt Oxide) and Cobalt has been known to have an issue with **thermal** **run away**. Therefore, the batteries should not be over/under charged or used, the cells should be prevented from being punctured, and the battery pack should not be attached such that it cannot be removed quickly should the any of the cells become dangerous (i.e. explode, catch fire, leak gasses.)
* There is some risk of electrical shock if the device is opened; and therefore, proper safety precautions should be used when accessing any of the components. Remember that it only takes about 15 mA in order to kill an human and this device can pull up to 12 A (peak current).
* The clear acrylic tube is meant to protect from fragmentation that may occur; however, the tube may break itself if over loaded or over time.

# Operation Procedures

When the power button is switched on the Arduino starts its boot up procedure. In order to indicate when this procedure is completed “done” will be flashed on the screen. The device tares itself each time the device is turned on and no weight/force should be applied to the hook before the boot up procedure is completed. The two buttons on the side of the device are for pushing the hook down and running the testing procedure.

* The **blue button** (the one on bottom) will push the hook down as long as the button is depressed. The speed of the downward motion is hard coded as about 3 .
* The **green button** (the one on top) has a delay of roughly two seconds before the motor will be turned on.
  + The motor is initially set to 155 (see above for correlation to linear speed).
  + As the force being read, and logged, the force reading is checked in order to determine the new motor ratio coefficient.
    - This is done by setting thresholds and setting certain motor driver ratio coefficients.
  + The test is run until one of the interlocks is detected.
    - The device in version 2.0 requires the user to release the run button to terminate the test if the test was not terminated by another interlock condition being met already.
  + Once the test has been terminated then maximum value will be displayed on LED display for three seconds.
    - The code can be made to display either maximum *force* or maximum *tensile stress*. There is a constant area/volume, so it only involves a simple division. However, the code currently stores the force read into the SD card, allowing the user to do their own calculations with their own desired tolerances.
* The **microSD card** can be put into an adapter to be used in a regular SD card slot and the data is stored in a single text file that is comma delimited.
  + The file has a header to separate each time the device was turned on and empty lines between each test. The header can be changed or removed as the user prefers.
  + The test data is only stored in that single text file, but the contents of that file can be cleared each time the test data has been read from the SD card on the computer.
* The **batteries** fit into slots in the detached battery pack with the cells going in each slot.

# Regular Maintenance

The device does not require much in the way of regular maintenance and only the batteries need regular charging. The batteries, as mentioned previously, will last for about an hour, but will require regular charging. The battery charger that was included in the deliverables to the client will charge four cells in about three to four hours form dead.

# Long Term Maintenance

The device will require several components to be check and possibly replaced over long term use.

* The battery cells will need to be replaced, depending on use, within about five years of cell life. Lithium Ion battery cells typically have life spans of about five years.
* The batteries need to be discharged to a “storage level” if they will not be in use for long periods of time in order to maintain the health of the battery.
* The LED display will need to be replaced if any of the LEDs in the array go out.
* The buttons will need to be checked for function (observe while in use) and changed if nonfunctional.
* The plastic outer casing *could* be replaced if the damage warrants it; however, the outer casing is only to provide a cover for the internal components.
* The screws and connectors will need to be checked for fit and replaced if loose or otherwise damaged (i.e. too must rust has built up).
* For all replacements and redesigns see the work compiled in the main folder as replacing parts may require ordering a similar product from a different company.