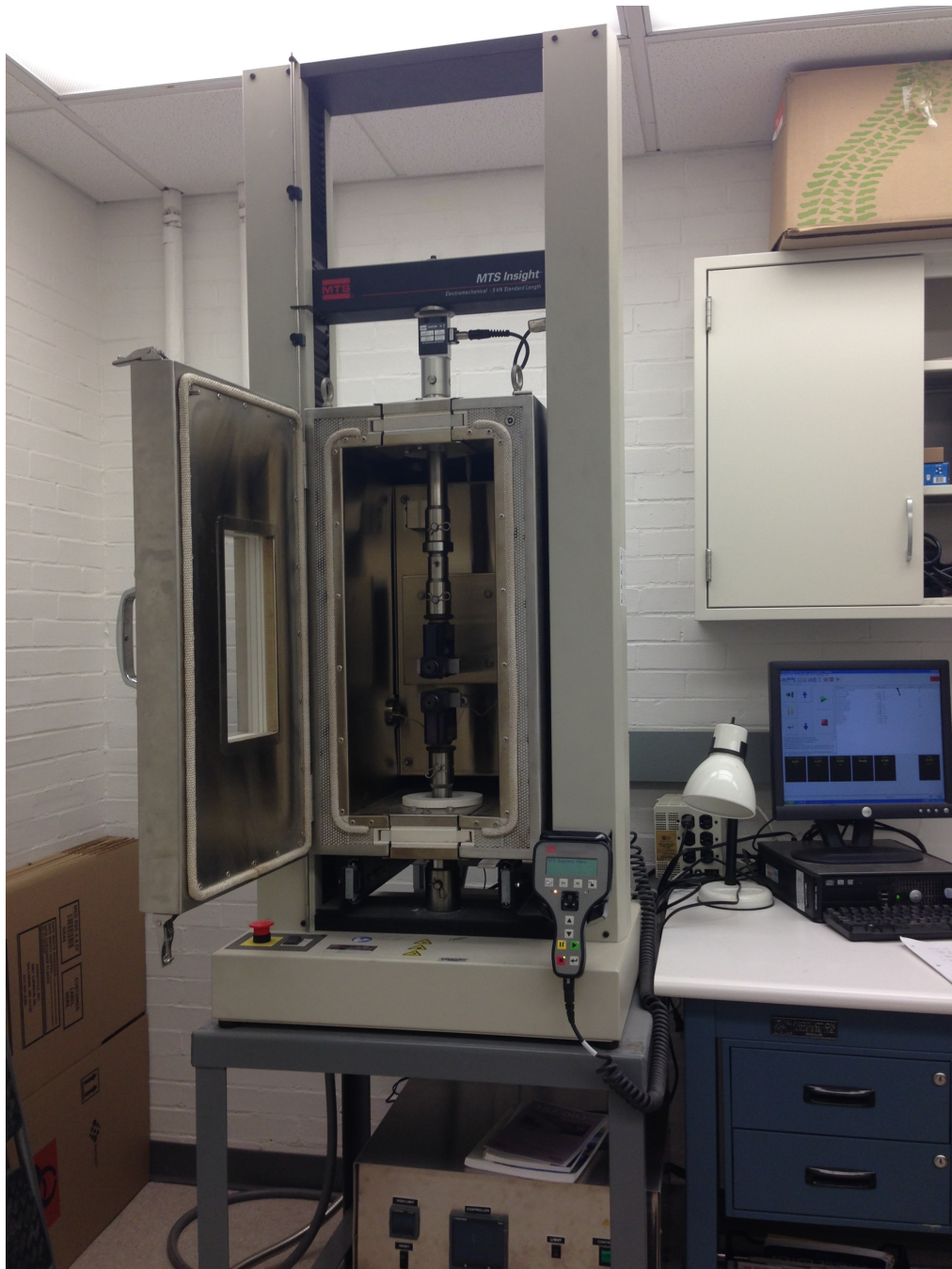


Nguyen Lab, Latrobe 1

# MTS/TestWorks Manual



June 2015

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# 1. General Information on the equipment

## Contacts MTS

General information: info@mts.com

Technical support: em.techsupport@mts.com

HELP Line 800-328-2255

Weekdays 7:00 A.M. to 6:00 P.M., Central Time

See the MTS Insight Manual for instructions on information to have on hand before calling.

## Frame

Model Insight 5 Tabletop + Extra height option

Maximum load 5kN

	Decimal units	US units
<b>Minimum Speed</b>	0.001 mm/min	0.00004 in/min
<b>Maximum speed</b>	1000 mm/min	39 in/min
<b>Vertical test space</b>	1400 mm	55 in
<b>Column spacing</b>	405 mm	15.9 in
<b>Dimensions</b>	1900 x 650 x 450 mm	75 x 26 x 18 in
<b>Weight</b>	123 kg	271 lbs.

Position accuracy +/- 0.01 mm

Speed accuracy +/- 0.05% of set speed

**CAREFUL** do not connect the frame directly to the wall outlet! It needs to go through the transformer, otherwise the electronics could be damaged and need to be replaced.

## Load cells

Two load cells are available for the MTS, with maximum load of 500 N and 5 kN.

1) Model 661.11 series 661.11B-10

Capacity 500N

Repeatability 0.02% of full scale

2) Model 661.19 series 661.19F-05

Capacity 5kN

Repeatability 0.03% of full scale

## Environmental chamber

	Decimal units	US units
<b>Temperature range</b>	-129 to +315C	-200 to 600 F
<b>Internal height x width x depth</b>	660 x 356 x 432 mm	26 x 14 x 17 in
<b>Weight</b>	Approx. 68 kg	Approx. 150 lbs.

- Controller Eurotherm 2404: detailed manual on how to control the chamber is available on the wiki and in the lab.
- Roller mounting: the chamber can be removed by pushing it back on the rails - see description in MTS chamber manual - in order to test at room temperature and use the full crosshead travel length.
- **CAREFUL** the chamber needs a 30 Amp power supply.

## Grips

### 1) **Roller Action Tensile Grips Model 5000 Self-tightening**

Capacity 5kN – part number 100-184-842

Max specimen thickness 7 mm

Max specimen width 75 mm

Temperature range -130° to 250° C

### 2) **Compression Platens**

Capacity 10kN - part number 100-182-229

Temperature Range: -130° to 150° C

Max specimen diameter 50mm

### 3) **Advantage Screw Action Tensile grips**

Capacity 5kN – part number 055-426-901

Max specimen thickness 25mm

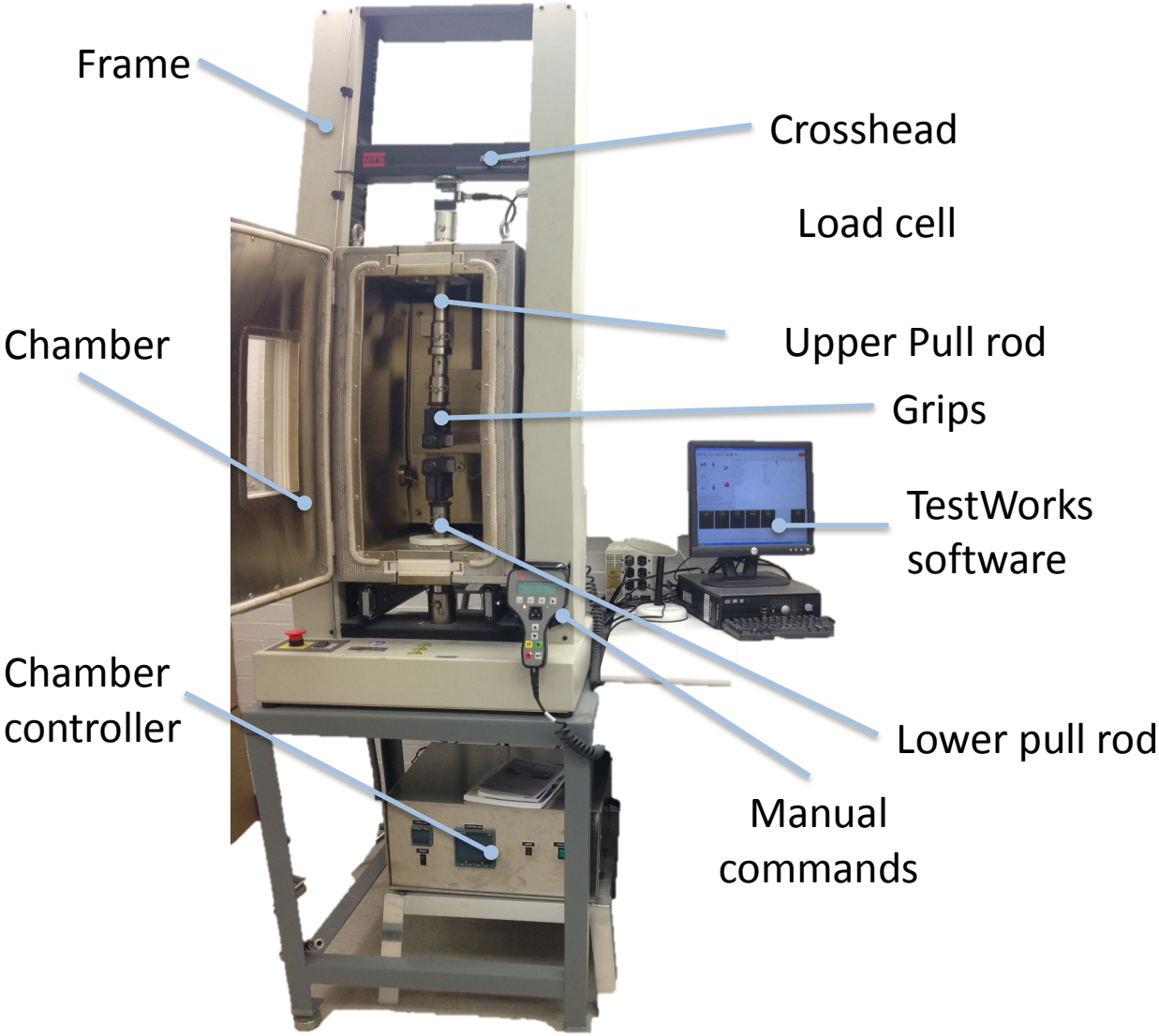
Max specimen width 75mm

With two grip faces, either smooth or corrugated

Temperature range -129 to 200C



Nomenclature



## 2. Powering and Shutting off

### Powering up devices

- The following systems must be turned on **in this order** to properly start the machine: Frame and then the computer.
- The chamber can be turned on and off at any point. The green on/off button for the chamber is situated on the front side of the controller. If it does not turn on the controller, check that it is plugged in and that the main switch on the back is on.
- Check that the stop button of the frame is not on. If it is, release it.
- Launch the TestWorks software. You will not be able to move the crosshead until TestWorks can communicate with the frame.
- Create a folder with your initials in Documents and add a shortcut on the desktop. You will save your methods and your tests results in it. *Note: If you save your methods and results in the common MTS folder, there is no guarantee that they won't be deleted.*

Wait 20 min for the load cell to warm up before doing any testing.

### Starting TestWorks software

- Press the TestWorks 4 icon on the desktop of the computer.
- Press OK on the next screen with user login MTS, no password.
- Before doing anything else, the software needs a method to open. Either click ok to open the one proposed (by default it is the one used last) or press Advanced to browse for another one.
- Check the bottom right corner for the state of the motor. IF the indicator is red, the software is not communicating with the frame.
- PICTURE Motor Red
- Click on Motor Reset, the indicator should become green, which means that the frame is enabled.
- PICTURE Motor Green
- If the software does not ask for a method or if the test buttons (stop, play,pause) remain gray, it is probable that the software cannot communicate with the frame.
- Quit the software, check that the frame is powered, check all the cables, and start the software again.
- The manual for the software is available on the wiki and physically next to the machine (on the temperature controller). Each user should scan it to make sure they are aware of the different options provided to them to program a test as well as control the frame and the data acquisition.

From there you can either start a test or create a new method.

## Shutting off

### At the end of a 'normal' test day

- **Do not shut off the frame.**

The frame is almost never shut off (main reasons would be maintenance or moving).

- **Shut off the chamber controller and unplug the chamber.**

The chamber controller should be shut off and the chamber unplugged at the end of the day.

- If you did a test in temperature:
    - Dry the inside of the chamber
    - Leave the door of the chamber open for a while (15 min) to avoid moisture.
    - Remove the grips and DRY them with a rug.
- Put them on a rug on a table. It will take roughly an hour for the grips and pull rods to return to ambient temperature if they were below -50C.

### Complete Shut off of the system

Turn off **IN THAT ORDER**

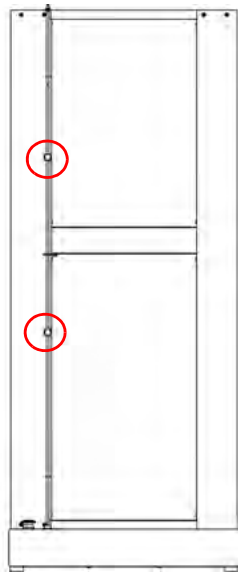
- Chamber controller
- Unplug the chamber (30Amp plug)
- Quit TestWorks
- Frame, on/off switch in the front
- Computer + computer screen
- Press the stop button of the frame, just in case

### 3. Safety Notes

#### Position limits and emergency stops

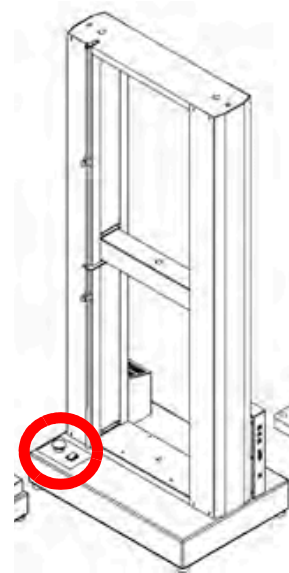
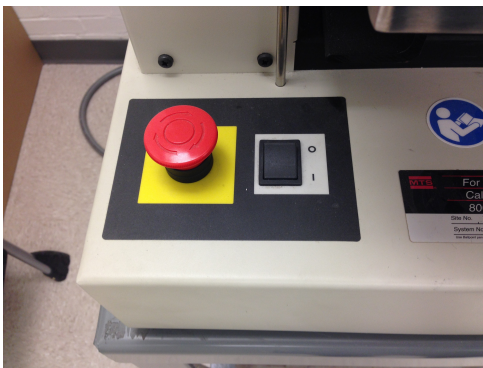
- \* Wear eye protection, specimens can snap.
- \* Always check that you have established proper **position limits** for the grips and pull rods you are using. To make sure that their position is right for your setup:
  - Move the crosshead up until the grips approaches the ceiling of the chamber. This should be the upper limit. (The frame can pull on the ceiling of the chamber and damage it badly)
  - Move the crosshead down until the grips almost touch each other. It should happen before the load cell presses on the chamber but both sides need to be checked. A pin in the pull rods can actually press on the chamber if it is not centered properly. Whichever happens first defines the lower limit.

*Note: The crosshead cannot be jogged up and down if the TestWorks software is not open.*



The position limits are the yellow screws on a metal rod in the right column of the machine (right figure). They can be moved by unscrewing, gently sliding and screwing back. They act as emergency stops. If you move them too fast or without completely releasing them, the emergency stop will be triggered and will have to be removed in the TestWorks software (see next page).

The stop button can be pushed at any time (left figure). It can be pushed often and is easy to reinitialize once the danger is gone. Consequently, it should be used without any reserve.



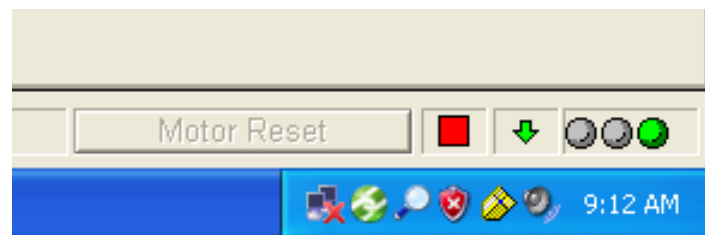
## Dealing with emergency stops

At the bottom right corner of the screen in the TestWorks software are the stops indicators.

- The first one indicates the upper limit has been reached.
- The second indicator indicates the lower limit has been reached.
- The last indicator indicates the frame is not communicating with the computer. It could be because the emergency Stop button has been pushed.



Click on the Motor Reset button to enable it after an emergency stop. The indicator should look like this:



**Then use the manual command to move the crosshead away from the danger.**

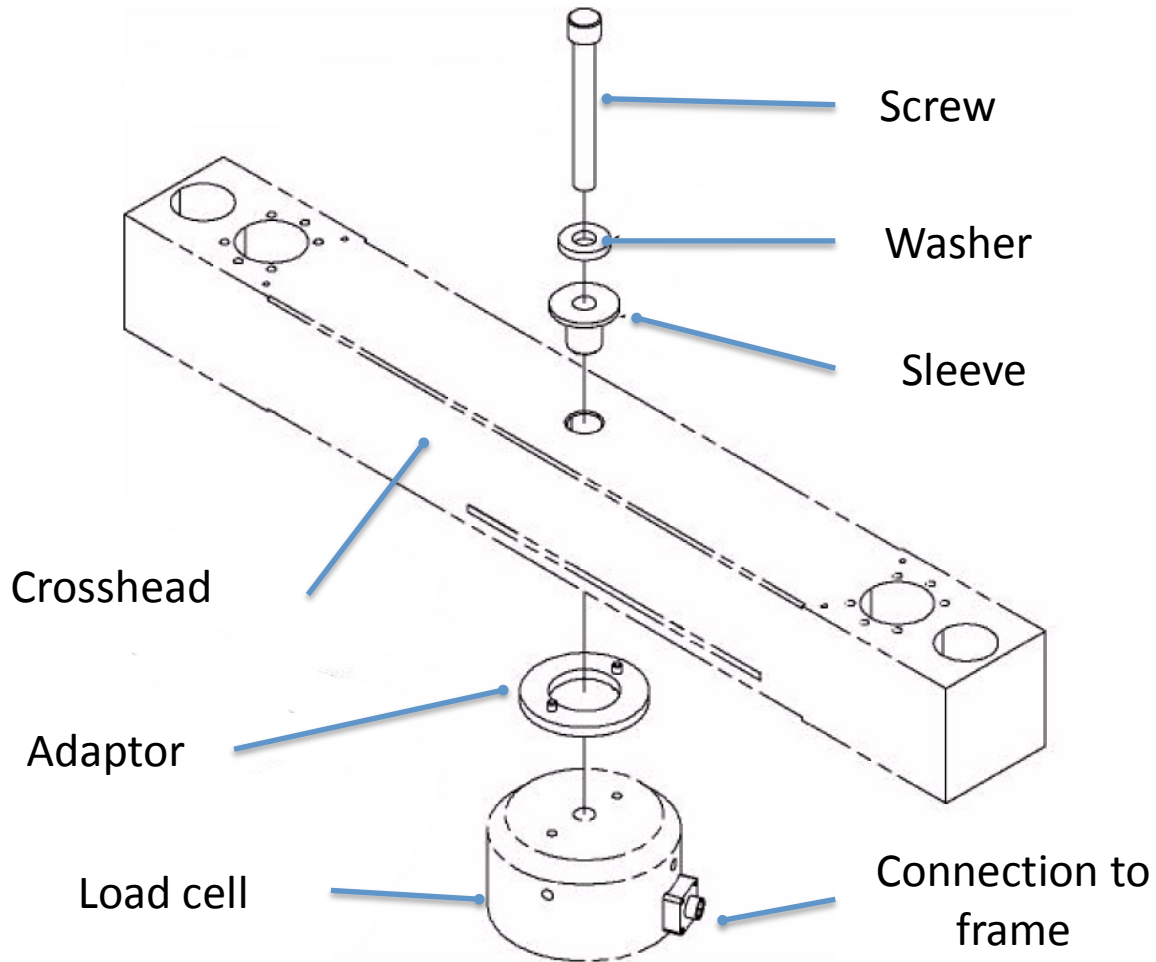
If the stop indicator does not turn to green, check that the stop button is released and that the crosshead is not pushing the position limit again. Check the whole set up.

If it still does not turn to green, call MTS helpline. Check MTS contacts on the wiki and make sure you assemble all necessary information.



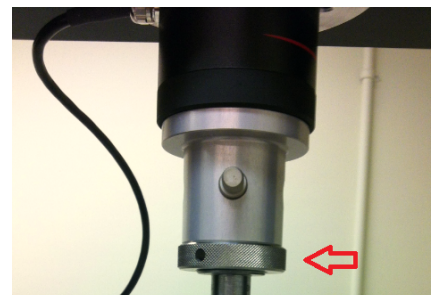
## 4. Mounting the load cells

The picture shows all the pieces that need to be placed between the load cell and the crosshead. Tighten the screw, the load cell should not move at all once on the crosshead.



Make sure the connection cable is properly attached to both load cell and the frame.

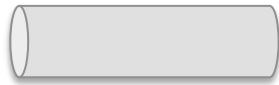
Finally attach the pull rods under the load cell. Make sure that ALL the tightening bolts (red arrow) are as tight as possible. If one of them is moving, it will produce a plateau on the measured stress-strain curve and introduce a large error in the measurement.



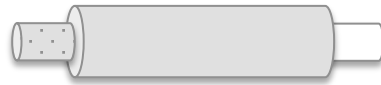
## 5. Install and remove the chamber

### Installing the chamber

- 1) Remove all the grips and pull rods.
- 2) Move the crosshead up so that it is fully above the chamber
- 3) Reset the gauge length.
- 4) Place the position limits so that the crosshead cannot come down on the chamber while it is being moved.
- 5) Slide the chamber into the frame, until it touches the front bar.
- 6) Lock the chamber in place using the two bolts on the bottom sides.
- 7) Put the top pull rod back.
  - a. Use type D pins out of the chamber.



Type O pin



Type D pin

- b. Don't forget the metal circle on top and bottom of the chamber.
- 8) Reset the position limits so that, in this new setup, the grips cannot touch each other or the ceiling of the chamber.
- 9) Bring the top fixture back down and reinsert the upper grip. Use type O pins inside the chamber.
- 10) Put the grips on the lower pull rod and then insert the pull rod through the floor of the chamber.
- 11) Reset the gauge length and balance the load

## Removing the chamber

- 1) Remove all the grips and pull rods.
- 2) Move the crosshead up so that it is fully out of the chamber
- 3) Reset the gauge length.
- 4) Place the position limits so that the crosshead cannot come down on the chamber while it is being moved.
  
- 5) Unscrew the two bolts located at the bottom sides of the chamber
- 6) Slide the chamber into its non-use position. Make sure it is secure in this position.
  
- 7) Put the top pull rod back if needed.
- 8) Reset the position limits so that, in this new setup, the grips cannot touch each other or damage the chamber ceiling.
- 9) Bring the top fixture back down and reinsert the grips.
- 10) Put the lower pull rod and grip back.
- 11) Reset the gauge length and balance the load.

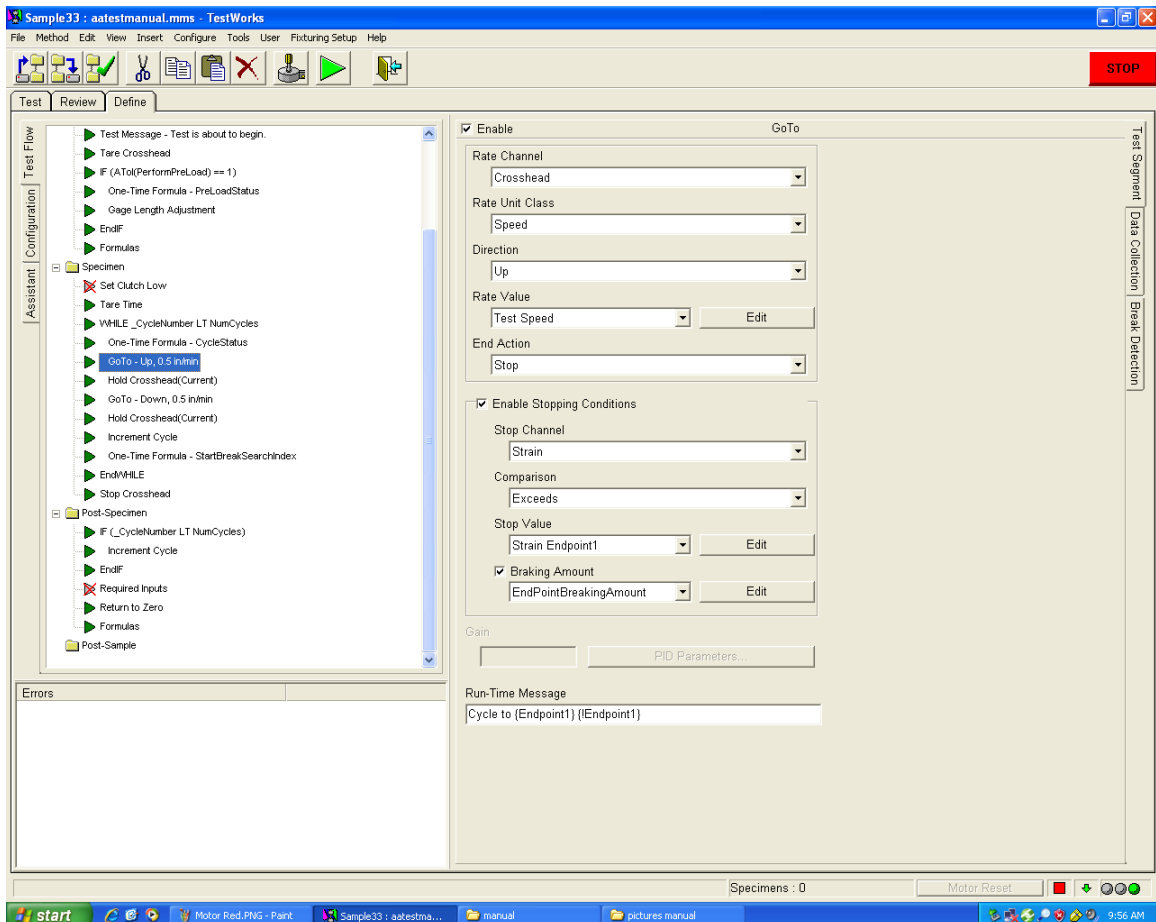
## 6. Creating a New Method

There is no create method in this software. The way you are supposed to create a method is by starting from an existing one and modifying as needed. MTS provides user with methods packages for different types of test. The ones available in our lab are:

- Creep, Relaxation, and One Cycle Hysteresis
- Compression
- Flex
- Peel-Tear
- Tensile
- Multicycle

There is however an Assistant to the creation of methods. I have never used it, so I would not be able to recommend it to anyone. It is in the Define upper tab, Assistant left tab.

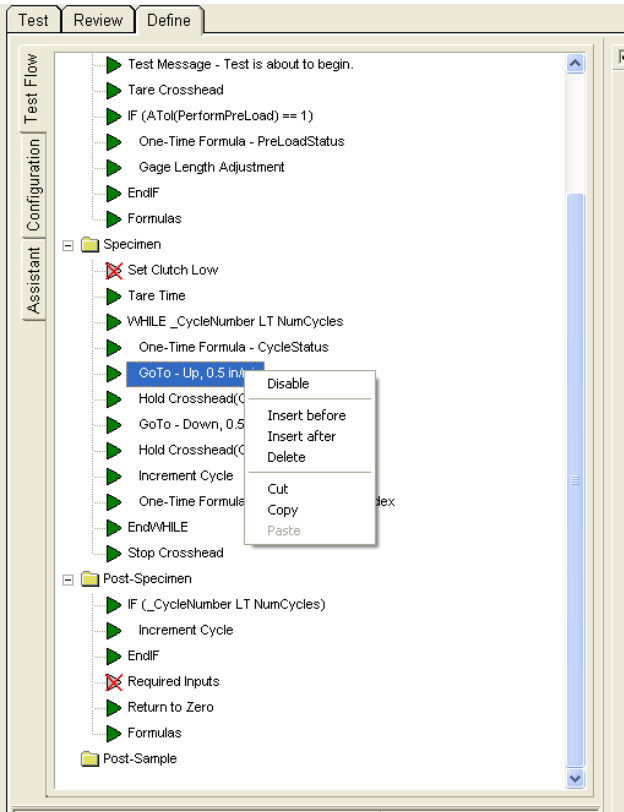
### Set up



1. On the TestWorks startup screen, Go to Method > Open method.
2. Choose from the templates the test that is closest to what you want. It is important to get the closest one, it is not necessarily possible to program a clean cycling test from a simple tensile test method.
3. **Save it with a new name in YOUR folder right away. Go to Method > Save Method As**
4. The software has 3 main upper tabs: Test, Review, and Define. As expected, the creation of a new method happens in the Define tab.

**Test Flow**

5. There are now three tabs on the left of the screen: Test Flow, Configuration,



Assistant. Make sure you are in the Test Flow tab (see picture above). You should see all the steps (called segments) of the test on the left of the screen and, when you click on one segment, the properties of that segment on the right of the screen. Note that the right part of the screen also has three tabs now: Test Segment, Data Collection, and Break Detection.

6. At this point, the software is pretty much self-explanatory. Your goal is to insert/delete/disable/modify segments until you set up the test you were aiming for. To modify, click on a segment and change the properties on the left. To insert, disable, or delete, right click on the segment. Use the manual or the software help in case of doubt.

**\*\*\*\* Here are the tricks of the trade: a few points you should be careful about and that can ruin your test. \*\*\*\***

### Variable creation or modification in Configuration

- One of the trickiest thing to do in TestWorks is to properly create a variable. For that, leave Test Flow and go to Configuration left tab. In this tab, you can see all the variables of the method, sorted in categories.
- **DO NOT touch the channels variables.** You will probably break the method since those are either the signals from the hardware or needed computations for the controls.
- The formulas are mostly useless to me since I tend to post-process raw data myself in Matlab. I would not necessarily trust a Young's modulus given directly by the machine.
- Now the interesting part: the **inputs**. In this folder, you can either add a variable or modify one. For example, if you need more than 2 strain endpoints, copy and paste Strain Endpoint 1. The software will ask you for an internal name (no space).
- Once the variable is copied, in the bottom right quarter of the screen, you can pick all the characteristics of the variable, such as display name, units, default value.
- Make sure the limits correspond to what you want.
- Important: In options you decide where this variable will be input. If you do not chose anything you won't be able to modify that variable from the default value. Required input means that a screen will appear each time you press play to start a test. (I do not know about you but that drives me nuts.) I would recommend to chose **panel input** for all the variables you want to manually control before each test. This will put the list in the upper right quarter of the screen in the Test upper tab (you can check right away). Then before starting a test, you go through the whole list and you are done.
- You can now use this variable in the segment characteristics of your test flow.

### Data Collection

- For each segment, click on the **Data Collection** right tab and make sure it is enable! Otherwise, you will perform a perfect test but recording no data.



- Make also sure the data acquisition rate you are planning to use makes sense regarding the length of your test and the load and displacement rates you are programming.
- Finally, at the bottom of the Data Collection tab, there is a section called **Buffer**. This section can make your life hell. You must input a buffer size for this segment specifically. The buffer size can be calculated from the duration of the segment (or an approximation) and the data acquisition rate. Don't forget to add a margin!
- When the buffer reaches a maximum, the smartest thing to do not to lose any data is to use the **Fold and reduce data rate** option in the Buffer Full Action menu. Other horrifying options include stopping the whole test, going directly to the next segment, or removing all points at the beginning of the segment to add them to the end.

Note: Fold and reduce data rate means that if your buffer size is too small, the software will remove every other point from the first part of the test and will keep recording data at a lower rate for the time being (until the limit is reached again). At least, all the parts of the segment are recorder. BUT you will end up with segments with varied data acquisition rate which can be problematic if the data acquisition rate is not high enough for the phenomenon you wanted to observe and can make post processing tricky.

**CAREFUL The machine limits the number of points per test.** Obviously considering the impact of a buffer size that is not large enough, you could try to just put a high value in each buffer and run with it. First, what seems a high number to you might actually not be high enough depending on your data acquisition rate. We tend to underestimate the number of points resulting from a test. Second, if the total of all the buffers is actually too high, the machine just stops recording! It will record the first segments that fit into the limit, pursue the test as if everything is fine, and once you export your data, you realize that you are missing most of your test. so try to estimate properly the buffer size you actually need.

### Break Detection

- Next, go to the Break Detection tab. If you are expecting large load changes in small time, which can mimic a break (you should not but ...), make sure to disable the break detection or to change the threshold values otherwise the test will simply stop.

### Exporting data

The last part of every method is instructions to export the data that you want.

This is less of a problem than the data acquisition because you get as many do-overs as you want: these instructions can be changed after the test to export the data again. I will here describe to you the method I use, definitely not the only possible one, but this one works and allows me to save the raw data text file wherever I want to.

- a. Go to left tab Configuration > Specimen Export
- b. in Export Template, click Browse and choose MTS Export All with tabs.txt
- c. in File Mode choose Sample Name - Append to prevent the software from overwriting any test file.
- d. if you have data to export you can check the format by going to File > Export Preview > Specimen. Notepad will open a text file with all your data.

*Note: if you are planning to use the Matlab function available on the wiki to read your text file, make sure you save one test per text file, the function will only read the first one and the bash script will crash. To do that, always save a specimen and not a sample (all specimens of one test).*

## 7. Measuring specimen dimensions

### Using a caliper or micrometer

Use preferably a caliper to measure lengths and a micrometer to measure thickness of rectangular specimens or height of compression specimens.

- Apply the device (caliper or micrometer) without applying pressure on the dimension you want to measure, especially for soft elastomers.
- Block the device.
- Then remove it from the specimen.

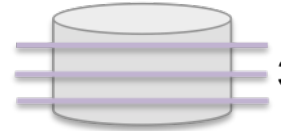
*If you are having trouble removing the device without modifying the measured length, it means that some pressure was applied on it.*

- Write down value.

**Write down in your lab notebook every measurement performed.** And then, next to them, the mean you will input in the software.

### Compression specimens

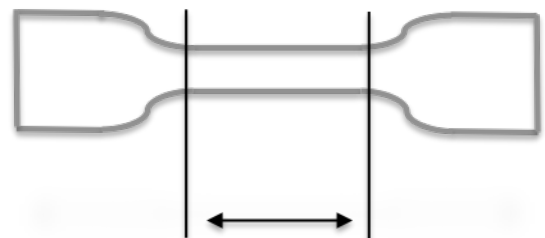
- Measure the height in 3 places evenly distributed along the total circumference. Take the mean.
- Measure the diameter in 3 places evenly distributed along the height. Take the mean.



### Tensile specimens

Tensile specimens are called dumbbell specimens and have the following shape:

- Measure the gauge length 3 times. The gauge length corresponds to the straight part of the specimen with the smallest section. Take the mean.
- Measure the width in 3 places evenly distributed places along the gauge length. Take the mean.
- Measure the thickness in 3 places evenly distributed places along the gauge length. Take the mean.

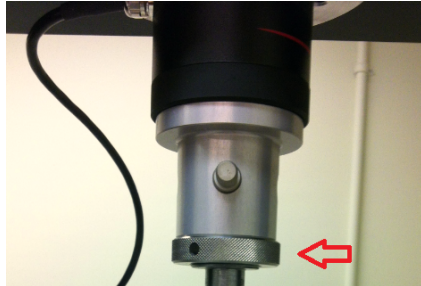


Gauge length

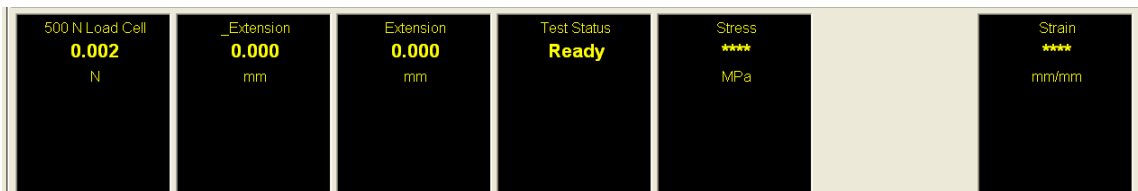
the

## 8. Testing the Specimen

1. If necessary change the grips, the pull rods, and **the position limits**. Before doing any testing, check again that the tightening nuts (red arrow example on the picture) are tightly secure.



2. On the TestWorks startup screen, click the **Test** tab.
3. Select the method you have created in Method open.
4. Measure the specimen (see manual, measuring specimen dimension). Input the dimensions into the input panel fields. **Check that each dimension is in the right field.**
5. For Tensile Test:
  - a. Place the specimen between the two grips. Center the specimen for uni-axiality. Check that the specimen is not sliding in the grips.
  - b. Balance the load: right click on the Load Meter (See picture below) and select **[zero the channel]**.
  - c. Move the crosshead upwards until the specimen is taut. Use the small displacement jog. The gauge position will be indicated when the load increases by a minuscule amount as you move the crosshead.



5. For Compression test:
  - a. Place the specimen between the two compression plates. Center it as much as possible.
  - b. Balance the load: right click on the Load Meter and select **[zero the channel]**.
  - c. Adjust the jogs until the specimen is slightly touching the specimen. Use the small displacement jog on the manual command to bring the crosshead

down until the load increases by a small amount.

6. Once the specimen is in place, zero the displacement and load: Right click on the Extension meter and select **[zero the channel]** and right click on the load indicator and **[zero the channel]** to reset the gauge length and the load. You should start your test with a 0mm extension and a 0N Load.
7. Check that all the variables in panel input are correct.
8. Click **[PLAY]** to run the test.
9. At the end of the test, return to gauge length if possible without damaging the machine or the specimen. Otherwise, manually move the crosshead until you can remove the specimen from the grips.
10. To rerun the test on a different specimen, repeat steps 4-9. Although, I would advise to start a new sample every time you change specimen. This makes the exporting and processing of the data much easier.
11. Once the test is complete, click [Save as] and give a proper name to your specimen and test. You can edit this name according to the specific test you are performing. Try to maintain consistent names throughout your experiments. *For example, if you do compression tests at 3 different temperatures (0, 20, 40°C) on natural rubber, good file names could be NR\_comp\_00, NR\_comp\_20, and NR\_comp\_40.* The data will be saved in MTS format that can be reopened in TestWorks.
12. To get your raw data, click **[File >Preview Export > Specimen]** to open a text file containing all the raw data. CHECK that all the data you need is actually in there, and save the data to your folder.
13. Go to File> New sample to start a new test.

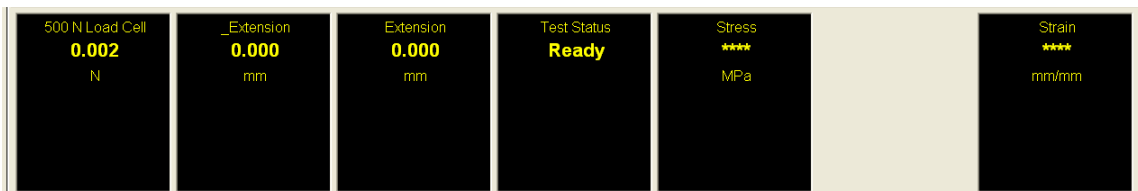
The code to read the raw data in Matlab is available on this wiki in the section Experimental Protocols subsection Data Analysis.

## 9. Thermomechanical testing

The temperature chamber is completely independent of the mechanical testing. This means that you cannot trigger a temperature variation by a mechanical signal. This also means that the software is NOT recording the temperature. What you can do is time the temperature program according to your mechanical test.

### If you want to do a test at constant temperature

1. Create a variable in your method called Temperature in panel input and make sure to document the temperature of the test.
2. Place the specimen in the chamber.
3. Set the target temperature using the arrows on the temperature controller
4. Close the chamber. There is a safety in the chamber door that prevents the chamber to try to reach the target temperature if the door is not fully closed.
5. Once the temperature equilibrates, open the door just enough to reach the specimen, leave the specimen as much as possible inside, and measure the dimensions of the specimen at the target temperature. WEAR the right protective equipment for the temperature you are reaching. If you touch very cold pieces of metal, such as the grips or the pull rods, your skin will stick to them.
6. Place the specimen in the grips. Zero the \_Extension and load channels: Right click on the corresponding Meter (see picture) and select Zero channel.



7. Close the door and wait for the chamber to go back to the right temperature. Make sure the load stays at zero during that time. Use the manual commands if necessary to move the crosshead up or down.
8. In the mean time, input the specimen dimensions in the software and prepare the test.
9. Start the test.



## If you want to change temperature during the test.

1. You need to program either a temperature program or temperature set points directly into the temperature controller. Use the controller manual to do so. It is tricky.
2. Make sure you time your changes properly and leave a lot of margin time for the temperature to reach a stabilized value before the mechanical testing.
3. During the temperature changes, make sure that the method in TestWorks corresponds to either zero load if you want to adapt to the change in length or hold the strain if you want to measure the change in load. A zero load segment will need PID parameters corresponding to our material. Go to the help of the software to figure out how to set up PID parameters. From our experience with very soft elastomers, the PID regulation of the machine is very weak.

*Note: from what I know of the system, it might be simpler and more efficient to actually prepare three methods, for before, during, and after the temperature change. You can then manually go from one to the other and change the temperature on the controller. You will have small breaks in between tests, so time management might be an issue.*